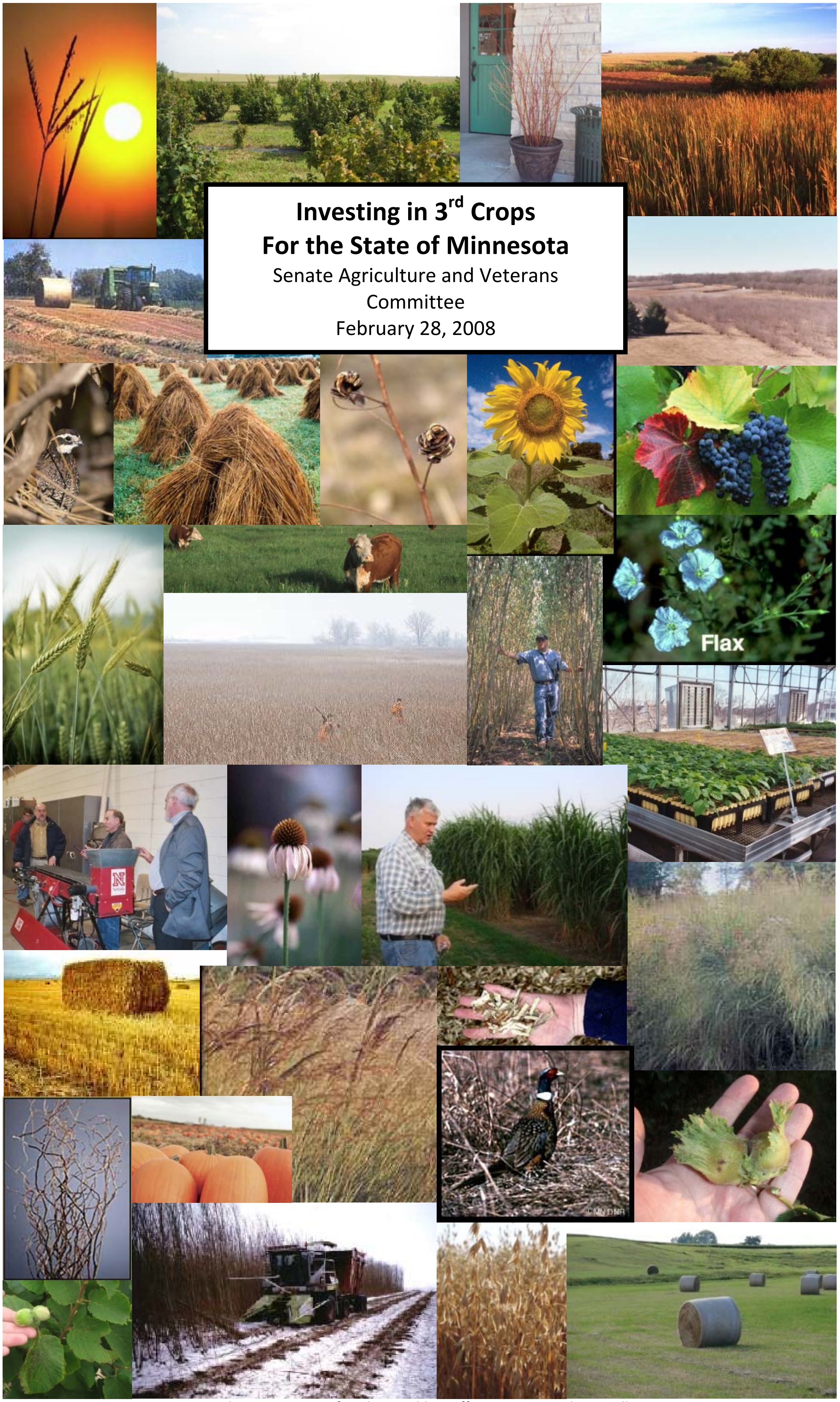
Investing in 3rd Crops
For the State of Minnesota

Senate Agriculture and Veterans Committee

February 28, 2008



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3rd Crop Overview

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Chairman Senator Vickerman, Senator Skogen, Members of the Committee. Thank you for allowing us to speak to you today about 3rd crops, where we are with 3rd crops today and where we feel Minnesota can be with this industry in the future. My name is Linda Meschke and I am President of a nonprofit corporation based in Fairmont, Minnesota working on issues related to agriculture, the environment and rural communities.

During the past twenty years I have worked with water quality issues in south central Minnesota. Most of my work in this area has been around agricultural nonpoint source pollution issues- sediment, nitrogen, phosphorous and pathogens- and was focused toward implementation and getting changes on the land to improve water quality.

