Mireille Schipper

# Agriculture in Alaska

Minor Arctic and Antarctic Studies

Sciences in Polar areas 2

Suprervisor: Maarten Loonen

## Abstract

Alaska is the only Arctic region in the United States. For much of the state, average annual temperatures are below freezing. Due to the state's high northern latitude, food production is limited and contributes only to a very small part of the economy. This paper assesses if it is possible to advance agriculture in Alaska in an economically sustainable way. To answer the research question, the challenges farmers need to overcome in order to successfully operate in Alaska are analyzed and identified as being environmental/geophysical or socioeconomic in nature. Environmental challenges to Alaskan agriculture are linked to high latitudes and include strong varieties in sunlight hours, the cold and harsh climate, availability of water, and the quality of the soils. Socioeconomic challenges include low financial reward for farmers, limited markets, high costs and limited availability of land, lack of infrastructure, and a negative mindsets towards farming in native communities. To overcome these challenges, several field-based, social and political solutions to the problems of high latitude farming have been proposed and some are already being put into practice. Field based solutions include season extending techniques such as high tunnels, improving soil structures, identifying cultivars with greater adaptive capacity, and introducing hydroponic gardens. Social and political solutions are reached by stakeholders and government, often through cooperative interactions and discussions. These solutions include more appropriate funding for new farmers, addressing the high costs and preservation of agricultural lands, improving market strategies, advancing infrastructure and the establishment of agricultural education programs to reach Alaska's rural communities. However, food security in Alaska cannot be obtained exclusively though local agriculture in its current form, nor can it exist with the state's current level of dependency upon importend foods. Therefore, more time is necessary to successfully advance agriculture in Alaska in an economically sustainable way.

**Key words**: agriculture, economy, Alaska, climate change, greenhouses, challenges

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## Introduction

The Netherlands is one of the world's largest agricultural producers, exporting around US $85 billion worth of vegetables, fruit, flowers, meat and dairy products each year. With a total surface area of 41,534 km$^2$, there is only a limited amount of farmland (Government of the Netherlands, 2016). In contrast, in Alaska, America's largest state with a surface area of 1,718,000 km$^2$, the total value of the entire agriculture industry was only around US $59 million in 2012 (National Agriculture Statistics service, 2012).

Alaska is the only Arctic region in the United States (Fig. 1). The range of weather one can experience in Alaska varies widely – from the cold and dry continental climate of the interior, to the mild and wet maritime climate of the Southeast. Alaska's northerly global position, 51°N-71°N latitude, and varying amount of solar radiation throughout the year play important roles in controlling Alaska's climate. For much of the state, average annual temperatures are below freezing (United States Environmental Protection Agency, 2017).


**Figure 1 – The geographic location of Antarctica in relation to the Arctic Circle (National Geographic Maps, 2015).**

Energy production is the main driver of the state's economy. It provides more than 80% of the state government revenue and creates thousands of jobs. Alaska also has abundant natural resources: oil, minerals, forest and fish. However, due to the state's high northern latitude, food production is limited and contributes only for a very small part to the economy (Hladick et al, 2013; Chapin et al., 2014).

Alaska's extreme climate causes all kinds of challenges for agriculture: very cold winter temperatures, highly varying annual cycles of solar radiation input, dominance of snow cover, and relatively low rates of precipitation. As a result, the agricultural industry of Alaska is really small compared to the rest of the US. Less than one percent of Alaska's 365 million acres of land is farmed. Most rural communities are therefore heavily dependent on imported food resources for survival. Around 80-95% of food consumed by Alaska's residents comes through long supply lines. (Seefeldt and Helfferich, 2014). These globalized food systems are vulnerable to economic and environmental influences. Supply lines into the North are fragile and can be broken by natural disasters or world conflicts. Both production and transportation of imported food is also energy-intensive. Therefore, Alaskans have expressed concerns that as the price of imported fuel rises, the state will face great difficulty in obtaining food for its people (Seefeldt and Helfferich, 2014).

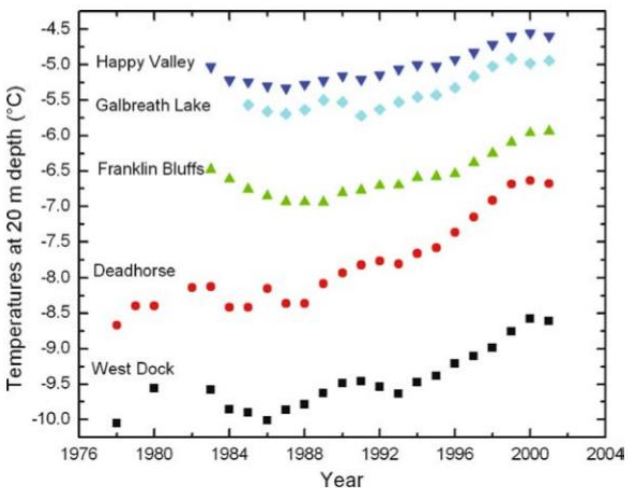


**Figure 2 - Temperatures measured at 20 m depth in boreholes in permafrost on the North Slope of Alaska display broad scale warming over the recent decades (Osterkamp, 2003).**

The changing climate may provide new opportunities for agriculture in Alaska. In the last 400 years a wide variety of changes within the Arctic system have been detected (Overpeck et al., 1997). Over the past sixty years, the average temperature across Alaska increased by approximately 2 degrees Centigrade (Fig. 2) (Osterkamp, 2003). Precipitation in Alaska is projected to increase during all seasons by the end of this century (Hinzman et al., 2005).

