



PROJECT TITLE: Developing Forever Green Crops for Minnesota's Agricultural Landscapes

I. PROJECT STATEMENT

There is an urgent need to develop new crops that farmers can plant on environmentally sensitive areas of Minnesota's agricultural landscape and that will provide effective long-term solutions to nonpoint source pollution problems associated with current annual crop based agricultural systems. These "working agricultural landscapes" will provide economic return to the farm family and environmental benefits to Minnesota.

Major agricultural regions of Minnesota are dominated by annual cropping systems, comprised mainly of corn, soybean and spring wheat, that are unable to provide adequate ecological services to meet local and state water quality goals; protect sensitive aquifer recharge areas; manage excessive water flow at critical times; and maintain biodiversity to support wildlife including pollinators. By selectively adding winter-annual and perennial crops to our agricultural landscapes, we will be able to enhance the prosperity of Minnesota agriculture, support rural communities, and provide major environmental benefits to all Minnesotans. All of these benefits are possible because perennial and winter-annual crops provide a continuous living cover during a large portion of each year, including periods of the fall, winter and spring when summer annual crops are absent and landscapes are brown and barren. For this reason, perennial and winter-annual crops—working in tandem with summer annuals—can capture solar energy, water and nutrients with very high efficiency.

The University of Minnesota played a key role in developing the annual crops like corn, soybean, and spring wheat that currently cover large portions of Minnesota's agricultural landscape. Now, the University is well positioned to develop the next generation of winter annual and perennial crops for Minnesota's future agricultural landscapes. These perennial and winter annual crops will have powerful capacities to provide ecological services and conserve resources, while also producing marketable agricultural commodities since these services will be provided without taking land out of production.

We are proposing that LCCMR funds be used to accelerate three new crop development programs that focus on the development of crops that have the capacity to provide environmental services as well as economic return for producers. These crops are intermediate wheatgrass, field pennycress, and perennial sunflower.

II. DESCRIPTION OF PROJECT ACTIVITIES

ACTIVITY 1: Domesticate intermediate wheatgrass (*Thinopyrum intermedium*) for grain, forage and biofuel production and ecosystem services. Budget: \$ 412,000

The goal of this activity is to develop intermediate wheatgrass as a perennial grain and biomass crop and to enhance grain quality for food products through plant breeding and genetics. As a perennial crop, intermediate wheatgrass not only provides ecosystem services (water quality and wildlife habitat), but it also has many desirable agronomic traits such as large seed size, easily threshed grain, and disease resistance. We have initiated a breeding program to accelerate the development of intermediate wheatgrass for grain and biomass production on Minnesota's agricultural landscapes. In this project, standard breeding methods will be complemented by new genomic technologies to make rapid improvements in intermediate wheatgrass seed size, grain quality, and grain and biomass yield. This project will allow us to build on our ongoing domestication research to rapidly develop intermediate wheatgrass lines that are efficient producers of grain and biomass and are adapted to Minnesota conditions.

Outcome	Completion Date
1-1. Evaluate the grain and biomass yield, and ecosystem services of 50 intermediate wheatgrass germplasm lines at 5 locations in Minnesota.	Spring 2016
1-2. Select and develop 20 intermediate wheatgrass lines with large seed size, high grain and herbage biomass yields using modern genomics and plant breeding approaches.	Spring 2017
1-3. Develop and use a genetic map to identify genetic factors controlling seed size and food quality traits of intermediate wheatgrass to support the breeding program.	Spring 2017
1-4. Identify the grain quality traits of intermediate wheatgrass that will support the development of intermediate wheatgrass grain for use in traditional cereal food products.	Spring 2017



Environment and Natural Resources Trust Fund (ENRTF)

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ACTIVITY 2: Domestication of field pennycress: A new winter annual oil seed crop for use as a double crop/cover crop in the corn/soybean rotation **Budget: \$ 213,900**

We have initiated a breeding program to develop field pennycress (*Thlaspi arvense* L), a winter annual dicot, that is adapted to Minnesota and throughout a large portion of the Midwest that can be grown as a cover crop, and harvested as an oil seed crop, during the period of time between corn harvest and the planting of soybean in late May. The planting of this oil seed crop will allow farmers to continue to grow corn and soybean in the traditional way while adding a new crop/cover crop that provides a continuous living cover that will also increase the profitability and environmental profile of the corn/soybean rotation. As a winter cover crop, field pennycress will control spring annual weeds and thereby reduce herbicide use, contribute to building soil health; prevent soil erosion, reduce nutrient runoff, and lower nitrate-N leaching thereby reducing the downstream impact of the corn and soybean rotation in Minnesota and throughout the Midwest. The addition of pennycress as a high value oil seed crop grown between corn harvest and soybean planting will not compete with food crops for land use.

