Sisseton Wahpeton Oyate
Hemp Economic Feasibility Study
Phase I Final Report
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SWO Hemp Economic Feasibility Study
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Prof. Weiblen and colleagues prepared this report on behalf of the University of Minnesota in fulfillment of sponsored project award number 00070638 (31 May 2018 - 31 December 2018).

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Rationale

The Sisseton Wahpeton Oyate (SWO) aims to bring new economic development to its agricultural land and develop a hemp industry around products with substantial value-added market opportunities. The tribe is particularly interested in hemp as a crop alternative to sustain environmental quality and support a healthy community.

Project History

The Native American Business Development Initiative (NABDI) supported a hemp economic feasibility study initiated by the SWO Planning Division in 2017. The University of Minnesota (UMN) partnered with SWO Planning, SWO Natural Resources Division, and Dakota Nation Industries in 2018 to demonstrate the cultivation of fiber hemp on SWO land, to identify markets for hemp fiber, and to recommend value-added hemp product options.

Project Team

Principal Investigator George Weiblen (UMN) oversaw the project team. Dakota Nation Industries CEO Josh Flute was licensed by the North Dakota Department of Agriculture Industrial to participate in its Industrial Hemp Research Program. Research Associate Jonathan Wenger (UMN) coordinated SWO hemp agronomic research with Mr. Flute, SWO Natural Resource Manager Charlene Miller, and Agronomist Burton Johnson (North Dakota State University). Professor Dean Current investigated current production costs and markets. Professor Eric Singsaas examined processing technologies for manufacturing hemp composite materials. Clemon Dabney, a PhD candidate in Plant & Microbial Biology, also assisted the project.

Background

Fiber hemp has a history of cultivation in the Upper Midwest dating from the 19th century. It was cultivated during 1943 in the Minnesota River Valley when the United States Army supported hemp, intended for canvas and cordage. Today, hemp fiber can be processed into a remarkable number of different products including plastics, paper, fiberglass, insulation, cement-bonded composites, geo-textiles, and other fabrics. Hemp stalks are 'decorticated' to separate the pithy core of the stems ('hurd') from the long and strong outer fibers ('bast'). Both fractions have value as they can be used in a number of product applications (Figure 1). Emerging applications range from using fiber hemp to absorb spilled oil to building super capacitors and carbon nanosheets.

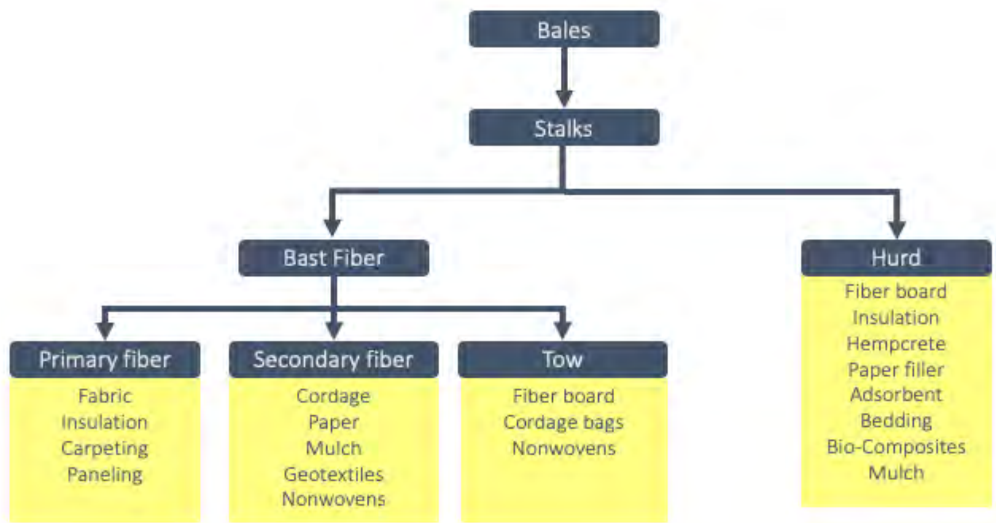

Figure 1. Hemp fiber fractions and their potential uses.

In Europe, hemp fiber-based composites are used to create lightweight but strong and flexible automobile panels (Schmidt & Bayer, 1998). Lucintel (2016) forecasted the natural fiber composite materials market to grow to more than $500 million dollars. The hemp textile industry is moving toward blended fabrics and is projected to see a compound annual growth rate of 17% from 2018 to 2025 since hemp fibers are strong, hypoallergenic, and resistant to UV light (Grandview Research, 2018). Demand for hemp-based plastics in the automotive industry is expected to register a volume-based compound annual growth rate of 17.5% from 2018 to 2025 as an attractive alternative to fiberglass (Grandview Research, 2018).

The crop value of fiber hemp has not been competitive with that of other Upper Midwestern crops. However, market forces and tariffs have driven down the price of soybean and corn to the point where industrial hemp might be a profitable alternative for farmers. For example, soybean crop gross revenue was projected in 2016 at $653 per acre based on a yield of 71 bushels per acre yield and $9.20 per bushel in 2016 while corn crop gross revenue was projected at $762 per acre based on a yield of 231 bushels per acre yield and $3.30 per bushel (Schnitkey, 2016). With an average raw hemp fiber yield of 3 tons per acre at $200-$250 per ton, projected gross revenue per acre is $600-$750. The SWO Hemp Economic Feasibility Study was motivated by interest in assessing demand for hemp fiber, estimating the investment necessary for a regional processing facility, and exploring markets for value-added products made from hemp fiber composites.

Study Objectives

The objectives of this study were threefold:(1) hemp fiber crop demonstration, (2) market opportunity and economic feasibility, and (3) cost and needs assessment for hemp production, processing and manufacturing.

Hemp Fiber Crop Demonstration

It was important to demonstrate how hemp is cultivated and what it looks like in the field for several reasons. First, social stigma and questions about illegality arise from the close relationship of hemp to its sister plant, marijuana. The demonstration plot was intended to show that hemp can be grown legally in the state of North Dakota, that it is not marijuana and that it does not attract the attention of drug users. Second, it was necessary to demonstrate the feasibility of hemp production on SWO land for tribal members and stakeholders. Thirdly, the demonstration crop provided raw materials (bast fiber and hurd) for future study of hemp-composite materials and markets.

The 2018 SWO hemp cropping project was conducted with a focus on demonstrating production of high quality fiber hemp. A North Dakota Department of Agriculture Industrial Hemp Pilot Program (NDDA-IHPP) license was issued to Joshua Flute, SWO Tribe member and CEO Dakota Nation Industries. Working in consultation with SWO Natural Resources, a five acre site was identified for conducting the demonstration near Havana, North Dakota on SWO Tribal trust land. The site is immediately adjacent to the Coteau des Prairies Lodge with which SWO Natural Resources maintains an excellent working relationship. This location provided a convenient venue for working meetings conducted during the growing season. Physical characteristics of the site that favored its selection were medium textured clay loam soil, ~6% slope, and an inconspicuous location easily accessible from adjacent roadways. Planting seed was obtained by foreign import to the North Dakota State Capitol in Bismarck and transported to SWO by the principal investigator. High quality fiber hemp varieties ‘CS’ and ‘Carmagnola’ were used for the trial.

Burton Johnson, an agronomist at North Dakota State University with expertise in hemp cultivation, was contracted to undertake the planting of the seed. Following seedbed preparation by SWO Natural Resources technicians, a 3.3 acre section of the plot was drill seeded on July 12, 2018. This was approximately 4-6 weeks later than what would have been optimal due to permitting, contracting, seed importation and weather delays. The plot was planted in two sections at different seeding rates: low-density for inner stem (hurd) production and high-density for outer stem (bast fiber) production. Hemp variety CS was planted in the low-density (hurd) section. The high-density (bast fiber) section was planted with hemp varieties CS and Carmagnola. A combination of fertile soil and abundant rain at the site over the course of the season provided ideal conditions for germination, emergence, stand establishment, and canopy closure. At 34 days after planting, there were an average of 12.4 plants/ft^2 in the low-density section and 15.5 plants/ft^2 in the high-density section. During the same interval, the hemp plants grew about an inch/day to an average height of 34 inches and 38 inches in the low and high-density sections, respectively. At 46 days after planting, plants were about 66 inches (5.5 feet) to 72 inches (6 feet) tall and male plants had begun flowering (Figure 2, Tables 1 and 2).