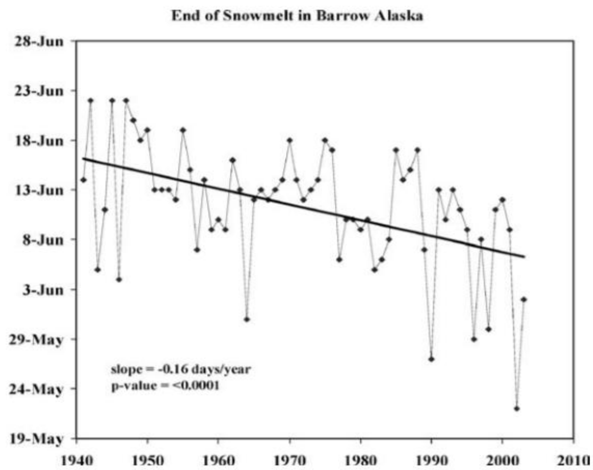


**Figure 3 - The disappearance of snow cover at Barrow, Alaska, presents a consistent trend of earlier snow melt (Stone et al., 2002).**

The annual snow melt in Barrow, Alaska, shows increased variability over the last sixty years, and indicates a trend towards an earlier snow free season (Fig. 3). Furthermore, total snow accumulation in winter has decreased in recent decades. Earlier snowmelt can have beneficial effects for plant growth, such as an extension of the growing season (Stone et al., 2002).

Overall, global warming is likely to open new avenues to expand the agricultural industry. However, while improving yields or finding ways to extend the growing season are attractive, also other more intractable issues that limit agriculture industry in Alaska need to be resolved (Stevenson et al., 2014). These issues require social and political solutions, incorporating stakeholders and government input and cooperation. This paper will analyze the challenges farmers need to overcome to successfully operate in Alaska and will assess the possible solutions that could benefit and advance sustainable agriculture in the state. The following research question will be answered:

***Is it possible to advance agriculture in Alaska in an economically sustainable way?***

## Approach

In order to answer the research question stated above, this paper will start with an introduction about the history of agriculture in Alaska and its current situation. In the second chapter the challenges farmers need to overcome to operate in Alaska will be identified and characterized. These challenges will be categorized into environmental/geophysical challenges (field-based challenges) and socioeconomic challenges. Subsequently, this paper will explore solutions and recent agricultural developments that could be used to overcome these challenges. Due to the vast amount of information and the limited scope of research, this paper only adresses the possibilities for arable farming in Alaska, livestock farming will not be discussed.

# Results

## 1. Introduction into Alaska's Agriculture

*1.1 Short description of the history of Agriculture*

Historically, hunting and gathering, has been the primary method of supplying food for a large segment of the population of Alaska. Change however became inevitable influenced by wars and resource extraction such as whaling, fur trade, lumbering, mining, and drilling. Permanent settlements became the norm and populations in the communities increased (Seefeldt and Helfferich, 2014).

Early settlers brought agriculture with them to Alaska. They began to cultivate the land and raise domestic livestock. Farming that had already been present under Russian administration of Alaska continued on Kodiak Island, on the Kenai Peninsula, and near Sitka after 1867. American settlers also tried to raise crops and livestock in other areas of Alaska, mostly cultivating around trading posts. These farms were relatively small and only served local markets. Prospectors and missionaries who began to arrive in Alaska in the 1870s likewise established small farming operations. Many of these early residents and prospectors brought cattle and horses with them. Furthermore, innovative residents in the very cold interior of Alaska planted gardens on the roofs of their cabins. The soil would be warmed by the heat from the cabin and seeding could begin early in spring (Alaska Humanities Forum, Historical and Cultural studies, 2016).

Most potential farmers discovered that bringing farm machinery and fertilizers to Alaska was prohibitively expensive. More importantly, roads, ships and airplanes that transported raw materials to areas outside the circumpolar north could also be used to bring food and supplies. On top of this, economic policy has not always supported expansion of the agricultural industry. Due to these factors, agriculture in Alaska saw minimal growth and has always fallen far below fishing, mining, trapping, and recently, tourism, in its significance to Alaska's economy (Alaska Humanities Forum, Historical and Cultural studies, 2016).

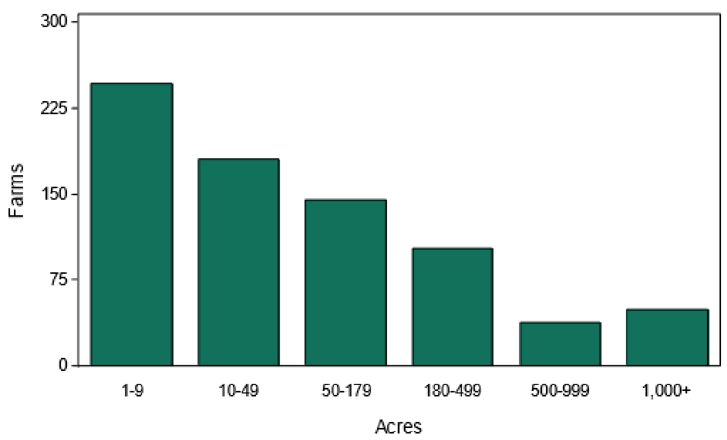


**Figure 4 – Farms in Alaska by size in 2012 (National Agricultural Statistics Service, 2012).**

*1.2 Current agricultural industry*

According to the 2012 Census of Agriculture State Profile, there are currently 762 farms in Alaska. In 2007 the number of farms was 686. The census of agriculture, established by the U.S. federal government, provides a detailed picture of U.S. farms and is the most accurate source of comprehensive and uniform agricultural data for every state (National Agricultural Statistics Service, 2012).