During the 13 years I was involved with the Blue Earth River Basin Initiative, we put over $4.5 million of typical cost share water quality improvement practices on the landscape in south central Minnesota. These practices resulted in approximately a 9% reduction in pollution loading from the Blue Earth River system to the Minnesota River system. While these practices were effective and resulted in improvements, we are still a long ways from meeting our water quality goals. To meet our local and state water quality goals requires about a 40% pollution reduction. We were able to reduce 9% over 13 years. We do not have 40–50 years to meet our water quality goals. TMDL's have a 13 year timeframe for improvement.

As a result of this information, I was trying to figure out how we could be more effective in our implementation and came to the conclusion that we needed to go to a higher level with our Best Management Practices if we were going to be successful with meeting local and state environmental goals. Third crops are a higher level BMP. Strategically placed in the landscape, they can help us reach our water quality goals plus provide other economic and community benefits within a reasonable timeframe. Working with faculty at the University of Minnesota in 2002, we submitted an LCMR request, and were funded for work around third crops and the water quality benefits. That funding along with other funding we have received has helped place third crops on the landscape, evaluated the water quality benefits and provided a variety of outreach and educational programming around third crops.

Third crops were developed to indicate a variety of crops other than corn or soybeans. Valid examples include wheat, rye, cover crops, canola, native plants for seed or bioenergy production, hybrid poplars, hazelnuts or perennial flax and sunflower. Today, representatives from several of these crop areas will speak more specifically about these crops and the potential they have for Minnesota.

Major agricultural regions of Minnesota are dominated by landscapes that are unable to provide adequate ecological services to meet basic local and state water quality goals; protect sensitive aquifer recharge areas; manage excessive water flow at critical times; and maintain bio-diversity. In addition, the trend for these industrialized agricultural landscapes has been a 24% increase in corn and soybean acreage over the last two decades. This trend parallels increasing water quality impairments from sediment, nitrogen, phosphorous and pathogens from agricultural nonpoint source pollution.

Third crops are a higher level BMP that when targeted to environmentally sensitive areas of the landscape, can provide a multifunctional landscape that provides a systemic approach to the many challenges from agricultural nonpoint source pollution and results in benefits to the landowner, the local community and the State. These “working agricultural landscapes” provide economic return back to the farm family and are not “land retirement”.

Benefits include:

- Reduced soil erosion
- Reduced nutrient losses
- Improved soil health
- Stabilized water flows to reduce flooding
- Water storage and aquifer charge
- Carbon sequestration and reduced greenhouse gas
- Improved biodiversity
- Improved quality of life and recreation opportunities
- Increased rural economic development opportunities

These landscapes have powerful capacities to provide ecological services and conserve resources, while also producing marketable agricultural commodities using a broad palette of both perennial and annual plant species to diversify agricultural landscapes. The secret is to put the right plants in the right place, targeting diversification to the relatively small portions of agricultural landscapes that are unsuited to industrialized annual agriculture and which are responsible for most of the environmental degradation caused by such agriculture. Several studies of agricultural landscapes have shown that 60-80% of discharges of nutrients and soil sediment may result from unsuitable land use in only 5-10% of these landscapes.

Minnesota has a strong history of being leaders in the development of the major agricultural crops raised in the state today. For example, many prominent public soybean varieties were developed by research conducted at the University of Minnesota and played a key role in the overall development of the soybean industry that we know today. It started with a state investment in a scientist to breed, test and release soybean varieties. The story is similar for corn, wheat, oats, barley and a variety of forage and turf species. All of these are agricultural crops that are now major economic engines in our Minnesota economy.

Unfortunately, over the last 15 years, the state has not invested in the breeding and development of alternative crops. The University of Minnesota has maintained highly active breeding programs for corn, soybeans, wheat and small grains and leads the nation in several areas. However, the State has not invested effectively in the development of breeding programs for alternative crops. The interest in 3rd crops over the past decade and the national stage for bioenergy crops, local foods and the derivatives from crops indicate that it is time for the state to once again make an investment in germplasm development for alternative crops. A base investment- and commitment over a ten year period would greatly accelerate and elevate Minnesota’s position in advancing industries based on alternative crops within the state.

Hybrid Hazelnut Production in Minnesota: A Potential Energy and Food Crop

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Hazelnuts, also known as filberts, are a worldwide commodity grown commercially in places like Turkey, Italy, Spain, and the United States. Hazelnuts are currently produced for use in the confectionary, and food oil market, and in the future there is great potential for use in the renewable energy market. Virtually all domestic production (99%) occurs in the state of Oregon where the climate is conducive to growing the European hazelnut; which has a large nut size, moderate yields, and good overall nut characteristics. The European hazelnut is the commercial variety of choice but is not cold hardy and is susceptible to a fungal disease called Eastern Filbert Blight (EFB).