The high-density section of the plot closest to the access road was harvested with a sickle mower on September 18, 2018 (68 days after planting) when bast fibers were well developed but before stalks had thickened extensively and when plants had reached an average height of 70 inches. Mowed plants were left on the field for retting – a natural process of degradation in which the stems change color and the separation of long bast fibers from the inner stalk is facilitated. The low-density section was mowed on October 18, 2018 (98 days after planting) when the stalks had thickened allowing more extensive hurd development and when plants had reached an average height of 82 inches. Both the retted bast fiber harvest and the dried hurd harvest were raked and baled on October 23, 2018 for future processing. The total yield of the plot (11,000 lbs.) was approximately 1.7 ton per acre. This is considerably lower than what was expected for fiber hemp but still impressive given the late planting date.

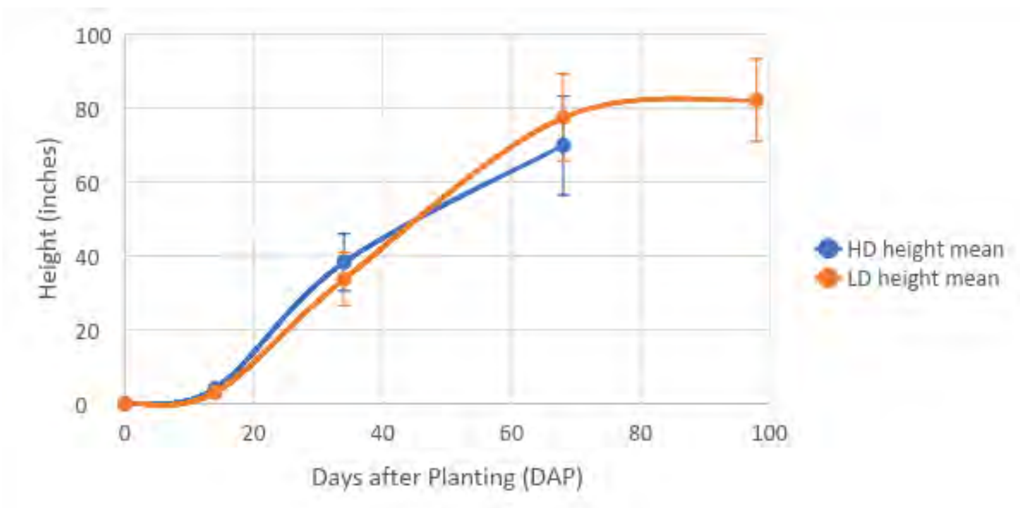

Figure 2. Plot of average stand height of 2018 SWO industrial hemp demonstration fiber crop planted July 12, 2018. Blue = higher density (HD) plot mowed 68 days after planting on September 18, 2018; orange = lower density (LD) plot mowed 98 days after planting on October 18, 2018.

Table 1. Mean (and standard deviation) plant height (inches) and growth rate (inches/day) of the SWO industrial hemp demonstration fiber crop during three intervals (0 to 14, 14 to 34, and 34 to 68) days after planting (DAP) on July 12, 2018.

	height (inches)			growth rate (inches/day)		
	14 DAP	34 DAP	68 DAP	0-14 DAP	14-34 DAP	34-68 DAP
higher density	4.1 (1.0)	38.3 (7.7)	69.9 (13.4)	0.29	1.71	0.93
lower density	3.01 (0.9)	33.7 (7.2)	77.5 (11.9)	0.22	1.53	1.29

Table 2. Mean plant density (plants/foot^2) at 34 days after planting (DAP) and 68 DAP of the SWO industrial hemp demonstration fiber crop. All plants were counted at 34 DAP whereas only plants taller than 48" (canopy) were counted at 68 DAP. Percentages of male and female individuals are also reported.

	34 DAP plants/foot^2	68 DAP plants/foot^2	% male	% female
high density	15.5	5.8	38.5	61.5
low density	12.3	5.5	52.3	47.7

Cost and Needs Assessment for Hemp Production, Processing and Manufacturing

Currently, there are only a handful of commercial hemp processing facilities in the USA. The lack of processing capacity has been identified as a major constraint to the development of industry for hemp fiber in the USA with perhaps the exception of BastCore Inc. (Omaha, Nebraska. Equipment and facilities are also available in Canada and may provide advice to clients on equipment, costs, and process startup.

Because of the lack of processing facilities and experience in processing hemp fiber in the USA, as well as the continually evolving technology at this point in time, it is difficult to estimate equipment costs and feasibility. To do that, we will need to identify a market which will demand a price sufficient to guarantee profitability. In parallel we will provide some guidance on market opportunities based on anticipated volumes of hemp bast and hurd to help estimate return on investment.

In addition, recent changes in law under the 2018 the Farm Bill will have a significant impact on future options in the market for industrial hemp in the United States. This can provide an opportunity to SWO as one of the first suppliers in the hemp fiber market but will require an understanding of the impacts of the changes in the laws governing the production, transporting and processing of hemp fiber which will become apparent as the changes in the law are implemented.

As we are able to explore options for market development, the team worked with Jim Lupien of BastCore Inc. to explore decortication and market development. BastCore purchased the industrial hemp bales from this years trial at $300/ton, and also paid the transportation costs for transport to their decortication facility in Omaha. They aim to identify potential clients for the fiber and we are told that they have been in discussion with the Patagonia outdoor supply company about providing SWO fiber for manufacture of clothing.

BastCore represents an opportunity for SWO for a number of reasons. They have access to different buyers of hemp fiber, they are evaluating SWO hemp fiber quality, and they are excited about the opportunity to work with SWO and UMN in selecting and testing hemp varieties for high end fiber markets. They could potentially continue to be a partner as SWO develops its capacity to decorticate and process industrial hemp into value added products as long as the terms of the partnership are fair and favorable. Currently Bastcore is providing decortication and marketing services to SWO.

Decortication is a physical milling process to separate and screen the fiber (Figure 3). The outer bast fiber produces two sizes of fibers. The longest and highest quality are primary, followed by shorter secondary fiber. The inner hurd (pith) comprises a third category of relatively uniform fine fiber. It would be ideal to develop markets for all marketable fiber types.

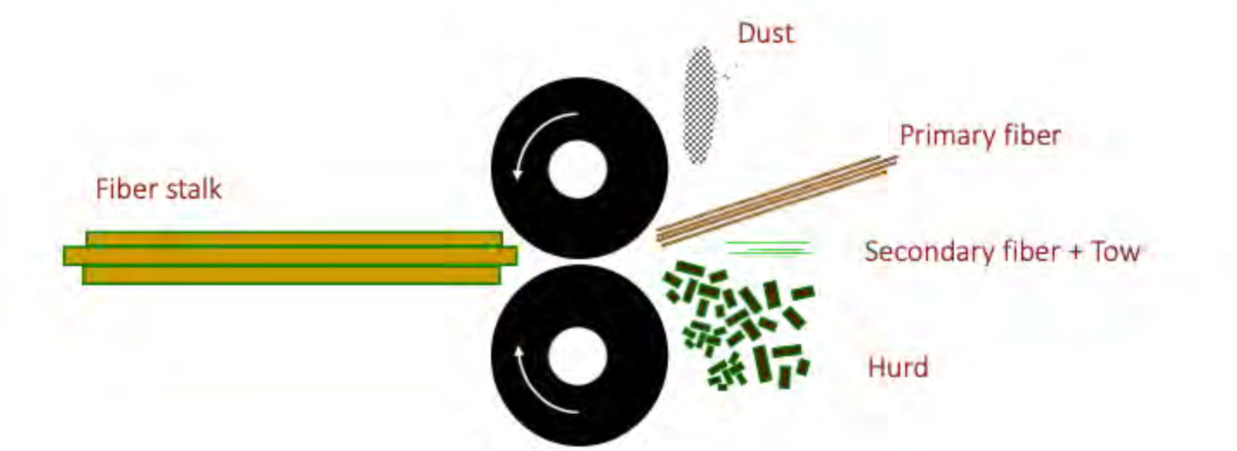

Figure 3. Hemp decortication.