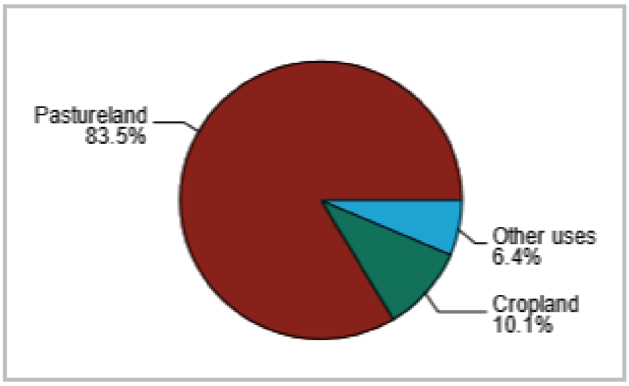


**Figure 5 – Purpose of Alaska farmland in 2012 (National Agricultural Statistics Service, 2012).**

Roughly 140 of the total 762 farms have a turnover of less than one thousand dollars per year. These 762 farms operate on a total of 833,861 acres of land, while more than 50% of the farms in Alaska operate on less than three acres. Due to the friendlier climate, most are located more in the South-Central region of the state (Fig. 4). The vast majority of this land is used as pastureland; areas of land covered with grass or other plants suitable for the grazing of livestock (Fig. 5) (National Agricultural Statistics Service, 2012).

Alaska's top agriculture commodities include greenhouse and nursery products, hay, cattle and calves, potatoes, and dairy products. Assessing the amount of all vegetables harvested, Alaska ranks 48$^{th}$ out of all 50 states in the U.S. Ranking (National Agricultural Statistics Service, 2012). For the last decade, the total value of Alaska's agricultural products has remained mostly flat due to the high operating costs. Typically, Alaskan farmers sell to local markets and individuals (Hladick et al., 2013). Regarding all factors discussed, it is safe to say that Alaska has not reached its full agricultural potential.

## 2. Challenges for Agriculture in Alaska

As mentioned, agriculture is limited in Alaska, as well as in much of the circumpolar world. Only a very small portion of the demand for food is met by local agriculture, and limitations for agriculture stem from a suite of challenges. In this paper these challenges will be categorized as being environmental/geophysical or socioeconomic in nature. Some of these challenges are interrelated. Furthermore, as Alaska is a large state, it can best be divided into six major regions: Arctic, Interior, Western, Southwestern, Southcentral, and Southeast. Growing conditions are variable across these six different regions.

### *2.1 Environmental / geophysical challenges*

Environmental factors that influence crop growth and yield in Arctic regions are tied to larger physical forces. These physical forces operate at a global scale and include the earth's tilt and global ocean and air currents. These forces are subsequently manifested regionally (Stevenson et al., 2013). The photoperiod for example, which is the interval in a 24-hour period during which a plant or animal is exposed to light, climate, weather events, precipitations, humidity and cloud cover, differs across regions. Other landscape variables, such as topography and land formation (e.g. hills, mountains and valleys), and land and water cover, further influence the microclimates in Alaska (Stevenson et al., 2013).

The environmental challenges to sustainable agriculture in Alaska are most commonly linked to high latitudes. In this paper the major environmental and geophysical challenge, also called field-based challenges, will be discussed.

2.1.1 Variation in daylight hours

Even though some residents of Barrow, one of the northernmost towns of Alaska, won't see the sun for 67 days in winter, they enjoy the midnight sun all summer: 80 days of uninterrupted daylight. These long summer days in high-latitudes often have beneficial effects on plants and can produce exceptionally large crops. In a relatively short period of time, mature crops can be produced (Stevenson et al., 2013).
During midnight sun, Fairbanks, Alaska, located at 64.84° N, receives approximately 22 hours of direct sunlight. The city of Palmer, Alaska, 61.60° N, located in the Matanuska Valley receives between 19 and 20 hours of sunlight. For comparison, Oregon, California and Washington, three major agricultural exporters, receive around 14 to 18 hours of direct sunlight during the mid summer (Stevenson et al., 2013).

The influences of light intensity and the duration of the photoperiod can vary significantly among different crops and cultivars. In lettuce, a 50% increase in day length can increase the mass, sometimes even doubling the weight (Koontz and Price, 1986; Kitaya et al., 1998). Some strawberry species also show a strong response to day length, some are well adapted to short or long days and some are day-neutral. Furthermore, other influences, such as temperature, can interact with day length. This can result in increased, decreased, delayed, or faster fruit and flower production in strawberries (Serce and Hancock, 2004).

A major challenge arising from the long summer days in Alaska is bolting, particularly in crops such as cabbage, lettuce, or spinach. Bolting is a survival mechanism in a plant species. During the proces of bolting a plant fails to properly form a head because of excessively rapid stem elongation (Stevenson et al., 2013). Bolting is exacerbated by overexposure to warm temperatures and long days. This process uses a plant's entire energy reserve for seed production and leaves the plant tissue tough, woody, tasteless and bitter (Dennis and Dullforce, 1974; Klapwijk, 1979). Susceptibility to bolting can vary among cultivars, although there are some 'bolt-resistant' varieties.

Additional challenges associated with high-latitude photoperiods have been demonstrated by Van Veldhuizen and Knight (2004) in legumes and other agronomic crops. Arctic photoperiods can cause problems for timing of flowering in soybeans, which could potentially germinate and grow well in Alaska. Soybeans do not flower until 10 hours of darkness are present in mid-August, which in Alaska could not leave the beans with enough time to reach maturity before the first killing frost. This can result in low winter survival rates.

<u>2.1.2 Climate and weather</u>

Farmers in Alaska experience a very short growing season and conditions that are often unreliable and harsh. The regional effects of the Siberian and Arctic high-pressure systems and the Aleutian low-pressure systems influence daily temperature (Martyn, 1992; Overland et al., 1999). Moreover, multiple medium- to short-term climatic cycles and patterns interactively govern the weather patterns affecting agriculture in Alaska (Bone et al., 2010; Stevenson et al., 2012).