Two species of hazelnut native to Minnesota and the greater Midwest, the American and Beaked hazelnut do not have the commercial nut characteristics of the European hazelnut but are cold hardy and tolerant to EFB. Efforts to combine the cold hardiness and resistance to EFB of our native hazels with the commercial nut characteristics of the European hazel have been on-going.

In Minnesota, Badgersett Research Corporation has developed hybrid hazelnuts that have become the primary source of hybrid hazelnuts planted in the Midwest. These plants are resistant or tolerant of EFB, produce moderate yields, and have some of the nut characteristics desired in the commercial market. The hybrid hazelnuts currently grown are propagated from open-pollinated seed, which results in plantings with a high level of plant-to-plant variability which makes it difficult to manage the plantings on a commercial scale. Thus, most of the plantings in the state today are most accurately described as research plantings. Eliminating this variability requires the evaluation of producing plants (3-6 years old) and then selecting those plants with desirable characteristics to be vegetatively propagated. Once propagated the new seedling is identical to the parent plant. Replicating this process yields plants that are uniform in plant structure, nut flavor, and maturity. Currently there are no consistently reliable methods for the vegetative propagation of hybrid hazelnut. So the genetic variability issue continues to be one of the barriers to large scale commercialization for current and prospective growers.

Oregon State University and Rutgers University are two additional research institutions that are working with hazelnuts. Each university maintains a collection of hazelnut germplasm collected throughout the world. While OSU is primarily interested in the European variety, Rutgers is interested in hybrid plants that are cold hardy, resistant to EFB, and of commercial value. Each brings expertise and knowledge on specific topics and issues that can move the hazelnut industry in Minnesota forward. Rutgers in particular has developed an EFB screening technique that cuts by more than half the time needed to determine if a hazelnut breeding line is resistant to EFB. They have also discovered two potentially new lines of EFB resistant material that they are evaluating in the Midwest.

Hazelnuts in Minnesota

Growing annual crops contributes to soil erosion and loss of organic matter through tillage and increases pollutants such as chemicals, fertilizers and sediment in our water bodies. In contrast perennial crops, like hazelnuts, actually improve many of the degradations annual crops contribute to in addition to producing a saleable crop. Some of the multiple benefits include reduced soil erosion, carbon sequestration, improved wildlife habitat, reduced inputs, improved water quality, and potential for increased revenue.

In Minnesota hazelnuts can be grown on marginal land not used for row crop production, in environmentally sensitive areas like buffers and steeper slopes, as well as small parcels of land like old feedlots and abandoned pasture. Minnesota is home to at least 30 growers that have hybrid hazelnut bushes in the ground ranging from just a few seedlings up to 10,000 plants. Annual production is estimated at less than 5000 pounds and fully one third of that comes from only 3 growers. However, there is no commercial marketing that occurs in the state or in the greater Midwest. Typically nuts are sold at farmers markets, directly to consumers and restaurants, or direct marketed via Internet sales. Although production is miniscule compared to the almost 34,000 tons averaged by Oregon since 2000; at least five additional growers, of substantial size, will be coming into production in the next year. It is estimated that production could double to roughly 10,000 pounds in the next two years. This would represent about 0.1% of U.S. domestic production.

Recently the Minnesota Hazelnut Producers Council was formed. This non-profit group of hazelnut growers is dedicated to the goal of developing a commercial hazelnut industry in Minnesota and the greater Midwest. By partnering with Badgersett Research Corporation, Rutgers University, the University of Minnesota, and Oregon State we are developing a network of activity to overcome some of the obstacles to commercialization.

Research needs

Hazelnuts in Minnesota must be cold hardy, resistant to EFB, and possess nut characteristics that are commercially viable. Furthermore, to develop a commercial hazelnut industry a certain level of mechanization is necessary for planting, harvesting and processing. This is not currently possible with the high level of genetic variability present in the hazelnut plants currently available in Minnesota. Plants differ in size, nut maturation, and growth making hand harvesting necessary and laborious. Research on the vegetative propagation of high quality hazelnut plants would be a major step forward in developing uniform plants for commercial plantings. It would also allow growers to produce their own identical seedlings on-farm lowering costs and improving the bottom line. Other research needs include:

- Breeding and selection of superior plants
- Conduct state wide yield trials
- Develop of production practices
- Develop harvesting and husking equipment
- Value-added food products
- Environmental impact of hazelnut production

The potential for a hazelnut industry in Minnesota is very high. An already established market is present for hazelnuts, we have producers that want to grow them and we have the necessary partners in OSU, Rutgers, Badgersett, and the University of Minnesota to make it happen. Support at this crucial juncture could be the stimulus needed to propel hazelnuts forward as a viable 3rd crop in Minnesota.