Bastcore has an innovative process that allows them to use both the bast and the hurd and convert them into high value products. They currently are working with some high end opportunities to produce textiles and also using the hurd for innovative applications including' use in the petroleum industry as mentioned above. Bastcore is developing markets for apparel, textiles and other uses and offers the opportunity to access those markets. Bastcore is a leader in the hemp fiber industry and is developing the markets and innovative technology for hemp fiber processing and looking towards "green" processing.

We also made contact with Hemplogic USA. Hemplogic USA has developed and initiated the use of a mobile decorticator. Hemplogic USA provides consulting services and could potentially be a source of information and design for a processing facility at SWO. They offered their services to SWO and could also be an option for moving ahead with hemp fiber processing on tribal land.

The first step in determining the feasibility of hemp production and processing is determining the costs of production and the potential price for hemp fiber and whether the price covers the costs and generates a profit for the farm enterprise. There are a number of production cost estimates from several states in the USA and provinces in Canada as well as estimates prepared by Universities in the USA. Because the production of hemp for fiber is such a new activity many estimates are based on limited data. We selected an analysis and calculation tool that was produced by Penn State Extension which builds off of data gathered from studies from several available sources of information.

We selected the Penn State Extension model because it represents an "average" production scenario but also because it allows the user to modify the data based on particular site and equipment parameters. Thus it provides a good estimate of the potential costs and benefits of hemp fiber production which will be helpful in making decisions related to developing a hemp fiber enterprise and can be fine tuned to reflect the particular production methods selected by the operator or SWO (Figure 4).

Estimated production budget - costs per acre for Hemp Fiber Crop				
Item	Quantity	Unit	Price	Total
Variable Costs				
Custom				
Soil test	1.0	acre	$2.00	$2.00
Hauling round bales	83.0	bale-miles	$0.20	$16.60
Fert./Soil Amendment				
Lime+spreading	0.5	ton	$26.00	$13.00
N	100.0	lb.	$0.24	$24.00
P	20.0	lb.	$0.30	$6.00
K	20.0	lb.	$0.23	$4.60
Other				
THC testing fee	1.0	acre	$20.00	$25.00
Seed				
Industrial hemp seed	35.0	lb.	$2.50	$87.50
Rye cover crop seed	2.0	bu.	$7.50	$15.00
Operator labor				
hour	2.3	hour	$17.00	$39.10
Diesel fuel				
Tractors	8.7	gal.	$2.80	$24.36
Repairs & Maintenance				
Implements	1.0	acre	$12.45	$12.45
Tractors	1.0	acre	$7.72	$7.72
Interest on operating capital	1.0	acre	$5.62	$5.62
Total Variable Costs				***$282.95***
Fixed Costs				
Implements	1.0	acre	$27.48	$27.48
Tractors	1.0	acre	$18.40	$18.40
Land charge	1.0	acre	$150.00	$150.00
Total Fixed Costs				***$195.88***
Total Costs		acre		**$478.83**

Note: Adapted from https://extension.psu.edu/industrial-hemp-production with 2018 data. Estimated land rent of $150/acre for SWO lands was used in calculations.

Figure 4. Hemp production cost estimates.

Determining the potential productivity in terms of tons per acre of stalks produced is especially problematic due to the proliferation of industrial hemp varieties for grain, fiber, CBD oil and dual purpose varieties. North Dakota State University Research trials at Langdon, North Dakota provide a good estimate of the range of potential productivity on SWO lands because of their proximity. NDSU has been carrying out trials of industrial hemp since 2015 and provide some good initial data.

The disadvantage of the Langdon data is that the varieties tested have been grain or dual purpose varieties although early trials did include fiber varieties. Across varieties, fiber production varied between 3,500 and 7,000 lbs of dry stalk per acre (1.75-3.0 tons/acre). The lowest dry stalk weights per acre were from grain varieties as expected. Three dual purpose varieties tested in 2018 had dry stalk weights varying between 6,699 and 7,199 lbs (3.35-3.6 tons) per acre. Based on research in other locations, it would be reasonable to assume that a fiber only variety would produce greater tonnage than grain or dual purpose varieties.

Prices for hemp fiber can also be variable and there is not a well established market for hemp fiber in the US because of the lack of processing facilities. Based on publications, conversations with potential buyers and the sale price we received for the sale of hemp from our research plot, $300/acre seemed reasonable price in a market that is very young and subject to change. Preliminary assessment by BastCore suggest that the varieties and conditions produced fiber of exceptionally high quality so that higher prices might be attainable in future.

Given of the variability in prices and crop productivity per acre, we carried out a sensitivity analysis of gross income showing the impact on income of different prices ($150-$350/ton) for the hemp stalks and at different levels of productivity of the crop (2-4 tons). We estimated (1) gross income, (2) gross income minus variable costs, and (3) gross income minus variable and fixed costs at dry tons per acre with different combinations of crop price and productivity levels Tables 3-5).

Table 3. Gross income (price per ton x tons/acre).

	Price per ton (stalks in bales)					
Tons/acre		**150**	**200**	**250**	**300**	**350**
	2	300	400	500	600	700
	2.5	375	500	625	750	875
	3	450	600	750	900	1050
	3.5	525	700	875	1050	1225
	4	600	800	1000	1200	1400
Note – These are low and high estimates of both price and tons/acre.						

Table 4. Net income (gross income minus variable costs and production costs only).

		Price per ton (stalks in bales)				
		150	200	250	300	350
Tons/acre	2	17	117	217	317	417
	2.5	92	217	342	467	592
	3	167	317	467	617	767
	3.5	242	417	592	767	942
	4	317	517	717	917	1117

Note: Source of production costs – Penn State Extension - http://extension.psu.edu/ag-alternatives - 2018

Table 5. Net income (gross income minus variable costs, production costs and direct costs) Direct costs include machinery and land costs. We assumed $150 per acre as a land cost because SWO leases agricultural land at this rate.

		Price per ton (stalks in bales)				
		150	200	250	300	350
Tons/acre	2	-179	-79	21	121	221
	2.5	-104	21	146	271	396
	3	-29	121	271	421	571
	3.5	46	221	396	571	746
	4	121	321	521	721	921

*Note: This calculation includes fixed costs – Implements, tractors and land cost which was entered as $150/acre based on rental rate. Source of cost estimates – Penn State Extension - http://extension.psu.edu/ag-alternatives, and SWO Rental rates

Table 5 is the most accurate one as it takes into account the opportunity cost of land ($150/acre) and equipment costs. At the lower price and productivity levels, total costs are not covered starting at the current price of $200/ton and production of 2.5 tons/acre, the income covers all variable and fixed costs (including land rent) and generates a profit.

Market Opportunity and Economic Feasibility

Existing Market Options

We surveyed technical and business literature sources to better understand the landscape of fiber products, understand the business opportunities available today, and explore new product categories for the future. In consultation with SWO's tribal leadership and economic development office, we explored options that will allow for creation of new jobs in hemp processing or manufacturing of value-added projects within the community. This search, and subsequent discussions with regional companies has identified two immediate opportunities for bast and hurd fibers. We recommend exploring these further to plan for developing value-added manufacturing businesses on tribal land.

Our contact at Bastcore Inc. identified opportunities with high-end clothing manufacturers (e.g., Patagonia) who have expressed interest in sourcing greater quantities of hemp fiber from domestic sources rather than from their current overseas suppliers. This presents a unique opportunity for SWO to develop a relationship with an established brand that could lead to investment in new processing facilities (decortication, cottonizing, fabric weaving) on tribal land. The other advantage of Bastcore is their interest in expanding decortication facilities regionally. This could present an opportunity for SWO to form a business partnership to locate a decortication plant on tribal land. We recommend further negotiation with Bastcore to explore business models such as joint ventures.