Not the entire state of Alaska is climatically suited for agronomic crops. Growing seasons may be too short to allow maturation of crops or rainfall patterns can restrict planting and harvesting of crops. Alaska has two major agricultural regions. These regions experience somewhat varying climates because of their differences in latitude, topography, and proximity to ocean (Stevenson et al., 2013). The first region, the Interior region of Alaska, ranging between 63° and 65° N, is located several miles from the oceans. Interior Alaska can experience temperatures approaching -51 °C in winter and up to 32 °C in summer. The other major agricultural region, the Matanuska-Susitna Valley, experiences slightly milder summer and winter climates because its geographical location near to the ocean. However, this valley receives less sunlight, is windier and experiences cloudier days than the Interior.

Optimum temperature curves and net photosynthesis varies among plant species (Gijzen, 1995). There can be a few days per year in Alaska when high temperatures become an issue for agriculture. Crops can get excessively warm, which can cause light reactions to be less efficient and enzyme activities to decrease, thereby negatively affecting the quality of the plant (Gijzen, 1995). On the other hand, frost and cold weather are hazards for crops in Alaska (Smith, 1975). Low-lying areas are particularly susceptible to unseasonal cold winds and frosts. The cold winds in high-latitude areas are often associated with very cold air masses flowing through mountain passes or off glaciers. In Alaska and other high-latitude areas, ice covers can result in considerable damage to wintering crops (Smith, 1975).

Agriculture in Alaska is very likely to be affected by changes in climate. The specific effects will depend on the region and the direction and degree of regional change. The overall level of predictability of weather events also plays an important role. Northern environments like Alaska contain multiple levels of uncertainty that are driven by specific climatic cycles, weather patterns, and seasonal extremes in comparison to more temperate latitudes (Alessa et al., 2011; Stevenson et al., 2012). Warming in some regions of the state could cause further permafrost melting, resulting in an increase of water availability. On the other hand, freshwater ponds and lakes may drain into thawed soils, leading to a decrease in the amount of available freshwater (Osterkamp, 2007; Alessa et al., 2008 ). Climate change could also pose additional challenges for sustainable agriculture in Alaska; changes in the abundance or type of diseases, invasive species and reduced regional winter survival rates of perennials (ACIA, 2004: Key finding 3).

#### 2.1.3 Water availability

Water stress during the growing season occurs frequently in the Arctic. Despite Alaska's abundance of freshwater, not all Alaskans have easy or affordable access to sufficient water (Kenny et al., 2009; Alessa et al., 2011). Furthermore, precipitation is relatively low in Alaska. Access to water can be a factor that limits farming, because sufficient water is necessary for irrigation systems. An irrigation system is an essential way to reduce water stress and bolster in crop production. As many farmers do not live within city limits, they cannot take advantage of city water systems. These farmers can have water delivered, or set up a snow or rain water catchment system. Not all farms require irrigation, depending on the crops they grow. For many local farmers however, irrigation can increase yields and reduce risk (Sharrat, 1994).

#### 2.1.4 Soil quality and distribution

The quality of soil plays a crucial role in crop productivity. The native soils of some regions, including Alaska, are not always naturally well-suited for agriculture. According to Restand and McNicholas (1983), the ideal soil for agriculture must be at least 46 cm deep, should have a loamy texture, should not be overly wet, and experience limited wind erosion. Next, terrain should have no slopes steeper than 7%. In Alaska, soil moisture content presents a serious challenge in many areas. Soils in the rainy Southeast can become too wet during the growing season, while those in other areas of Alaska can become too dry. At high latitudes, soils are relatively cold. The soil temperature affects plant growth; cold soils can slow microbial activity and affect the uptake of nutrients. Furthermore, cold soils offer less frost protection in fall. Seed germination for vegetables in spring requires soils with temperatures above 4.5 °C (Stevenson et al., 2013).

Another constraining factor in Alaskan agriculture is the minimal microbial activities in seasonally frozen soils (Husby and Wooding, 1985). The release of available nutrients from these processes occur for only a few months per year in many high-latitude areas. This results in lower natural fertility and a higher fertilization requirement.

In Alaska, frozen soils in spring can bring complications to farming that last well into summer. Such soils can remain wet throughout the complete summer season without warming to a level that is ideal for agriculture.

### *2.2 Socioeconomic challenges*

The environmental and geophysical challenges discussed in the sections above cannot be studied in isolation from the socioeconomic and cultural challenges to farming in Alaska.

These socioeconomic challenges may even be the most arduous and limiting factors influencing sustainable farming in Alaska. State and federal policies can vastly influence the development of a sustainable agriculture system in Alaska. The socioeconomic issues related to consumer preferences, marketing, competition with global markets, limited social supports and subsidized inexpensive food for producers are the most challenging issues facing Alaska's local growers (Francis, 1967; Shortridge, 1976). There is a growing concern that Alaska's food system is over-dependent on outside distribution systems and therefore very vulnerable (Alaska state Senate, 2010; AFPC, 2014). More importantly, there is serious concern for the health of Alaskans and the lost economic opportunities for the state, as it lacks local agriculture. Even if a stronger agricultural presence wouldn't improve the food security in Alaska, it would still lead to greater overall economic developments within the state. To attain these goals, Alaska first needs to overcome significant economic challenges.

### 2.2.1 Economic challenges

Several of the larger economic challenges to sustainable agriculture in Alaska are already identified (Stevenson et al., 2013). There is a relatively low level of financial reward for the labor involved in farming in Alaska. Furthermore, in order to operate successfully, high capital investments and intensive management efforts need to be made. A high level of economic risk is taken on the operation of an agricultural business. Only few farmers have grown wealthy operating in the Alaskan agriculture industry. The average net cash farm income, from farms in Alaska in 2012 was a meager US $11.271 (USDA; 2014). Part of the reason of the low amount of farms in Alaska, is the fact that profits are low considering the effort and difficulty it takes to successfully produce crops. Furthermore, there are more lucrative and seasonally consistent jobs in Alaska than farming.