Native Plant Seed Production: A Third Crop Opportunity

Garth Kaste and Bill Olsen, Minnesota Native Wildflower/Native Grass Growers Association

The Native Seed Industry in Minnesota. There are approximately 25 growers of native seed in the state of Minnesota with the majority being members of the Minnesota Native Wildflower/Native Grass Growers Association. The industry is responsible for about $7 to 10 million dollars of sales per year. The industry has under cultivation in excess of 150 different species of native plants for seed production. Currently the vast majority of seed produced in Minnesota is used for federal and state mandated conservation programs and restoration projects. The demand for native seed is variable and largely dependent on the level of participation in Conservation Reserve Programs. In years when Conservation plantings are high, demand for seed will also be high. Currently, sales are somewhat lower due to the lack of farm program incentives.

1. Natives for Landscape Restoration. Despite uncertainty between farm bills about potential conservation acreage, the demand for native species for restoration and conservation projects for landscape stabilization, wildlife habitat, and recreation will likely remain strong. Supplies of source identified seed that meet the required definition of local ecotype for legislatively regulated restorations such as MnDOT projects, CRP, CREP and RIM programs are unstable. A major issue in the industry is the narrowing of seed transfer zones, these are the maximum allowable distances from the site of seed origin to the site of use. The transfer zones specified in project requirements vary from wide, where any seed originating in Minnesota or adjoining states is acceptable, to very narrow, where seed must originate within 25 miles of intended restoration site. The current trend is toward specifying narrow transfer zones but this needs additional research. Narrow transfer zones are intended to ensure adaptation of plant materials to the restoration site and to maintain the diversity of ecotypes across the state. Unfortunately, the reality encountered is that narrow transfer zone seed is usually not available for most native species. While native seed producers would like to provide seed for these restoration projects, they must balance the demand for specific ecotypes with the realities of economic production.

2. Natives for Biomass Production. As biomass crops, native species have potential uses beyond their use for restoration projects. There is great economic potential for energy production with native biomass crops, particularly grasses. In 2007, researchers at the University of Minnesota found switchgrass (*Panicum virgatum*), prairie cordgrass (*Spartina pectinata*), and indiangrass (*Sorghasrum nutans*) to have biomass yields at least equal to that of corn. Developing technologies such as cellulosic ethanol production, biomass gasification, pelletized grass for burning, and biodiesel production all have the potential to create markets for native crops. In his State of the Union Address in 2007, President Bush proposed a mandate for 35 billion gallons of ethanol production by 2017. The majority of this would be provided by cellulosic ethanol production, for which native grasses are be well suited. Cellulosic ethanol production from native grasses has the potential for 16 times greater ethanol yield per acre than current fermentation methods. As technologies evolve for conversion

of biomass to energy, the native seed industry would like to be in a position to supply the appropriate seed to Minnesota growers.

3. New Products from Natives. Native species are potential sources for a wide range of unique oils, fibers, cosmetic and pharmacological compounds, possibly even herbs and spices. Natural plant derived products are in demand by the cosmetic and personal care industries as replacements for animal and synthetic ingredients. Identifying these potential products from the vast inventory of Minnesota natives would require much characterization research. University of Minnesota research measuring antioxidant levels in native species hints at the unique properties that may exist. Several Minnesota native species were found to have particularly high levels of antioxidant activity. Highest activities were observed in butterfly weed (*Asclepias tuberosa*), fireweed (*Epilobium angustifolium*), prairie smoke (*Geum triflorum*), fowl manna grass (*Glyceria striata*), purple meadow rue (*Thalictrum asycarpum*), lead plant (*Amorpha canescens*), breadroot (*Pediomelum spp*.), and prairie blazing star (*Liatris spp*). These species showed antioxidant activities that were 5-9 times that of other high antioxidant seedstocks such as flaxseed meal. This research only scratches the surface but suggests the unexplored potential that may exist within native species.