We also identified a current market opportunity for hurd fibers in the hemp fiber composite industry. c2renew (Fargo, North Dakota) produces plastic composite resins incorporating natural fibers. Including fibers in a plastic composite can increase the strength and toughness of a molded part while reducing overall cost and reducing weight. C2renew have been seeking a regional source for more hemp fibers as demand for hemp-fiber composites has grown from 500 to 2000 lbs. per month in the past year. They expect significant market growth in the coming years, based on the number of calls they are receiving. Our team contracted with c2renew to produce travel coffee mugs from hemp fiber composites for market development and public relations. The mugs bear an SWO logo and the brand "Dakota Hemp". These will be available to SWO for market development and sharing with interested members of the tribe.

Potential Market Options

In addition to identifying immediate offtake opportunities, we surveyed research and development work on hemp fiber products to assess the breadth of potential opportunities. This list was narrowed to identify the most promising options, based on opportunities most likely to emerge in the near future, as well as those that meet criteria identified in conversation with SWO members. These criteria were: (1) opportunity to develop tribal businesses with a worker-owned democratic management structure, (2) potential synergy with existing Dakota Western Corp. blown plastics business, (3) opportunities to leverage federal 8A procurement status, and

(4) opportunities to address other tribal needs (e.g., housing). Based on these criteria, we have identified the following areas for further exploration and business development:

Clothing

Beyond the immediate opportunity for business development with Patagonia Inc. (as above) there are potential emerging markets in textiles and clothing markets. Hemp fiber has a long history of use for fabrics. Indeed, the scientific name *Cannabis* is derived from the old French word for canvas cloth (*chanevaz*). While other fibers, especially cotton and synthetics, have taken over the market in the past fifty years, there appears to be a recent market resurgence due in part to new processing techniques and consumer choices. Cotton production is very water and chemical intensive, and therefore some clothing manufacturers are seeking more environmentally responsible alternatives. We recommend that SWO explore market penetration opportunities with specialty clothing manufacturers.

Hemp Fiber Composites

There appear to be emerging opportunities for value-added manufacturing with hemp-based composites. Composites are made up of two or more different materials that each contribute different physical properties to the overall material. Some common composites include fiberglass and carbon fiber reinforced materials (e.g., materials for aviation, automotive, wind turbine blades) and mineral-plastic composites (e.g., quartz countertops and wood-plastic decking). Bio-composites contain one or more components that are biological in origin. Most commonly, biocomposites are plastic materials with natural plant fibers such as hemp or flax as a reinforcing agent. Natural fiber composites such as these were developed in the early 20th century but had been replaced by synthetics by the 1980's (Mohanty et al., 2018). Recently, interest in reducing the environmental impact of manufacturing, consumer preference, and new processing technologies have revived interest in natural fibers as part of composite materials. The recent upward trend in demand for hemp fiber composites seen by c2renew, mentioned above, is part of this trend. Likewise, international automotive manufacturers, including Toyota, Mercedes-Benz, and BMW have begun incorporating natural fiber composites in cars for elements such as door panels, trunk liners, and headliners (Akampumuza et al., 2016). In addition to working directly with c2renew, we recommend that the SWO begin to explore automotive applications through contact with tier 1, 2, and 3 suppliers to characterize the opportunities and identify a market entry point.

Another class of fiber-based composites are so-called linear composites made by extrusion or pultrusion. Various products have been explored in the past made from bio-based pultrusions including structural lumber, window components, trucking components, and architectural members such as window interior components and even structural I-beams (Fairuz et al., 2016; Smits 2016). In the standard pultrusion process the reinforcement materials like synthetic fibers, woven or braided strands are impregnated with resin, possibly followed by a separate pre-forming system, and pulled through a heated stationary die where the resin undergoes polymerization. The impregnation is either done by pulling the reinforcement through a bath or by injecting the resin into an injection chamber which is typically connected to the die. Many resin types may be used in pultrusion including polyester, polyurethane, vinyl ester and epoxy.

The University of Minnesota Natural Resources Research Institute is collaborating with regional companies to develop new materials containing completely bio-based resins that could represent entirely new family of renewable building materials made by pultrusion. While this manufacturing method offers lots of opportunities for new products and leverages Dakota Western Corp. expertise in plastics manufacturing, we recommend a thorough evaluation of the markets, especially in structural and architectural components, before investing in product development.

Pulp and Paper Products
Hemp-based paper production holds promise for making high quality products with lower environmental impact compared with typical wood pulp paper (da Silva Vieira et al. 2010). During phase I we made an introduction between SWO and W-Cycle (https://w-cycle.com/), a developer of molded pulp food service products. W-Cycle has worked with hemp fibers for new product lines as its strength and durability are superior to that of other pulp-based products. W-Cycle provided us with prototype pulp-based coffee cup lids as a potential first marketable product made from pulp (Figure 5). While this represents an interesting and novel product from hemp fibers, we recommend that SWO explore the business relationship with W-Cycle carefully to make sure that all parties can come to a satisfactory agreement before moving forward with product development.

Figure 5. Coffee cup with molded hemp fiber lid and close-up of molded fiber lid cross section.

Building products; There has been considerable past interest in using hemp as a concrete aggregate to produce hempcrete for housing and building applications. Three hemp-based building product concepts were explored in 2004-2005 by NRRI's building materials research team. Hemp was found to provide rigidity and insulating properties to hardboard products (similar to oriented strand board lumber) similar to other fiber-based boards (e.g., flax). A sample of hemp concrete block (hempcrete) made in Germany was subjected to physical testing and found to be less dense and potentially more insulating than concrete blocks, but absorbed and retained water in a moist environment. Another approach investigated by NRRI was to incorporate hemp fibers into phosphate cement. There is substantial intellectual property in this field, with products ranging from construction materials to oil well linings to dental cements. One promising approach would be to coat hemp fibers and press them into hardboard panels similar to wood wool concrete products commonly used in northern Europe (https://www.eltomation.com/eng). All of these concepts produce building materials that show some potential applications, but have not yet gained widespread acceptance. We recommend doing a thorough market assessment and techno-economic analysis to better understand whether these products represent real opportunities.

Biofuel

Biofuels have great potential market size, but are a low value product so only unmarketable portions of hemp should be considered as a fuel source. Because there are relatively few markets for the dust generated by the decordication process, and it represents approximately ten percent of the decordication products, there may be some opportunities to explore pellet fuel for heating systems in local markets. NRRI has developed low-cost binders from cellulosic ethanol and cranberry processing residues that can be used to produce a water resistant and durable pellet fuel from sawdust (Figure 6). A similar formulation could be developed for hemp processing dust to make maximal use of the plant. We recommend a thorough understanding of the market opportunity for formulated heating pellets to supply large users such as schools, businesses, and district heating systems as well as exploration of opportunities to convert residential heating systems to pellet furnaces and boilers. After that, there is an opportunity to develop custom fuel pellets and match them to boiler technology to ensure reliable and clean burning of the fuel.

Figure 6. Production of sawdust fuel pellets with lignin binder from cellulosic ethanol production. Low-cost production of hemp dust pellets is possible using similar formulations.