Maximum prices on produce and other crops are usually set by outside forces. Even though Alaska has a group of customers that buys the quality products sold at farmers' markets at prices significantly higher than those found in grocery stores, they are not the majority of the population (Stevenson et al., 2013). Alaska as a whole only offers a limited sales market, with its largest population centers in South-Central Alaska. Many communities may not provide a market sufficient to support local agriculture. In effect, growing may be considered relatively easy compared to the challenge of selling at a profit.

It is challenging for local growers to compete with food imported by grocery stores even though some supermarkets have recently begun to sell more Alaskan products (Stevenson et al., 2013). Alaska's farmers pay high retail costs for shipping in supplies to grow their entire crop. Grocery store competition pays wholesale shipping rates on just the edible portion of the crop. Grocery stores ship in large volumes of marketable crops.

Furthermore, farmland in Alaska is expensive and availability is limited. The likelihood of agriculture paying off on such high farmland prices is low. Economic viability is an essential component of sustainable agriculture (FACT, 1990).
The availability of infrastructure also limits sustainable agriculture development in Alaska. Rebuilding or improving infrastructure and developing cost-effective storage facilities are important needs (WSARE, 2010).

Making informed economic decisions and predicting costs are additional challenges to Alaskan farmers that are crucial to overcome. An example is deciding upon an irrigation system. The indirect and direct costs need to be considered in addition to the specific need. The different techniques available differ considerably in cost (Stevenson et al., 2013). This example shows the importance of agroeconomic education for farmers.

#### 2.2.2 Cultural challenges

Local and sustainable production of fruits, vegetables, crops and other foods could make Alaska more self-reliant and less dependent on outside food sources. One of the main challenges, particularly in remote locations in Alaska, is the lack of access to agricultural education. With only 762 farms in Alaska, those farmers who hope to farm sustainably are likely to be beginning or entrepreneurial farmers (USDA, 2009a, 2014). Furthermore, for the native Alaskans, the indigenous peoples of Alaska, traditional subsistence activities, including hunting and fishing, are usually a higher priority than farming or ranching (Rader et al., 2012). Today, Alaska natives account for just over 15 percent of the total Alaskan population, and they live in different regions of the state (U.S census, 2010). Only some of these rural Alaskan villages embraced or supported local farming and gardening (Stevenson et al., 2013).

A quote of Chad Nodlum, an aspiring Inupiaq farmer, shows the mindset of many residents of Alaska:

*"I am not a farmer. I grew up in Kotzebue, Alaska. Farmers do not come from Kotzebue. Snow mobile racers, dog mushers and fisherman come from Kotzebue, but not farmers. Hunting and gathering are the traditional ways of the Inupiaq people but the Inupiaq have always been adaptable… I have never been on a working farm. Although I am not a farmer now, I do hope to be someday."* Chad Nodlum (2012).

Alaska native communities have historically acquired their foods by hunting, fishing and gathering and still do so today. New or increasing influence of agriculture might affect their villages and households (Stevenson et al., 2013). Furthermore, is the status "farmer" one that entrepreneurs wish to aspire? It could be that the role would be perceived positively, perhaps even embraced as an avenue for leadership and food provision, like that of a hunter or fisherman. However, it could also be perceived as a less valued or inferior role in the community or family. The answers to these questions are still a bit unclear, but it is likely that a greater availability of fresher, local foods would be appreciated in remote locations in Alaska.

2.2.3 Food pricing

Two researchers, Loring and Fazzino (2009), reviewed food costs for 20 Alaskan communities. They reported that meals for a family of four can cost 250% of what a family in Portland, Oregon, would pay for the same meal (UAF, CES, 2009). They also reported, that in many remote communities, food prices sometimes reached 600%-1000% of the cost of food in the lower 48 contiguous states (Reed, 1995). Increasing the overall level and efficiency of food production would make food more affordable.

## 3. Solutions and new agricultural developments

### *3.1 New agricultural developments and solutions to overcome environmental/geophysical challenges*

Field based solutions are practical and technical strategies used to improve agricultural production in the cold regions such as Alaska with a short growing season. The ultimate goal is to generate the potential for improving year-round food supply. The major goal of sustainability is that the practices are socially acceptable and economically viable and do not pollute the system (Stevenson, 2014b).

3.1.1 High-tunnels and greenhouses

Season-extending techniques such as high- and low tunnels and other types of automated greenhouses are already in use in several sub-Arctic and Arctic areas. These techniques can be used to extend the growing season and produce warm-season crops that could not be grown in traditional gardens because of the cold environment (Waterer, 2003; Purser and Comeau, 1989; Maurer and Frey, 1990).

High tunnel systems may provide a solution in the short term, since they are already used in different places in Alaska. One of the regions where most of these greenhouses can be found, is on the Kenai Peninsula. Since the initiation of the high tunnel EQUIP program in 2010, the US department of Agriculture Natural Resources Conservation Service, cost-shared more than 510 high tunnels in Alaska. The majority of these systems are now growing diversified vegetables crops (Stevenson et al., 2014b).