Landscape Restoration Research. There is a need to determine appropriate seed transfer zones for ensuring successful prairie restorations. We would like to see research evaluating the establishment of prairie restorations using seed originating from narrow, intermediate, and wide transfer zones. Research is also needed to develop improved seed production practices for identity-preserved native plant ecotypes. More information is needed on weed control options for the widely varied species in production. Current information is very limited and needs to be expanded for purposes of production as well as for establishment of restoration plantings.

Bioenergy Research. Research is needed in biomass production, harvest, and handling for a range of Minnesota natives. We need research and development of more efficient cellulose hydrolysis enzymes and fermentation enzymes to increase cellulosic ethanol production. We would also hope to see in the near future cellulosic biomass demonstration and production facilities.

Research for Native Plant Products. The wide array of Minnesota native species need to be characterized for economically valuable constituents for pharmaceutical, cosmetic and other potential uses.

Benefits of Natives as a Third Crop in Minnesota. The perennial growth habit of native crops offers vast improvement in soil stability and water quality relative to row crop production. By their adaptation to Minnesota's climate and soil conditions, native species are productive at lower levels of input of fertilizers and energy. The environmental, recreational, wildlife, and scenic benefits of increasing natives in Minnesota are clear. The introduction of new technologies such as cellulosic ethanol generation would have direct economic benefit by increasing markets for producers and creating new jobs in rural Minnesota. If properly utilized, we believe that natives can be an economically important third crop for Minnesota.

Cover Crop Germplasm Development for Minnesota Cropping Systems

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The annual corn-soybean crop rotation that covers nearly 90% of the southern Minnesota landscape yields grain for human consumption, livestock feed, and most recently ethanol and biodiesel. While this bountiful rotation has contributed greatly to the affluence of our society, it requires high inputs of nutrients and energy. In addition, this rotation has several variable costs relating to soil loss, water degradation, and environmental protection that are typically not counted against net profits.

Winter cover crops lengthen the "green" phase of a corn/soybean cropping system by growing in the months between harvest and planting. Many species can be used as cover crops, but in Minnesota and the Upper Midwest, winter cereal grains, legumes, and forage grasses are most common, as their cold tolerance and winter hardiness are desirable. Cover crops are a useful management tool for enhancing the sustainability of agroecosystems and reducing negative environmental impacts in the corn and soybean systems. Cover crops grown following fall harvest of the annual crop have potential to decrease soil erosion, to provide green manure for incorporation, and to produce forage or grain for harvest. Cover crops improve agroecosystem functioning by recycling nutrients, improving soil structure, increasing soil organic matter, supporting soil organisms, and suppressing weeds, nematodes, and pathogens.

Cover crops play a unique role in remediation of excess soil nitrogen problems that can damage water quality. They reduce nitrate leaching by taking up nitrate from the soil and storing it in plant material. Additionally, the water and nitrate uptake of cover crops grown in the late fall and in early spring coincides with the time of the year when substantial amounts of nitrogen leach through the soil.

Improved erosion control is one of the main benefits of using winter cover crops. The use of cover crops for erosion control is based on the principle of increasing infiltration by improving soil structure, providing continuous ground cover to protect the soil against raindrop impact, and reducing the velocity and carrying capacity of overland flow. Increased infiltration results in lower runoff volumes and flow rates. This reduces the sediment transport and detachment capacity of runoff.

Winter cover cropping has been identified as a critical approach to diversify annual crop rotations. Unfortunately, there are currently a limited number of viable cover crop alternatives for the upper Midwest and all have limitations to their usefulness because all current cover crops have been adapted from grain or forage harvest systems. There are no cover crop breeding programs in the Midwest that have a specific goal of developing varieties with new traits to increase their value as cover crops. In the Midwest, winter rye and hairy vetch are currently used as cover crops. Austrian winter pea is widely grown as a green manure crop in the Pacific

Northwest and has great potential in the Upper Midwest as a winter cover and spring legume grain crop.

Winter Rye Background: Historically, rye has been grown for grain but today less than half of the rye grown in the United States is harvested for grain; the majority is grown as a cover crop. Rye is an excellent winter cover crop especially in the northern Midwest because of its winter hardiness, ability to scavenge nitrogen and sequester carbon, extensive root system to prevent erosion, and ability to provide quick and effective ground cover in the fall. It is the only small grain with sufficient winter hardiness to reliably overwinter and also has vigorous early spring growth. In addition, rye plant tissue contains several chemicals that upon decomposition suppress the growth of weeds. The specific objectives for the winter rye cover crop breeding program are to identify winter rye germplasm and develop varieties that 1) flower earlier in the spring to allow earlier grain seeding, and 2) have increased early season biomass (by May 15) compared to common winter rye varieties grown in Minnesota.