Outcome	Completion Date
2-1 Identify 20 ideal parental materials for use in the development of pennycress breeding lines.	Spring 2016
2-2 Develop a genetic map and identify genetic factors important for pennycress domestication.	Spring 2016
2-3 Select 25 pennycress lines that are high yielding have high oil content, and early maturity.	Spring 2017
2-4 Identify 5 pennycress lines, to be increased and made available to farmers, that have ideal seed composition, are high yielding and have good agronomic characteristics, and produce ecosystem services, will be evaluated at 5 Minnesota sites.	Spring 2017

ACTIVITY 3: Develop a perennial sunflower with high oil production potential. **Budget: \$ 222,000**

We have initiated a breeding program to develop a perennial sunflower crop by crossing traits for perennial habit from *Helianthus tuberosus* L. into domesticated sunflower (*Helianthus annuus* L). The combination of perennial habitat from *H. tuberosus* with the marketability and agronomic characteristics of domesticated sunflower will result in a high-value perennial crop that will also provide many ecosystem services to Minnesota landscapes including water quality, and bee and wildlife habitat. The new perennial sunflower will be a new source of high-oleic oil that is in high demand in the food industry, and a source of biodiesel.

Outcome	Completion Date
3-1. Identify the genetic factors that control tuber formation and winter hardiness in the sunflower hybrids resulting from crosses between <i>Helianthus annuus</i> and <i>H. tuberosus</i> .	Spring 2017
3-2. Determine the nutrient and energy allocation that will support biomass and seed production in perennial sunflower.	Spring 2017
3-3. Characterize the performance of 10 selected perennial sunflower lines for seed yield and oil production and quality, and ecosystem services when grown in 5 Minnesota environments.	Spring 2017

III. PROJECT STRATEGY

A. Project Team/Partners Craig Sheaffer, U of Mn,(F) germplasm evaluation, Gregg Johnson, U of MN, (F) germplasm evaluation, Jim Anderson, U of Mn,(F) intermediate wheatgrass breeding, Xiaofei Zhang, U of M, (F) intermediate wheatgrass breeding Lee DeHaan, Land Institute,(NF) germplasm resource, Pam Ismail, U of Mn,(F) food science, Peter Morrell, U of Mn,(F) plant domestication, Bob Stupar, U of Mn,(F) plant genetics, Brent Hulke, USDA-ARS,(NF) sunflower genetics, Mikey Kantar, U of Mn, (F) sunflower breeding, Kayla Altendorf, (F) pennycress breeding, David Marks, (F) plant genetics, Ray Norrgard, DNR,(NF) Wetland Wildlife Leader, DNR,

B. Timeline Requirements This request is for three years of funding which will provide the support necessary to develop the intermediate activities required for the development of a viable plant breeding program for the three species. However, additional support will be necessary from LCCMR for an additional 6 years to give each project enough time to develop and release perennial crop varieties adapted to Minnesota conditions.

C. Long-Term Strategy and Future Funding Needs We will leverage the LCCMR funding to obtain additional long-term funding from private, federal and U of Mn sources to expand the crop development effort. As part of a long-term funding strategy we will focus on USDA climate change, renewable fuel, water quality, and healthy foods programs to support the plant breeding effort.

2014 Detailed Project Budget

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IV. TOTAL ENRTF REQUEST BUDGET 3 years