**Figure 6 - High tunnels in Fairbanks, Alaska. (Stevenson et al., 2014b).**

A high tunnel is defined as a portable walk-in greenhouse-like structure without a permanent electrically powered heating or ventilation system (this is how they differ from automated greenhouses), covered with one layer of plastic and sited on field soil (Fig. 6) (Rader, 2006). High tunnels are ventilated by opening the ends or sides. High tunnels should not be confused with low tunnels. Low tunnels are used over single rows and are constructed out of wire hoops and plastic. They might only be in place for the early growth stages of a crop (Hall and Besemer, 1972). High tunnels can lengthen the growing season, increase yields, improve the quality and increase supply reliability. In New Hampshire, the use of high tunnels could extend the growing season up to four weeks in spring and up to eight weeks in fall (Wells et al., 1993). This is primarily due to higher temperatures inside of the high tunnel allowing for a milder microclimate (Lamont et al., 2003; Waterer, 2003; Wells, 1993; Wittwer, 1995). Shelter from wind and protection from harmful UV radiation are other benefits from high tunnel field production (Hodges, 1996). High tunnels also help to maintain an insect and pest free environment. These qualities can be especially helpful in Alaskan villages because of the cold harsh climate, short growing season, overexposure to light during midsummer and occasional and seasonal hard winds. Because of the simple nature of high tunnels, sophisticated artificial lighting needed to extend the growing season in Alaska's dark period is difficult to implement. This means that not all challenges are solved with this technique.

3.1.2 Other options to improve environmental conditions

As it is not possible to change soil textures, researchers are now considering management practices that can be used to enhance retention of nutrients and water, in order to increase soil organic matter content and to improve soil structure. A promising example is Biochar, a carbonaceous and unique material, that applied as soil amendment can effectively improve the chemical and biological properties of soil (Abedin et al., 2013). It could therefore possibly solve many of the existing soil-limitations in Alaska. In 2013, researchers found that biochar application can significantly increase plant growth and biomass yield, but only when applied along with other fertilizers (Albedin et al., 2013).

Another option is to identify cultivars with greater adaptive capacity to environmental stress, such as water availability, temperature, nutrients, and other factors. Modern hybrids are usually bred to exhibit several specific traits. This may limit their ability to adapt to adverse environmental conditions. Greenhouse studies could be conducted to assess the adaptive capacity and production potential of different cultivars. These results could be used to help inform regional producers of the cultivar that may best be suited for their farm.

A project conducted by the National Aeronautics and Space Administration's (NASA), focused on technologies to recycle human wastewater for food production, for use in circumpolar agriculture. The NASA research center and the University of Alaska joined forces to develop a high-efficiency, low-energy consuming technique for water treatment and food production. The Forward Osmosis (FO) technology for the recovery of water from sewage wastewater, already showed very promising results and can be well used for agricultural irrigation and other industrial applications. Biological testing showed that plant growth using FO recovered water in a nutrient solution, was equivalent to that using high purity water (Vogt et al., 2009).

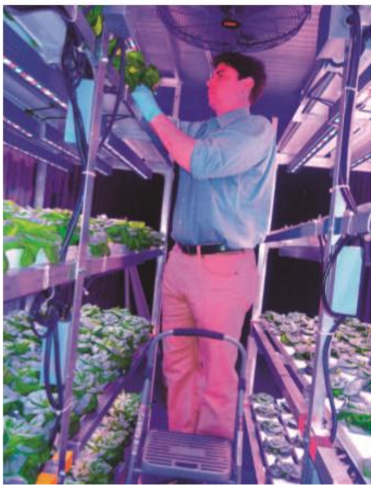

**Figure 7 – Harvesting butter leaf lettuce growing hydroponically in a reused shipping container. (Brown-Paul, 2016).**

Two Alaskan companies found another novel way to produce crops year-round. Alaska Natural Organics and Vertical Harvest Hydroponics are two indoor farm startups standing up to Alaska's short growing season by using hydroponics. This is a soil-and pesticide-free farming technique (Chow, 2016). The plants are grown in nutrient-rich water under blue and red LED lights that mimic sunlight. Vertical Harvest Hydroponics repurposes old shipping containers to grow food year-round and provide fresh greens to Alaskans (Fig. 7). This company designs and builds customizable "containerized growing systems", which are self-contained hydroponic farms inside a transportable shipping container. Such a unit costs around 100,000 dollar each, and comes with heating systems, shelves and electricity to support LED growing lights. The LEDS form the backbone of the growing system as light can be produced in the spectra plants need most. The units are capable of producing 1800 plants at a time in mineral rich water without soil. It is possible to grow a variety of leafy greens and herbs. The systems can be placed anywhere with power and potable water. Produce is grown on-site, eliminating expensive and lengthy supply chains (Brown-Paul, 2016).

*3.2 Solutions to overcome socioeconomic challenges*

In the past century, agricultural developments mainly focused on increasing production. However, in order to advance sustainable agriculture in Alaska, socioeconomic implications must also be considered (Altieri., 1995). Policy and Social solutions vary in their scope and complexity, but are typically the result of integrative efforts or cooperative strategie by working roups, stakeholders and state or federal agencies.

<u>3.2.1 Solutions to improve economic conditions</u>

The issue of high labor costs for relatively low returns, which is the case for farming in Alaska, is relatively difficult to solve. It is inherently more expensive to produce crops under harsh Alaskan conditions than it is to produce equal crops under friendlier conditions in other states. In order to provide farmers with fairer returns for the amount of work they put into their crop production, local and federal government could increase existing subsidy programs. Currently by far the largest program is the federal Agricultural Trade Adjustment

Assistance Program, designed to reduce the damaging impact of imports felt by certain sectors of the US economy. In the period of 1995-2014, these subsidies totaled $6.4 million for Alaska, of which approximately $6 million went to the salmon industry and the remaining $400,000 to farms. A quick analysis at these figures shows that practically no money is spent on Alaskan farms. $400,000 divided over roughly 20 years gives an average annual subsidy of a meager $20,000 for the entire state of Alaska. In order to stimulate local farming, federal and local government could increase these subsidy programs, to provide Alaskan farmers with equal opportunities as farmers operating in other states (EWG, 2014).