Recommendations

• Increase hemp fiber production to 40 acres in 2019
• Develop business relationships with c2renew, BastCore and Patagonia
• Explore planning for a decortication facility near Agency Village
• Prioritize product development opportunities based on market analysis and relationships

• The UMN team recommends that Dakota Nation Industries formalize a contract to sell the hemp bales resulting from Phase I to BastCore, Inc. with the following conditions: (1) SWO/UMN retains a small bale of mature stalks for demonstration & research purposes. (2) BastCore agrees to share information on the quantity and quality of the bast fiber & hurd resulting from decortication. (3) BastCore agrees to share with SWO/UMN samples of decorticated material (bast & hurd) for Phase II demonstration research purposes.
• Unless SWO has funds to support the cost of cultivating and decorticating in 2018, we recommend that SWO enter into a contract with BastCore to cultivate 40 acres of fiber hemp on SWO land in 2019. John Lupien of BastCore has indicated interest in working with SWO with potential to contract fiber-variety hemp production.
• We advise SWO to limit 2019 hemp acreage and minimize risk associated with scaling production until the project team has demonstrated success with larger acreage.
• We recognize that maintaining ownership of the crop and downstream products is more desirable than selling the crop to BastCore and allowing them to develop their relationships with other customers. A long term goal of SWO should be to maintain ownership over as many of the business transactions as possible for flexibility and profitability. Beyond 2019, we advise SWO to either pay for decortication or establish a decorticating facility in order to maintains ownership of hemp fiber and hurd for sale by SWO to customers. We understand that BastCore and/or Patagonia have expressed interest in siting decortication equipment at SWO in the future.
• Lastly, we recommend that the hemp composite coffee mugs bearing an SWO logo and the "Dakota Hemp" design be used to communicate the direction of the project to the community during a tribal event such as a community gathering or pow wow and also to pursue market opportunities at trade shows during Phase II.

Phase II

The second year of the SWO hemp economic feasibility study has three objectives: (1) collecting voice of the customer information to build a business case for entering the hemp marketplace, (2) increasing SWO hemp cultivation to 40 acres in 2019, and (3) identifying costs for decorticating hemp and manufacturing hemp-based plastics at SWO.
In Phase II we will expand SWO hemp production to provide the raw material needed to pursue market opportunities, customer segments, and market size for hemp products. A final report will include specifications and costs for Phase III (a) identifying markets, (b) building a decortication facility to process hemp regionally, and (c) expanding an existing tribally owned manufacturing operation at SWO for value-added hemp composite products.

Voice of the Customer for Industrial Hemp

Joining the team for Phase II is business advisor Chris Shay who proposes to conduct a voice-of-customer study and develop a business plan for Dakota Hemp.
• Product ideation including hemp canvas, hemp reinforced fiberboard, and hemp reinforced cement blocks. Examples of new product development opportunities include: compostable drinking cups, dinnerware, and food containers. Pultrusion technology has the potential to employ hemp composites in producing high-strength materials such as wind turbine blades, solar panel supports, flooring, fencing, siding window and door parts. Thermal modification of hemp composites could allow for other applications.
• Identify potential product markets for hemp, including but not limited to clothing and hemp-fiber reinforced plastics, and building products.
• Interview customers to identify market pull for product areas
• Select focal product areas and identify target prices for focal product areas
• Identify value added opportunities by aligning UMN research capabilities
• Lead development of a business case for the target opportunity
• Evaluate clothing and fiber reinforced plastic markets for hemp options
• Interview SWO stakeholders at the Sisseton Wahpeton Oyate to understand their objectives for entering the hemp market
• Visit Natural Resource Research Institute to understand the research and development capabilities at UMN
• Attend trade shows: B2B Hemp Industry & Natural Products Expo West
• Visit two potential customers to gather customer requirements
• Use SWO 2018 harvest to gain feedback from customers
• Summarize market opportunity and target price for each application identified in market survey.
• Deliver report summarizing each customer and product opportunity

Increase SWO Hemp Production

• Identify an appropriate hemp variety for cottonized fiber production
• Consult with SWO Realty to identify 40 acres of SWO land in North Dakota near the 2018 plot
• Obtain 2,400 lb. seed from a North Dakota source (e.g. fiber variety hlukhovsjii 51 from Richard McDonald, Reiten Farms and Legacy Hemp) and sow at 60 lbs per acre
• Harvest and square-bale for transportation provided by BastCore
• Report results of an experiment comparing commercially available industrial hemp varieties for fiber production on SWO land according to the following protocol:

Plot dimensions: 6’ wide by 10’ long (allows 7.5” row seeding in single pass)
Replication: each of four replicates per variety per seeding rate
Aisle width: 4’ (allows maintenance/mowing with single pass)

Border width: 6’ wide planted with hlukhovsjii 51
Factors: varieties and seeding rate (40 lb/acre versus 60 lb/acre)
Varieties: hlukhovsjii 51, Beniko, CHG, Futura 75, Felina 32, & Santhica 70

Considerations for site selection include: loss of lease income ($155/acre or $6,200), prior rotation (soy or alfalfa perhaps requiring less fertilizer than corn), soil conditions (medium textured, well-drained loam, not prone to flooding), accessibility and isolation (security).

Production acreage and experimental plots require 100 lb/acre nitrogen, 60 lb/acre phosphorus, and 60 lbs/acre of potassium. Amendments will be based on soil test results to achieve these rates of fertility. Fields will be prepared using conventional tillage practices and fertilizer will be incorporated into the soil at a depth of 3 to 4 inches by cultivation. Fields will be prepared by disking to reduce weed pressure. No herbicides or pesticides will be applied. Seed will be drilled at a shallow, controllable depth.

Two to three weeks after planting, vigor will be measured by visual assessment of each plot and using a 1=high through 5=low scale. A month after planting, plant populations will be recorded by counting the number of plants in a foot-long section of a row, four times per plot. Every two weeks prior to harvest, data will be collected on plant height by measuring eight randomly selected plants per plot.

Stalks will be harvested at or after 20% flowering from two, randomly selected 1m^2 sub□plots from within each main plot, careful to avoid plot edges using a handheld sickle mower, baled and sent to BastCore for decortication and processing. Data to be measured from sub-plots will include plant density, stalk height, stalk basal diameter, total biomass (straw dry weight), fiber yield, hurd yield, and processed fiber yield.

Identify Options for Business Planning

• Assess costs and technical needs for a decortication facility to process hemp at SWO.
• Assess costs and technical needs for expanding an existing tribally owned manufacturing operation at SWO (Dakota Western Corp.) for hemp-based plastic products.
• Draft a business plan for hemp processing and/or manufacturing with respect to the following considerations: local hemp production capacity, competition, location, facility size, equipment costs, construction costs, operating costs, labor, transportation, subsidies for minority-owned business, capital investment needs, risks and alternatives.
• Establish a brand presence (e.g., Dakota Hemp) and trademark through USPTO.

The proposed objectives will position SWO to implement a business plan while minimizing exposure to risk in the emerging and uncertain marketplace for industrial hemp. Depending on Phase II outcomes, other future opportunities to consider include other product areas, new product development, hemp variety development, seed production and improvement of agronomic practices.

Phase II proposed budget

item	amount
1 mo. salary for principal investigator coordinator Weiblen	$13,979
6 mo. salary for project coordinator Wenger	$33,501
2 mo. salary for applied economist Current	$19,495
2.4 mo. salary for bio-composite engineer Singsaas	$33,048
professional services: voice of customer (Shay)	$42,280
professional services: planting (SWO)	$5,000
professional services: field maintenance & mowing (SWO)	$10,000
professional services: baling (SWO)	$4,000
planting seed	$9,600
supplies and materials	$1,000
shipping costs	$1,000
travel UMN/SWO for project meetings (16 person-visits)	$5,000
Total	**$177,903**

Acknowledgements

We gratefully acknowledge the many contributors to this project including. At the SWO Planning Department, Lee Ann TallBear, Crystal Owen, William Fish, David Spider, Vivienne Tateyuskanskan, Barbara Joseph, and Harold "Sonny" Hill provided valuable support over the course of the project. The Natural Resources Division of SWO contributed above and beyond, including Charlene Miller, Wayne Heminger, Lana Rencountre, Lona Miller, and Brett Price. Megan LaFramboise and Debra Flute in the SWO Legal Department provided counsel and guidance to the project. Joshua Flute, CEO of Dakota Nations Industries, was licensed by the North Dakota Department of Agriculture to participate in its industrial hemp program. SWO Chairman David Flute provided leadership and encouragement throughout the project. Photographer John Heminger (Sota tribal news), Tammy Decoteau and Leslie Neconish contributed images and graphic design. Tribal members Shaun Eastman, DelRay German, Helena LaBatte, Carol Jordan and others raised thoughtful questions during project discussions. Jerry Eastman at SWO Realty identified tribal land for situating the demonstration plot.