Hairy vetch background: Hairy vetch is a cool season annual or biennial legume used for cover cropping, green manure, forage and erosion control. It is unique in that it is the only legume that can be fall-seeded and that has potential for over-wintering to maturity in colder regions of the Upper Midwest. The benefits of growing hairy vetch as a winter cover crop include decreased soil erosion, weed suppression, reduced nutrient loss, soil structure improvement, attraction of beneficial insects, carbon sequestration, and contribution of nitrogen through biological nitrogen fixation. Because of these valuable traits, this legume has become an increasingly important cover crop in sustainable and organic systems. Hairy vetch is more drought tolerant than other vetches, and it scavenges phosphorous. As a cover crop, hairy vetch provides heavy mulch, which helps prevent soil erosion. A plant breeding program will be initiated in hairy vetch for use as a cover crop. The initial objectives of the breeding program will be to develop hairy vetch germplasm with 1) increased winter hardiness, and 2) earlier maturity. Secondarily, long term breeding objectives will include seed yield, seed size, lack of hard seed, and improved nitrogen fixation.

Winter Pea Background: Winter pea has potential for dual use as a winter cover crop and as a food crop but currently the crop is not adapted as a winter annual to the Midwest. Austrian winter peas, often referred to as 'black peas', have been produced in the inland Pacific Northwest as a green manure and for mature dry seed production since the 1930s. The USDA-ARS Grain Legume Genetics and Physiology Research Unit at Pullman has been developing improved breeding lines with greater winter hardiness for several years. In the early 1990s crosses were made between high quality, highly adapted traditional spring pea types and available Austrian winter peas. Selection within segregating bulk populations has yielded several winter hardy, white-flowered breeding lines with winter hardiness comparable to the Austrian winter pea. Two white flowered, winter feed peas, 'Specter' and 'Windham', were released in 2005 and 2006, respectively. Many characteristics of the Austrian winter pea are undesirable for human consumption including small seed size and pigmentation in the seed coat. More recent selections are approaching edible food quality. The specific objectives for a winter pea breeding program involve identifying winter pea germplasm that 1) has sufficient winter hardiness to survive winter conditions in the Upper Midwest, 2) have increased biomass production, 3) nodulate and have a high potential to fix atmospheric nitrogen in the fall and/or early spring, and 4) have short season duration to allow double cropping of corn or soybean after pea seed harvest.

3rd Crops - Woody Perennials for Biomass and Environmental Services

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Potential for use in a multifunctional agricultural system: The incorporation of woody crops and agroforestry systems (systems which combine agricultural crops and woody species) into Minnesota farming systems has the potential to produce biomass for renewable energy and high-value bio-based products, improve economic vitality in rural communities while achieving broader public goals of clean water, reduced soil erosion and carbon sequestration. In order to take advantage of that potential, research is needed which will allow us to ensure a consistent supply of biomass at a reasonable price from well placed plantings of biomass crops that are productive but also that provide needed environmental/ecosystem services.

Woody perennials can and have been used in: 1) biomass for energy production systems; 2) riparian buffers which protect our surface waters and stabilize stream banks avoiding erosion and taking up agrochemicals before they enter water courses; and 3) windbreaks that protect croplands from erosion and lower heating costs and energy use on farms and homesteads. When it is possible to combine bio-fuel production with high value bio-based products the whole production system becomes more profitable and robust. In addition woody biomass production provides two carbon sequestration benefits: 1) growing biomass and the residual stock following partial harvest store carbon as carbon builds up in the soil; and 2) if used for bio-fuels, renewable biomass fuels substitute for fossil fuels thus avoiding net emissions of carbon into the atmosphere.

These multiple benefits will be most readily obtained from an integrated biomass production system based on perennial crops planted in strategic areas of the landscape close to local and regional processing centers. Research is needed to develop reliable high productivity germplasm to support a comprehensive eco-industrial system that integrates perennial crop production, processing and conversion technologies to create diverse high-value products, and supports the use of low-value residuals for energy production in concert with other renewable energy sources.

Economic potential: The economic prospects for woody perennial systems are improving as the technology for cellulosic energy progresses. The Central Minnesota Ethanol Cooperative (CMEC) in Little Falls, Minnesota has signed a letter of intent with SunOpta BioProcess Inc. to develop a 10 million gallon a year cellulosic ethanol facility adjacent to their current corn based ethanol plant. That plant will provide a market for and depend upon woody biomass as the feedstock for their ethanol production

Parallel to the development of the cellulosic ethanol facilities in Minnesota are the current facilities that have switched from natural gas to biomass including CMEC in Little Falls, Rahr Malting in Shakopee which just broke ground on their biomass boiler and the Virginia and Hibbing Public Utilities in Northern Minnesota that are starting to burn biomass to meet local energy demand. There is a need to ensure that these new initiatives to develop renewable energy options have sufficient woody feedstocks available at a reasonable cost to be able to meet the State's Renewable Energy Mandate.