**Figure 8 – Display featuring Alaska Grown products in the entrance of an Anchorage supermarket. Photo: Kalb Stevenson, August 2013.**

To improve marketing the products of Alaskan farmers, several initiatives such as “Alaska Grown” advertising already has had positive results. The Alaskan Grown ad campaign is a promotional tool developed by the Alaskan Division of Agriculture to advance local agriculture by means of feature displays in local grocery stores and other markets (Fig 8). Online social media outlets also provide an inexpensive and efficient method for farmers to network, connect and market to consumers. According to a recent USDA news release there is rising interest in local foods among Alaskans. A growing number of Alaskans identify strongly with their local food shed and express concerns about the lack of food security (Helfferich and Tarnai, 2010). This trend could cause a shift in support away from a corporate-based food system to a more locally based food shed (Kloppenburg et al., 1996). This is of huge importance because buying local products is thought to keep money longer in the local communities, possibly resulting in a higher income for the people living in these communities. In addition to direct marketing, stores that feature and promote Alaskan products could be important in the competition with imported non Alaskan grown produce. Stores that already give priority to locally grown products include the Alaskan Homegrown Market and the Fairbanks Community Cooperative Market (Stevenson et al., 2014b).

In 2013, The Alaska Farmland Trust stated that only 4% of Alaska’s farmland is potentially suitable and available for farming. For many farmers, the purchase of farmland is challenging. Conversion of potential farmland to other land uses, for example industrial and urban uses, poses a threat to farmland loss in the United States. Fortunately, to solve this problem, several private non-profit groups such as the “Alaska Farmland” trust and “Greatland Trust” have purchased easements in Alaska on productive farmland in order to maintain continued farmland use (Stevenson et al., 2014b). The protection of farmland through government and private sponsored programs and the development of innovative ideas are another important aspect to help slow the trend of farmland conversion. The state of Alaska already possesses several agricultural projects in various locations, meaning that this land is restricted to farmland use only (Stevenson et al., 2014b). However, the purchase of farmland is still challenging for many entrepreneurs due to the high costs. Farm loans and other means of financial support could help these farmers to start up their operation. The Alaska Rural Rehabilitation Corporation, a non-profit organization located in the Matanuska Valley, sets a good example by providing loans to prospective farmers throughout Alaska.

As for the issue with infrastructure, as discussed before, there are inevitable costs attached to the development of new farmland. With the development of new farmland, new infrastructure to facilitate transportation of crops and raw materials needs to be developed as well. This makes the initial investment relatively high, as there are other regions that are more suitable for farmland, with better infrastructure already in place. It is this fact that makes the issue of infrastructure hard to solve, and provides great challenges for prospecting farmers, aiming to compete with the established “big boys”.

To be able to make informed economic decisions and predicting costs, farmers need proper agroeconomic education. Fortunately, to tackle this problem, Alaska state agencies and entities in collaboration with the Alaska Food Policy council and The State Food Resource development working group started to develop educational programs (Stevenson et al., 2014b). These programs inform Alaska's residents about the nutritional value of locally harvested food and produce. One project which started in 2013, the Alaskan Growers School, offers the knowledge and skills necessary  to successfully pursue sustainable agriculture in the state. The Alaskan Growers School is developed in collaboration with the Cooperative Exentsion Service experts as a way to reach and educate rural Alaskans, especially Alaska Natives, who want to learn how to start a fram or ranch in Alaska. The goal of the courses is to provide the students with the knowledge and skills necessary to grow food. The students also learn how to develop a whole farm business plan.

### 3.2.2 Solutions to overcome social challenges

Alaska native communities have historically acquired their foods by fishing, hunting and gathering and still do so today. These traditional susbsitence activities are usually a higher priority than farming or ranching (Rader et al., 2012). Therefore, young entrepreneurs are not always ambitious to start a farming operation, as the role of farmer can be perceived as less valued or as an inferior role in the community. In order to advance agriculture in Alaska it is necessary to change the mindset of these peoples in such a way that farming could be perceived positively and embraced as an new avenue for leadership and food provision.

To improve the image of agriculture and the role of the farmer in remote communities, it could help to introduce a sense of community and creating an environment of involvement. To achieve this, the government of the Northwest Territories through the Canada/NWT growing forward program introduced the Community Gardening Initiative in 2006. The aim of this program is to develop awareness and interest in local food production in remote Alaskan communities (Canada/Northwest Territories, 2010). The program is about learning, developing confidence, but even more important to have fun. In the near future, hopefully more of these type of programs wil be established in order to create enthusiasm among the communities for the life as a farmer and the possibility to provide healthy and fresh food.

Another interesting possibility to advance agriculture in native communities, while keeping important traditions and subsistence activities alive, could be to lay focus on the native woman. Men and women in Inuit cultures traditionally have different work responsibilities. Men are occupied with hunting, gathering, and constructing and maintaining of the hunting equipment – work that takes them out of the household for long periods of time, on a daily basis. The responsibilities of the inuit women on the other hand, are generally keeping them closer to home. Activities such as cooking, cleaning, and processing and sewing skins and other materials make up most of their daily chores. If programs like the Community Gardening Initiative could organize classes especially for women, these women could learn about agriculture and develop an interest in setting up a (small) farming operation. In this manner, the integration of sustainable agriculture into subsitence-based communities can occur without hindering the preservation of traditional sociocultural practices, as men are still occyping these subsitense activities (Ackerman and Klein, 2000).

## Discussion

In this paper, several environmental and socioeconomic challenges to farming in Alaska, and the solutions to overcome these challenges, are discussed. However, it is still necessary to find out if these solutions can be practically applied, and if they will have the desired result of advancing agriculture in Alaska in an economically sustainable way. Furthermore, there are numerous other possibilities and developments not discussed in this paper which theoretically also could improve the agricultural industry in Alaska.