Agronomist Burton Johnson of North Dakota State University and Rachel Seifert and Wayne Prindle at North Dakota Department of Agriculture provided essential support and oversight of the project. Joe Breker, at Coteau des Prairies Lodge, and Weston Quinn at Dakota Magic Casino were gracious in accommodating our hemp team. SWO Law Enforcement Officer Shindel Bower facilitated chain of custody of the hemp planting seed. Robert Huff at Dakota Western Corp. provided an informative tour of the plastic film facility at Agency Village. Alaura Williams delivered a proclamation from Senator John Hoeven (North Dakota) recognizing the SWO hemp harvest field day. Jeff Breker conducted a demonstration of crop raking and baling while John Lupien of BastCore Inc. (Omaha, Nebraska) stepped up to process hemp fiber resulting from the project. Corey Kratcha of c2renew (Fargo, North Dakota) was contracted to produce hemp composite coffee mugs under the project. Lastly, we acknowledge the University of Minnesota team for contributing to diverse aspects of the project including George Weiblen and Jonathan ("JP") Wenger (Department of Plant & Microbial Biology), Clemon Dabney III (Graduate Program in Plant & Microbial Biology), Dean Current (Department of Forest Resources), and Eric Singsaas (Natural Resource Research Institute, University of Minnesota-Duluth). Arnie Frishman (University of Minnesota General Counsel) assisted with the development of the sponsored project agreement between the tribe and the University of Minnesota.

References

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Hanson, Bryan K, Burton L. Johnson, Travis W. Hakanson, Lawrence E. Henry, and Venkat Chapara. 2018. Industrial Hemp Variety Performance in North Dakota – 2018 NDSU Langdon Research Extension Center. 3pp.

Project expenses

Sponsored/Non Sponsored Summary - Overall	Report Run Date:Thursday,2/7/2019 Data as of Thursday,02/07/2019 02:11 AM
Encumbered Facilities and Admin: Included	
Through Period:	FEBRUARY - 2019
Name:	Weiblen,George D
Internet ID:	GWEIBLEN
Department:	Plant Biology
Campus Address:	Room 250 BioSci

Sponsored

Inception to Date Through FEBRUARY - 2019

	Project Period		A	B	C = A - B	D	E = C - D	F = E / A * %
Sponsored Project Description	Begin Date	End Date	Expenditure Budget	Actual Expenditures	Balance before Encumbrances	Encumbrances	Balance after Encumbrances	% Left
Sisseton-Wahpeton-Oyate (SWO)-00070638	05/31/18	12/31/18	50000.00	50316.99	-316.99	0.00	-316.99	-0.63%
	Total Sponsored		50,000.00	50,316.99	-316.99	0.00	-316.99	-0.63%

Encumbered Facilities and Admin is included on this report.
* Special conditions for % Left calculated values.
When the Expenditure Budget and/or Resources are less than or equal to $0.00 and the Balance after Encumbrances is greater than $0.00, the % Left is populated as 100.00%.
When the Expenditure Budget and/or Resources are less than or equal to $0.00 and the Balance after Encumbrances is less than $0.00, the % Left is populated as -999.99%

Sponsored Project:	00070638 - Sisseton-Wahpeton-Oyate (SWO)
Encumbered Facilities and Admin:	Included
Sponsor:	SISSETON WAHPETON OYATE
Award:	CON000000072812
Department:	10876 - CBS Plant & Microbial Biology
Project Start Date:	5/31/2018
Project End Date:	12/31/2018
Principal Investigator:	Weiblen,George D

F&A: RSRCH MTDC1 0.00%

F&A Distribution: 10876 CBSPIMB 100.00%

FEBRUARY 2019

Account	Account Description	Expenses	A Project Period Budget	B Project Period Expenses
700200	Salaries-P/A/Police-FinBdgOnly	0.00	25,741.00	24,910.79
710200	Fringe-P/A/Police-FinBdgOnly	0.00	8,711.00	8,519.53
	Total Payroll/Fringe Expenses	0.00	34,452.00	33,430.32
720200	Lab/Med Supplies-FinBdg Only	0.00	1,001.00	987.95
720300	Gen Oper Services-Fin Bdg Only	0.00	10,107.00	2,500.00
720600	Travel/Mileage/Mov-FinBdg Only	0.00	4,140.00	4,098.72
730200	Professional Svcs-FinBdg Only	0.00	300.00	9,300.00
	Total Non-Payroll/Non-Fringe Expenses	0.00	15,548.00	16,886.67
	Direct Cost Total	0.00	50,000.00	50,316.99
	Project Total	0.00	50,000.00	50,316.99

Account	Journal ID	Journal Date	Encumbrance	Actuals	Employee or Vendor	Description
700201 - Salaries-Academic Professional	RTD1042995	08/21/18	0.00	960.14	Wenger,Jonathan P	1527753-062518-070818Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1042995	08/21/18	0.00	954.60	Wenger,Jonathan P	1527753-061118-062418Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1052726	09/27/18	0.00	321.13	Current,Dean Alan	1225860-072318-080518Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1052726	09/27/18	0.00	1,109.06	Current,Dean Alan	1225860-070918-072218Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1052726	09/27/18	0.00	321.13	Current,Dean Alan	1225860-080618-081918Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1052726	09/27/18	0.00	321.13	Current,Dean Alan	1225860-082018-090218Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1052726	09/27/18	0.00	321.13	Current,Dean Alan	1225860-090318-091618Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	PYN1056521	10/10/18	0.00	341.93	Current,Dean Alan	Salaries-Academic ProfessionalGross to Net Company UMN
700201 - Salaries-Academic Professional	PYN1059811	10/24/18	0.00	341.93	Current,Dean Alan	Salaries-Academic ProfessionalGross to Net Company UMN
700201 - Salaries-Academic Professional	PYN1063939	11/07/18	0.00	341.93	Current,Dean Alan	Salaries-Academic ProfessionalGross to Net Company UMN
700201 - Salaries-Academic Professional	PYN1067227	11/21/18	0.00	341.93	Current,Dean Alan	Salaries-Academic ProfessionalGross to Net Company UMN
700201 - Salaries-Academic Professional	PYN1070108	12/05/18	0.00	341.93	Current,Dean Alan	Salaries-Academic ProfessionalGross to Net Company UMN
700201 - Salaries-Academic Professional	RTD1070561	12/06/18	0.00	1,920.28	Wenger,Jonathan P	1527753-102918-111118Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1070561	12/06/18	0.00	1,920.28	Wenger,Jonathan P	1527753-111218-112518Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1070561	12/06/18	0.00	1,920.28	Wenger,Jonathan P	1527753-100118-101418Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1070561	12/06/18	0.00	1,920.28	Wenger,Jonathan P	1527753-101518-102818Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1070561	12/06/18	0.00	1,920.28	Wenger,Jonathan P	1527753-082018-090218Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1070561	12/06/18	0.00	1,920.28	Wenger,Jonathan P	1527753-090318-091618Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	RTD1070561	12/06/18	0.00	1,920.28	Wenger,Jonathan P	1527753-091718-093018Salary / Fringe Adjustment
700201 - Salaries-Academic Professional	PYN1073700	12/19/18	0.00	341.93	Current,Dean Alan	Salaries-Academic ProfessionalGross to Net Company UMN
700201 - Salaries-Academic Professional	PYN1075972	01/02/19	0.00	341.93	Current,Dean Alan	Salaries-Academic ProfessionalGross to Net Company UMN
700201 - Salaries-Academic Professional	PYN1079666	01/16/19	0.00	341.93	Current,Dean Alan	Salaries-Academic ProfessionalGross to Net Company UMN
700201 - Salaries-Academic Professional	PYN1082472	01/30/19	0.00	341.93	Current,Dean Alan	Salaries-Academic ProfessionalGross to Net Company UMN
700202 - Salaries-Academic Admin	PYN1045010	08/29/18	0.00	1,055.59	Singsaas,Eric Lawrence	Salaries-Academic AdminGross to Net Company UMN
700202 - Salaries-Academic Admin	PYN1048727	09/12/18	0.00	242.20	Singsaas,Eric Lawrence	Salaries-Academic AdminGross to Net Company UMN
700202 - Salaries-Academic Admin	PYN1052240	09/26/18	0.00	121.10	Singsaas,Eric Lawrence	Salaries-Academic AdminGross to Net Company UMN
700202 - Salaries-Academic Admin	PYN1056521	10/10/18	0.00	968.83	Singsaas,Eric Lawrence	Salaries-Academic AdminGross to Net Company UMN
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700202 - Salaries-Academic Admin	PYN1063939	11/07/18	0.00	242.20	Singsaas,Eric Lawrence	Salaries-Academic AdminGross to Net Company UMN
700202 - Salaries-Academic Admin	PYN1067227	11/21/18	0.00	242.20	Singsaas,Eric Lawrence	Salaries-Academic AdminGross to Net Company UMN
700202 - Salaries-Academic Admin	PYN1070108	12/05/18	0.00	242.20	Singsaas,Eric Lawrence	Salaries-Academic AdminGross to Net Company UMN
700202 - Salaries-Academic Admin	PYN1073700	12/19/18	0.00	242.20	Singsaas,Eric Lawrence	Salaries-Academic AdminGross to Net Company UMN
700202 - Salaries-Academic Admin	PYN1075972	01/02/19	0.00	242.20	Singsaas,Eric Lawrence	Salaries-Academic AdminGross to Net Company UMN
710201 - Fringe-Academic Professional	RTD1042995	08/21/18	0.00	328.37	Wenger,Jonathan P	1527753-062518-070818Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1042995	08/21/18	0.00	326.48	Wenger,Jonathan P	1527753-061118-062418Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1052726	09/27/18	0.00	109.83	Current,Dean Alan	1225860-090318-091618Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1052726	09/27/18	0.00	109.83	Current,Dean Alan	1225860-072318-080518Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1052726	09/27/18	0.00	109.83	Current,Dean Alan	1225860-080618-081918Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1052726	09/27/18	0.00	109.83	Current,Dean Alan	1225860-082018-090218Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1052726	09/27/18	0.00	379.30	Current,Dean Alan	1225860-070918-072218Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	FBT1056518	10/10/18	0.00	116.94	Current,Dean Alan	Fringe-Academic ProfessionalFringe Expense