Current status of promising woody perennials: Hybrid poplar production has enjoyed a rich history of production research and genetic improvement over the past several decades. However, most of the genetic improvement work has targeted paper/timber production in northern Minnesota. Recently, there has been an effort to expand the genetic improvement program to include southern Minnesota with a focus on biomass production for energy. UofM agronomists and foresters (NRRI group) are collaborating on several field trials to evaluate new genetic lines of poplar in southern Minnesota. Hybrid willow is just now being established in Minnesota as a raw product for the bioenergy sector. Most of the work for willow in the U.S. is being done at SUNY in Syracuse, NY. Genotype performance is often location specific with hybrid willow clones requiring a more regional approach to clone evaluation. The UofM is collaborating with SUNY Syracuse to conduct trials across Minnesota to evaluate genetic performance of willow clones from New York. Efforts are currently underway to begin introducing native willow genetics into highly productive hybrid clones. This will allow production of willows that are more resilient and productive in the long run. The UofM is also working to develop production strategies that fit with the soils and climate of Minnesota as well as reducing establishment costs associated with willow production to increase overall profitability.

This coming spring and summer, trials of native and introduced alders, hybrid and native willow and hybrid poplar will be initiated at several locations across the state including mine sites to evaluate productivity and initiate the development of superior germplasm for biomass production. Alders, a native species, hold great promise for biomass production. All of the alder species are relatively fast growing, capable of growing in water saturated soils, and establish symbiotic relationships with nitrogen-fixing soil bacteria that allow for the conversion of atmospheric nitrogen to a plant-usable form. These characteristics make alders a plant that can grow in wet and/or nutrient poor sites that are not agriculturally productive. Developing these alder species into productive biomass crops, will alleviate some of the pressure to convert food production acreage to energy production acreage. In the next four years the University of Minnesota will be evaluating fourteen alder species in comparison with some more well-characterized willow, poplar, and hybrid aspen germplasm in six different Minnesota environments for winter-hardiness, growth rate, resistance to diseases and insects, wood composition, and yield of fermentable sugars. This initial evaluation will lay the groundwork for a long term germplasm development effort to be led by University researchers.

Research and development needs: In order for third crops to become economically sustainable, we need to be able to provide industry with custom-grown feedstock that meets very specific requirements set by a given end use (e.g. lower lignin content to improve conversion efficiency, longer fiber length for composite materials). By providing a custom-grown product, farmers and industrial partners will both benefit. Other uses such as extracting natural plant chemicals and increasing carbon storage should also be considered. Support is needed to conduct research that considers woody crops as: 1) a feedstock for multiple and highly valued products and 2) a potential solution for sensitive environmental and ecological issues. A site-specific approach to biomass crop placement is paramount. We hope to develop knowledge-based decision tools that can be used by farmers and other land managers to design cropping systems that meet market demands for food, fiber, and biomass, address critical environment issues (water quality, soil stabilization, carbon sequestration, and wildlife), and optimize profitability (multiple high value profit centers). We believe that industry will provide even greater efficiencies by creating small regional processing centers that take advantage of unique feedstock characteristic inherent in a given region thereby increasing efficiency and diversifying industry presence across the state.

Key to the success of these efforts will be a robust program of woody germplasm development and improvement to guarantee highly productive planting material adapted to diverse Minnesota conditions with the specific characteristics that industry requires.

Perennial Grains Development Initiative: Perennial Sunflower and Perennial Flax Potential 3rd Crops

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This project aims to bring perennial grain crops into agricultural systems to allow farmers to diversify their operations, improve profits, improve environmental quality, and reduce inputs of labor and supplies. Existing perennial crops, such as alfalfa, protect against soil erosion and nutrient loss and improve water use efficiency. Fall tillage is not necessary during the multi-year lifetime of the crop stand. Perennial crops provide living ground cover for longer periods during the year than annual crops because the plants can emerge from dormancy early in the growing season and are in many cases less susceptible to fall frosts. During this extended growing season, plants take up soil moisture, which decreases year-round drainage line flow and loss of nitrogen, a vital plant nutrient, from the soil. Nitrogen from tile drainage contributes to the pollution of surface waters in Minnesota.