Even though researchers have already proposed a number of technical field-based solutions that may improve the harsh environmental conditions in Alaska, some critical sidenotes can be made. For example, high tunnels, portable walk-in greenhouse-like structures used to extend the growing season, are still relatively new in the U.S. This means, there is still a significant amount of research to be done, such as the identification of appropriate cultivars for various geographic locations. Furthermore, just like with more automated greenhouse structures, there are relatively high start-up and operation costs. Another technical field-based solution mentioned are hydroponic gardens, entailing plants grown in reused shipping containers. The hydroponic project does have the potential to stabilize the food system in Alaska. The drawback, however, is that the units bring with them economic challenges in many communities. Vast shipping expenses apply, and steep electricity costs add several thousands of dollars to the costs of the imported containers.

Further development of the livestock industry in Alaska is not discussed in this paper. Livestock production in Alaska does however have the potential to contribute to a sustainable agricultural industry. Provided the animals have access to basic shelter from rain and wind, and are able to escape from the extreme cold in winter, traditional livestock can do well in Alaska (Stevenson et al., 2014b). Livestock farming in Alaska is often more limited by non-climatic factors, such as availability of processing facilities, rather dan directly by climate (ACIA, 2015). One major constraint to animal agriculture at high latitudes is the availability and production of reliable, inexpensive feeds. According to research done by Paragi et al (2010), only a small 2% of all red meat consumed in Alaska originates from Alaska-raised beef and pork. In the long term, the potential for livestock production in Alaska could be improved, if adequate precipitation or irrigation occurs, allowing for forage and grain production. Another possibility is to assess the potential of reindeer meat for consumption, as many native communities herd reindeer and these animals are well adapted to cold temperatures. Historic herding numbers of Alaskan reindeer, particularly from the first part of the 20$^{th}$ century, suggest that a much larger percentage of Alaska's red meat demand could be met with in state production (Stevenson et al., 2014b). To improve the agriculture in Alaka, the livestock industry evidently offers interesting opportunities.

As the third chapter indicates, there are several ways to advance agriculture in Alaska, but to make these farming organizations economically sustainable, other complex economic challenges need to be tackled. Agriculture research often only focuses on the possibilities in the Alaskan environment, but does not always mention whether the practice is sustainable. This paper discussess options to improve marketing strategies, such as the 'Alaskan Grown' campaign and raises the importance of subsidy programs in order to provide farmers with fairer returns for the amount of work they put into their crop production. However, not specifically mentioned in this paper, integrated and cooperative efforts between Alaskan stakeholders, state and federal agencies, and other entities are inevitable. The success of sustainable agriculture in Alaska is strongly influenced by U.S. policies and funding on statewide priorities. For example, there is still not much federal support for the nursery and greenhouse industry, which is an industry offering many possibilities to advance the agricultural sector in Alaska (USDA, 2009a). The population of Alaska is small, and the agriculture base even smaller, meaning that the state often finds its needs and priorities being diminished by those of the lower 48 states.

Even though new possibilities to cope with Alaska's cold climate are being developed at a very fast pace, and if subsidy programs would be increased vastly, young entrepreneurs, passionate to set up a farming organizations are an indispensable part of the equation. Farming is not part of the culture of the indigenous peoples living in Alaska. This paper also discusses agricultural education. Education teaches the residents about the benefits of fresh Alaskan grown produce and attempts to change the mindset of these peoples towards a positive view considering the role of farmer. Since native communities in Alska have historically acquired their foods by gathering, hunting and fishing, and still do so today, there is a need to understand how a new influence of agriculture might affect households and villages. Research done by Graves (2005), has shown that a decline in the emphasis on native men's responsibilities for hunting and fishing can affect household resiliency. Graves also mentioned feelings of alienation and even depression linked to alcoholism in these men.

Finally, developing arable and livestock farming can increase the contribution of the agricultural sector to Alaska's economy. As the development of agriculture could affect nature and biodiversity, possible negative influences on other sectors of the economy, such as tourism, should be considered. Modern agriculture has already resulted in a loss of diversity in the agricultural landscape because of habitat loss, which threatens ecosystems. Erosion commonly occurs following conversion of natural vegetation to agricultural land. The use of pesticides and fertilizers are a potential source of pollution (Bengston et al., 2005). Tourists coming to Alaska to enjoy the maginificent arctic landscapes, usually full of wildlife, could be in for a unpleasant surprise if the landscapes are transformed to more monotonous farming areas.

## Conclusion

The focus of this paper is to explore if it is possible to advance agriculture in Alaska in an economically sustainable way.

Agriculture is still an underveloped industry in Alaska. Farmers must overcome a diverse set of challenges to be able to farm in the harsh environment and to achieve greater sustainability. Several field-based, social and political solutions to the problems of high latitude farming have been proposed and some are already being put into practice. Field based solutions include season extending techniques such as high tunnels, improving soil structures, identifying cultivars with greater adaptive capacity and introducing hydroponic gardens. Social and political solutions are reached by stakeholders and government, often through cooperative interaction and discussion. These solutions include more appropriate funding for new farmers, addressing the high costs and preservation of agricultural lands, improving market strategies, advancing infrastructure and the establishment of agricultural education programs to reach Alaska’s rural communities. Collectively, these solutions will work to improve the outlook for sustainable agriculture in Alaska.

However, food security in Alaska cannot be obtained exclusively though local agriculture in its current form, nor can it exist with the state’s current level of dependency upon importend foods. Therefore, it can be concluded that more time is necessary to successfully advance agriculture in Alaska in an economically sustainable way.

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