Account	Journal ID	Journal Date	Encumbrance	Actuals	Employee or Vendor	Description
710201 - Fringe-Academic Professional	FBT1059774	10/24/18	0.00	116.94	Current,Dean Alan	Fringe-Academic ProfessionalFringe Expense
710201 - Fringe-Academic Professional	FBT1063936	11/07/18	0.00	116.94	Current,Dean Alan	Fringe-Academic ProfessionalFringe Expense
710201 - Fringe-Academic Professional	FBT1067207	11/21/18	0.00	116.94	Current,Dean Alan	Fringe-Academic ProfessionalFringe Expense
710201 - Fringe-Academic Professional	FBT1070105	12/05/18	0.00	116.94	Current,Dean Alan	Fringe-Academic ProfessionalFringe Expense
710201 - Fringe-Academic Professional	RTD1070561	12/06/18	0.00	656.74	Wenger,Jonathan P	1527753-082018-090218Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1070561	12/06/18	0.00	656.74	Wenger,Jonathan P	1527753-111218-112518Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1070561	12/06/18	0.00	656.74	Wenger,Jonathan P	1527753-102918-111118Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1070561	12/06/18	0.00	656.74	Wenger,Jonathan P	1527753-101518-102818Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1070561	12/06/18	0.00	656.74	Wenger,Jonathan P	1527753-100118-101418Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1070561	12/06/18	0.00	656.74	Wenger,Jonathan P	1527753-091718-093018Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	RTD1070561	12/06/18	0.00	656.74	Wenger,Jonathan P	1527753-090318-091618Salary / Fringe Adjustment
710201 - Fringe-Academic Professional	FBT1073697	12/19/18	0.00	116.94	Current,Dean Alan	Fringe-Academic ProfessionalFringe Expense
710201 - Fringe-Academic Professional	FBT1075969	01/02/19	0.00	116.94	Current,Dean Alan	Fringe-Academic ProfessionalFringe Expense
710201 - Fringe-Academic Professional	FBT1079643	01/16/19	0.00	116.94	Current,Dean Alan	Fringe-Academic ProfessionalFringe Expense
710201 - Fringe-Academic Professional	FBT1082469	01/30/19	0.00	116.94	Current,Dean Alan	Fringe-Academic ProfessionalFringe Expense
710202 - Fringe-Academic Administrative	FBT1045007	08/29/18	0.00	361.01	Singsaas,Eric Lawrence	Fringe-Academic AdministrativeFringe Expense
710202 - Fringe-Academic Administrative	FBT1048720	09/12/18	0.00	82.83	Singsaas,Eric Lawrence	Fringe-Academic AdministrativeFringe Expense
710202 - Fringe-Academic Administrative	FBT1052237	09/26/18	0.00	41.42	Singsaas,Eric Lawrence	Fringe-Academic AdministrativeFringe Expense
710202 - Fringe-Academic Administrative	FBT1056518	10/10/18	0.00	331.34	Singsaas,Eric Lawrence	Fringe-Academic AdministrativeFringe Expense
710202 - Fringe-Academic Administrative	FBT1059774	10/24/18	0.00	165.67	Singsaas,Eric Lawrence	Fringe-Academic AdministrativeFringe Expense
710202 - Fringe-Academic Administrative	FBT1063936	11/07/18	0.00	82.83	Singsaas,Eric Lawrence	Fringe-Academic AdministrativeFringe Expense
710202 - Fringe-Academic Administrative	FBT1067207	11/21/18	0.00	82.83	Singsaas,Eric Lawrence	Fringe-Academic AdministrativeFringe Expense
710202 - Fringe-Academic Administrative	FBT1070105	12/05/18	0.00	82.83	Singsaas,Eric Lawrence	Fringe-Academic AdministrativeFringe Expense
710202 - Fringe-Academic Administrative	FBT1073697	12/19/18	0.00	82.83	Singsaas,Eric Lawrence	Fringe-Academic AdministrativeFringe Expense
710202 - Fringe-Academic Administrative	FBT1075969	01/02/19	0.00	82.83	Singsaas,Eric Lawrence	Fringe-Academic AdministrativeFringe Expense
720206 - Field Supplies	EAC1075339	12/28/18	0.00	987.95	Weiblen,George D	NATIONAL CAMERA EXCHANGE replacement digital camera used
720399 - Other General Services	ACC1070621	12/06/18	0.00	2,500.00	NORTH DAKOTA STATE	NORTH DAKOTA STATE UNIVERSITY Accounts Payable
720601 - Travel in Minnesota	ACC1036416	07/27/18	0.00	77.28	FLEET SERVICES	FLEET SERVICES Accounts PayableFleet Leasing and Rental
720601 - Travel in Minnesota	ACC1045413	08/30/18	0.00	314.74	FLEET SERVICES	FLEET SERVICES Accounts PayableFleet Leasing and Rental
720601 - Travel in Minnesota	ACC1053161	09/28/18	0.00	437.31	FLEET SERVICES	FLEET SERVICES Accounts PayableFleet Leasing and Rental
720601 - Travel in Minnesota	ACC1061323	10/30/18	0.00	287.37	FLEET SERVICES	FLEET SERVICES Accounts PayableFleet Leasing and Rental
720601 - Travel in Minnesota	ACC1075328	12/28/18	0.00	355.77	FLEET SERVICES	FLEET SERVICES Accounts PayableFleet Leasing and Rental
720601 - Travel in Minnesota	EAC1076979	01/04/19	0.00	168.96	Singsaas,Eric Lawrence	8002281 Singsaas,Eric Lawrence Drove Personal Car to/from
720602 - Travel Domestic	EAC1054607	09/21/18	0.00	72.90	Wenger,Jonathan P	1527753 Wenger,Jonathan P Lodging in Hankinson (1 night)
720602 - Travel Domestic	EAC1054607	09/21/18	0.00	38.25	Wenger,Jonathan P	1527753 Wenger,Jonathan P Last day meals
720602 - Travel Domestic	EAC1054607	09/21/18	0.00	38.25	Wenger,Jonathan P	1527753 Wenger,Jonathan P First day meals
720602 - Travel Domestic	EAC1059168	10/19/18	0.00	504.00	Weiblen,George D	1395464 Weiblen,George D 1 night lodging for Weiblen, Wenger,
720602 - Travel Domestic	EAC1059869	10/23/18	0.00	55.00	Weiblen,George D	1395464 Weiblen,George D Full day
720602 - Travel Domestic	EAC1059869	10/23/18	0.00	232.72	Weiblen,George D	1395464 Weiblen,George D Round trip mileage accrued from St.
720602 - Travel Domestic	EAC1059869	10/23/18	0.00	38.12	Weiblen,George D	1395464 Weiblen,George D Partial Day--travel
720602 - Travel Domestic	EAC1059869	10/23/18	0.00	486.00	Weiblen,George D	1395464 Weiblen,George D 2 nights lodging for 3 people (Weiblen,

