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Theme 3. Sustainability of grasslands- social and policy issues
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Utilizing grassland resources for sub-arctic agriculture: Sustainable Muskox farming in Alaska

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The 2005 Millennium Ecosystem Assessment broadly classifies Alaska as a Polar Ecosystem, characterized as being frozen most of the year and underlain by permafrost. Despite this bleak portrayal, some of the largest herds of grazing ungulates are indigenous to Alaska - and thriving. This is both a testament to the resilience of grazing systems in general as well as a statement to the suitability of grazing systems specifically for Alaska. In a state economy dominated by non-renewable resource extraction, agricultural production has remained largely undeveloped (Fried 2013). However, today there is increasing interest in local agricultural production with the goal of developing an economically diverse, sustainable agricultural model for Alaska.

Muskoxen (*Ovibos moschatus*) are uniquely adapted to the arctic. They thrive on local forages, do not require protection from the cold and adapt well to many traditional husbandry practices. Muskoxen have been farmed since the 1960's for their fiber, known as qiviut, a luxurious and highly valued underwool that is their primary insulation during the arctic winter. Adult muskoxen annually shed 1.5-2.5 kg of qiviut throughout their life. While muskoxen can be farmed for qiviut, the question remains whether this endeavor is a sustainable enterprise for northern farms? What impact will grazing practices have on pasture and soil health in sub-arctic environments? In this research, we investigated two aspects of the sustainability triad with respect to farming a non-traditional species, musk oxen, in Alaska: i) economic feasibility ii) potential impact of managed grazing on sub-arctic pasture ecology.

Economic feasibility

Currently, there are three sources of qiviut: naturally shed qiviut collected off the tundra, qiviut shaved or plucked from hides of harvested wild animals, and qiviut combed from farmed muskoxen. From these limited sources, qiviut yarn, garments, and accessories are successfully sold to established niche markets over the internet and through specialty boutiques. The increasing popularity of fine fibers, coupled with the increased market demand for sustainable, organic, and heirloom products creates an opportunity for qiviut producers to expand an existing niche market.

Wild harvests remain the primary source of qiviut but the ability to harvest wild muskoxen varies with biological and regulatory limitations. Hence the market supply of qiviut fluctuates with muskox populations creating disruptions in the supply chain and limiting the growth of the industry. Muskox farming has the potential to stabilize market supply by ensuring a consistent availability. Thus, farmed qiviut may be instrumental in the growth of the qiviut market.

The potential of muskox farming has been recognized for well over 100 years, yet early muskox farm enterprises struggled to have their relatively small amounts of qiviut processed into value added goods, gain access to developing niche markets, and find support for herd health and veterinary care. Many of these challenges have been diminished by advances in small custom mill processing, internet sales, and research on muskox health and husbandry. The first part of this study addresses the economic sustainability of farming muskoxen in Alaska exclusively for qiviut.

An enterprise budget was used to estimate the fixed and variable costs and to model different revenue scenarios using six different combinations of qiviut, sold as raw fiber or value added yarn, and livestock sales to estimate the total economic potential of farming muskoxen at two scales, 36 and 72 muskoxen. The economic data for this enterprise budget has been extrapolated from the two operating non-profit muskox facilities in Alaska, The Robert G. White Large Animal Research Station (LARS) at the University of Alaska Fairbanks (UAF) and The Muskox Development Corporation (MODC) in Palmer, Alaska. Interviews with experts and stakeholders in the field of muskox husbandry, cost quotes from suppliers in the Fairbanks area, and example budgets from the bison industry were used to determine potential costs not accurately represented by the non-profit facilities (Foulke *et al*., 2001). The value of qiviut per harvested kg, after transaction and

processing costs, was $480 (all $ are USD) sold as raw fiber and $1,335 sold as value added yarn. Livestock was valued at $8,000 per head after transaction costs.

Farming muskoxen was economically sustainable under several revenue scenarios. The most profitable scenario for either herd size was selling all the qiviut as value added yarn coupled with livestock sales. The enterprise was profitable at either scale assuming all the yarn sold at full retail price. If no livestock were sold, selling the total qiviut harvest as yarn was the only profitable option. When selling raw fiber alone, the break-even point was at a herd size of 124 muskoxen. Economies of scale accounted for a decrease in costs of approximately 21% overall, 30% in labor, and 23% in herd health, as the herd doubled in size.

Environmental impacts

Agriculture in Alaska has been constrained by extreme climactic conditions, expensive imported farm inputs, a lack of research into farming practices appropriate for northern environments, and competition from the high yields and low prices of global and domestic markets. To shift the paradigm towards ecological and economic sustainability, we need to develop management techniques and strategies that exploit the natural ability of indigenous species to thrive in sub-arctic ecosystems. The Fairbanks region is characterized by a short growing season, slow organic residue decomposition rates due to low annual mean temperature and undeveloped soils that are sensitive to compaction and erosion. Current unmanaged grazing has resulted in a heterogeneous pattern of use, with animal feeding preferences creating patches of both over- and under-utilization, and degradation.

Grazing strategies that mimic the short but intense grazing of wild, migratory ungulates help prevent land degradation and enhance ecosystem function (Teague *et al*., 2011). Intensively managed rotational grazing (IMRG) is described as a tool to increase homogeneous pasture utilization by reducing the animal's ability to engage in preferential plant selection through limited access, time, and perceived competition. This could result in more spatially homogeneous dung and urine deposition coupled with organic matter incorporation through trampling, and an increase in available soil nutrients from root sloughing, a response to plant defoliation. Increased organic matter incorporation lends stability and resilience to soil structure, mitigating adverse effects from trampling and soil compaction (Teague *et al*., 2011).

The effects of grazing in arctic and sub-arctic ecosystems may benefit cold soils from mechanical incorporation of organic matter and more rapid digestive decomposition. Range production of forage grasses in the arctic was improved under heavy grazing by muskoxen (McKendrick *et al*., 1980). A simulated grazing study conducted on sub-arctic grasslands in Sweden reported an increase in abundance of bacteria, and bacterivore /omnivorous nematodes in plots that received both trampling and fertilization as opposed to plots that received fertilization only (Sorensen *et al*., 2009).

For this study, we employed simulated grazing techniques to evaluate above and below ground response to an IMRG regime and to gain insight on the role of grazing disturbance mechanisms on sub-arctic soil and plant health. A full factorial experiment of simulated trampling, muskox dung/urine deposition, and forage clipping, mimicking IMRG timing and intensity, was conducted at LARS, UAF. We used a randomized block design with 96-1 m^2 plots in two established pastures with different soil types, over the 2014 and 2015 grazing seasons. Changes in soil microbial communities, microbial activity, physical soil characteristics, above ground plant biomass, and plant community composition were measured from one and two years of treatments. Preliminary data from 2014 indicated plant biomass increased (p<0.001) in both pastures in response to full grazing treatment. Data on soil and plant interactions will be presented.

Creative agricultural endeavors that are in harmony with their environment have the greatest chance for success and sustainability in marginal ecosystems. The findings from this integrated research suggest that using an indigenous species such as muskoxen to harvest landscape resources in marginal habitats, enhance ecosystem services in Alaskan pastures, and exploit niche markets, could promote a unique and sustainable agricultural model for the future.

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