We propose to perennialize sunflower and flax through crosses with related species or direct improvement of related perennial species. These crops have valuable seed oils that make them profitable for farmers to grow. In particular, sunflower has high-oleic and mid-oleic (also known as NuSun®) oil profiles, which are important seed oil profiles for the production of no-trans-fat vegetable oil. For the last several years, demand for NuSun oil has exceeded supply. This demand is mostly from processed food manufacturers such as Frito Lay. Flax oil is also in demand as a health supplement, and has one of the highest concentrations of Omega-3 oils found in plants. Consumption of Omega-3 oils has been linked to improved heart health. Additionally, the black-and-white seeded sunflowers are grown for the production of snack-type sunflower seeds. This is a particularly high-value market.

Perennialization of sunflower, in particular, was proposed by scientists as early as the 1930s. The reason is that perennial sunflowers cross easily and naturally with crop-type sunflower. Over the years, our knowledge of these perennial sunflowers has increased, due to world-wide interest in both the perennial sunflowers and their domesticated, crop-type relatives. Scientists have used the perennial species to introduce disease resistance into sunflower. This has led to white mold resistant sunflowers that are now common in the USA.

To begin our work, we collected perennial sunflowers in 2001 from the UMore Park, Rosemount, MN. These sunflowers were transplanted to the St. Paul Agricultural Experiment Station, where they continue to live as a permanent collection. In the years that followed, we crossed these perennial sunflowers with high-oleic oilseed sunflower lines, which were contributed from the Sunflower Unit of the USDA-ARS, Northern Crop Science Laboratory, Fargo, ND. The seed obtained from these crosses produced plants that were all perennial. Scientists who have previously studied these crosses have also observed that these crosses are perennial, but if these plants are used in additional crosses with annual, oilseed sunflower (known as "backcrossing"); you immediately lose the perennial habit. Backcrossing is used in our work to bring yield, oil quality, and all of the desirable traits from the crop-type, oilseed sunflower while introducing only the perennial habit from the perennial sunflower parent. We attempted backcrossing on our breeding material, and also lost the perennial habit. This indicates that our backcrossing procedure severely limited the genetic contribution of the perennial parent. The next step was to change our crossing methods in such a way that we can obtain perennial sunflowers after backcrossing. In 2006, we developed a technique that allowed us to obtain 8 different perennial plants that were a product of backcrossing. These had an appearance that was more similar to the crop-type annual than the non-crop-type perennial. This indicates that backcrossing can lead to perennial sunflower, unlike the results of many other scientists. In addition, new genomic information is now available for both the crop-type sunflower and the non-crop perennial sunflower. With the assistance of Professor Bob Stupar in the Department of Agronomy and Plant Genetics, we hope to add to this existing database with additional genetic information. This information will potentially allow us to determine which genes are "turned on" in perennial plants, and "turned off" in annual plants, leading eventually to the formation of genetic markers for marker-assisted breeding. Marker assisted breeding is a relatively new approach that improves efficiency in the breeding process. We believe that continued plant breeding work in these populations will lead to perennial sunflowers with even better field performance, with the eventual goal of releasing varieties of perennial sunflower from the Minnesota Agricultural Experiment Station to Minnesota farmers.

Perennial flax is a newer idea, and plant breeders and agroecologists from the University of Minnesota remain at the forefront in this area. There are numerous flax species, most perennial, some annual. The perennial flax species that have the most similarity to the annual, crop-type

flax are very dissimilar to the crop-type flax at the genomic level. This prohibits us from taking a similar approach in flax as we have done in sunflower. Fortunately, the perennial flax species tend to have Omega-3 oil content similar to that of the crop-type flax, indicating that little improvement of oil quality is needed. These plants also produce many seeds per plant, more than a comparable annual plant; however, the seeds are smaller. The goal of this breeding program is to develop populations with a broad genetic base in order to breed for perennial flax with larger seed, high yield, and better agronomic quality. Currently, we are working on two different populations, a large-seeded population and a broad-based population containing parent material from a large number of plant introductions from the USDA plant introduction centers. These populations have undergone selection for rapid germination, and the newest plants of these populations will be evaluated under field conditions beginning this year. This will be the first time that a breeding program in perennial flax has produced field plots for evaluation. These plots will be made available for public observation at selected state Agricultural Experiment Stations. Future effort in this area will continue to focus on improving the existing flax populations, perhaps eventually including marker-assisted selection after we learn more about the genetics of the crop. The end goal is to produce perennial flax varieties that will be made available to the public from the Minnesota Agricultural Experiment Station.