Account	Journal ID	Journal Date	Encumbrance	Actuals	Employee or Vendor	Description
720602 - Travel Domestic	EAC1059869	10/23/18	0.00	38.12	Weiblen,George D	1395464 Weiblen,George D Partial day--return travel
720602 - Travel Domestic	EAC1060954	10/26/18	0.00	64.80	Wenger,Jonathan P	1527753 Wenger,Jonathan P Lodging in Hankinson, ND
720602 - Travel Domestic	EAC1060954	10/26/18	0.00	38.25	Wenger,Jonathan P	1527753 Wenger,Jonathan P First day
720602 - Travel Domestic	EAC1060954	10/26/18	0.00	38.25	Wenger,Jonathan P	1527753 Wenger,Jonathan P Last day
720602 - Travel Domestic	EAC1076979	01/04/19	0.00	60.00	Singsaas,Eric Lawrence	8002281 Singsaas,Eric Lawrence Waiving Partial Per
720602 - Travel Domestic	EAC1081459	01/24/19	0.00	123.75	Weiblen,George D	1395464 Weiblen,George D Travel day ($41.25/person=$123.75)
720602 - Travel Domestic	EAC1081459	01/24/19	0.00	165.00	Weiblen,George D	1395464 Weiblen,George D Full day ($55/person=$165)
720602 - Travel Domestic	EAC1081459	01/24/19	0.00	85.88	Weiblen,George D	1395464 Weiblen,George D Travel day--return trip
720602 - Travel Domestic	EAC1081459	01/24/19	0.00	378.00	Weiblen,George D	1395464 Weiblen,George D 2 nights lodging for Weiblen and two
730213 - Field Services	ACC1070171	12/04/18	0.00	300.00	SPV018 COLLEGE OF	SPV018 COLLEGE OF BIOLOGICAL SCIENCES Accounts
730299 - Other Professional Svcs	ACC1073753	12/18/18	0.00	9,000.00	C2RENEW	C2RENEW Accounts Payable 0001687048Hemp Fiber

Vicinity of field site viewed from Couteau des Prairies Lodge (25 May 2018).

Field inspection with Crystal Owen (SWO Planning), Prof. George Weiblen and Charlene Miller (SWO Natural Resources) on 25 May 2018.

Senator Amy Klobuchar announces her support for hemp in the 2018 Farm Bill at her office in the Dirksen Senate Office Building, Washington DC (8 June 2018).

Professor Weiblen at the state capitol in Bismarck, North Dakota (July 8 2018).

Wayne Prindle, Industrial Hemp Program Coordinator (North Dakota Department of Agriculture) transferring hemp seed at the state capitol building to Professor Weiblen (July 8 2018).

SWO Law Enforcement Officer Shindel Bower takes custody of hemp planting seed at Dakota Magic Casino (9 July 2018).

Officer Shindel Bower, Megan LaFromboise (SWO Legal Department), and Charlene Miller (SWO Natural Resources Division) with hemp seed at Dakota Magic Casino (9 July 2018).

Hemp at 14 days after planting. Moist soil and warm temperatures resulted in excellent germination and establishment. (26 July 2018).

Hemp at 34 days after planting. Canopy closure completely suppressed weeds in the field. (15 August 2018).

Sota newspaper photographer John Heminger examines a volunteer hemp plant at the end of a row on day 34 after planting (15 August 2018).

University of Minnesota project team members Dean Current, Eric Singsaas, Clemon Dabney, George Weiblen and Jonathan Wenger are 'outstanding in their field' (15 August 2018).

Security sign at the SWO hemp demonstration plot. No disturbance was observed during the season.

SWO Natural Resources sickle bar used to mow fiber hemp.

Mike Heminger of SWO Natural Resources mowing hemp with a sickle bar at 68 days after planting (18 September 2018).

Bast fiber hemp, planted at higher density, on the ground as mowed on 68 days after planted (18 September 2018).
The crop was exposed to natural 'dew retting' in the field for the next several weeks.

Lana Rencountre (SWO Natural Resources) standing next to the lower density hurd crop at 76 days after planting (26 September 2018).

Several weeks after naturally 'retting' in the field the outer 'bast' fibers are easily separated from the pithy inner 'hurd' at 98 days after planting (18 October 2018).

Stubble shows row spacing. The cut stalks are naturally 'retting' on the ground. This aids in separating the outer bast fiber from from the inner hurd (26 September 2018).

Freshly mowed hemp stalks in foreground (green) compared to partially retted hemp stalks in background (gray) that had been harvested on 18 September (18 October 2018).

The lower density hemp plot after several nights of hard frost (18 October 23 2018).

Mike Heminger harvesting the lower density hemp plot at 98 days after planting (18 October 2018).

Fiber hemp as freshly raked and baled by Jeff Breker at 103 days after planting (23 October 2018).

Round bales of hemp showing differences in coloration depending on whether the stalks 'retted' on the ground for six weeks (left) compared to stalks that were killed by hard frost prior to harvest (right) and baled one week after harvest (17 December 2018).

Wayne Heminger uses a Bobcat to move fiber hemp bales from the field for transport to a processing facility (17 December 2018).

Clemon Dabney loads hemp bales for transport to the fiber processing facility of BastCore Inc. (Omaha, Nebraska) (17 December 2018).

Ten bales of fiber hemp weighing 11,000 pounds were transported to the fiber processing facility of BastCore Inc. (Omaha, Nebraska).

SWO has operated a blown film plastic bag factory at Agency Village for 25 years. Currently, a significant share of plastic bag production is for compostable bags made from non-fossil fuel feed stocks. Renewable feedstock is not available locally but hemp has the potential to replace this, creating a source of value-added raw materials locally.

John Heminger, Clemon Dabney and Crystal Owen examine the feedstock for manufacture of blown film plastic bags at the Dakota Western facility in Agency Village. Polylactic acid beads from bacteria are imported at considerable cost to produce compostable bags comprising 40% of Dakota Western's current output.

Polylactic acid (PLA) beads derived from bacteria are currently used by Dakota Western Corp. to produce compostable plastic bags. They might be replaced with hemp-based material if it could be produced and processed locally.

Compostable plastic bags derived from non-fossil fuel feed stocks are rolled at the Dakota Western Corp. facility in Agency Village. This product is the fastest growing component of Dakota Western's product line.

Robert Huff, General Manager of Dakota Western Corp., demonstrates machinery cutting compostable plastic bags prior to packaging.

Clemon Dabney (PhD student), Crystal Owen (SWO Planning) and George Weiblen (Principal Investigator) are pictured outside of the SWO Tribal Council Chamber with a bale of Dakota Hemp from the project (18 December 2018).

SWO Hemp Economic Feasibility Study report findings are presented to the SWO Tribal Council. Seated are Lee Ann TallBear (SWO Planning), Josh Flute (Dakota Nation Industries), and Harold 'Sonny' Hill (SWO Planning) (18 December 2018).