<u>BUDGET ITEM</u>	<u>AMOUNT</u>
Personnel:	
Graduate Assistantship, perennial sunflower, full time, 3 yrs \$40,000/yr	\$120,000
Two undergraduate students, perennial sunflower, part time 3 yrs x 2 x \$10.00/hr x 350 hr	\$21,000
Post doctoral plant breeder, intermediate wheatgrass, full time 3 yrs x \$60,000	\$180,000
Graduate Assistantship, intermediate wheatgrass, full time 3 yrs x \$40,000	\$120,000
Two undergraduate students, intermediate wheatgrass, part time for 3 yrs x 2 x \$10 x 350 hr/yr	\$21,000
Graduate Assistantship, pennycress, full time, 3yr x \$40,000	\$120,000
Two undergraduate students, pennycress, part time 3 yrs x 2 x \$10 x 350 hr/yr	\$21,000
Contracts:	\$0
Equipment/Tools/Supplies:	
Perennial sunflower field supplies (stakes, bags, etc.) \$2,000/yr	\$6,000
Intermediate wheatgrass, field supplies (stakes, bages, etc.) \$2,000/yr	\$6,000
Pennycress field supplies, (bags/stakes, etc.) \$2,000/yr	\$6,000
Pennycress, green house supplies \$2,000/yr	\$6,000
Acquisition (Fee Title or Permanent Easements):	\$0
Travel:	
Travel between research sites within the state per 3yrs x 10,000mi/yr x \$0.53	\$15,900
Additional Budget Items:	
Perennial sunflower genotyping (300 genotypes x \$150/genotype)\$22,500 yr2&3	\$45,000
Perennial sunflower seed analysis (oil/ protien) 1,500 samples x \$20/sample \$15,000 yr2&3	\$30,000
Intermediate wheatgrass, genotyping (300 genotypes x \$150/genotype \$22,500 yr2&3	\$45,000
Intermediate wheatgrass, baking quality analysis-protein & amino analysis 400 samples \$30/sample; mixing & processing baking tests 100 samples \$120/sample \$12,000 yr2&3	\$24,000
Intermediate wheatgrass, forage quality (160 samples/site x 5 sites x\$10/sample) yr2&3	\$16,000
Pennycress, seed analysis (oil/protein) (1,500 samples x \$20/sample) \$15,000 yr2&3	\$30,000
Pennycress diversity analysis (100 genotypes x \$150/genotype) \$7500 yr2&3	\$15,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND \$ REQUEST =	\$847,900

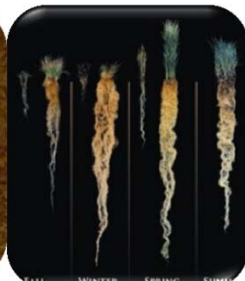
V. OTHER FUNDS

<u>SOURCE OF FUNDS</u>	<u>AMOUNT</u>	<u>STATUS</u>
Other Non-State funds: Integrated Program For Winter Annual Oilseed Production And Processing, USDA-NIFA	\$10,000,000	<i>Pending</i>
Other State \$ Being Applied to Project During Project Period:	\$0	
In-kind Services During Project Period:	\$0	
Remaining \$ from Current ENRTF Appropriation (if applicable):	\$0	
Funding History: Domestication of Field Pennycress: A new short season oil seed crop for use as a double crop/cover crop in the corn/soybean rotation; Development of Perennial Sunflower: A perennial oil seed crop for production of food, fuel and ecosystem services, Funding U of MN Experiment; Developing Intermediate Wheatgrass as a Grain and Biomass Crop, IonE Large Grant, University of Minnesota	\$300,000 3 yrs; \$695,000	U of Mn Agriculture Experiment Station & IonE

Figure 1. The Forever Green winter annual and perennial crops developed by the University of Minnesota will be evaluated for ecosystem services in the major ecoregions of MN. We anticipate that within 10 years we will be able to achieve adoption of these new crops on over 500,000 acres across MN. The new crops will provide new environmental and economic opportunities for Minnesota farmers and land managers.



Perennial sunflower lines will be evaluated for eco-system services in 5 MN ecoregions.



Intermediate wheatgrass lines will be evaluated for ecosystem services in 5 MN ecoregions.



Winter annual pennycress lines will be evaluated ecosystem services in 5 MN ecoregions.

BIOGRAPHICAL SKETCH

DONALD L. WYSE

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EDUCATIONAL HISTORY

The Ohio State University, 1970, B.S., Agronomy
Michigan State University, 1972, M.S., Crop Science (Weed Science)
Michigan State University, 1974, Ph.D., Crop Science (Weed Science)

PROFESSIONAL POSITIONS

Founding Director, Minnesota Institute for Sustainable Agriculture, Univ. of Minnesota, 1992-2000
Co-director, Center for Integrated Natural Resources and Agricultural Management, 1995-present
Professor, Dept. of Agronomy and Plant Genetics, University of Minnesota, 1986-present
Associate Professor, Dept. of Agronomy/Plant Genetics, University of Minnesota, 1980-1986
Assistant Professor, Dept. of Agronomy and Plant Genetics, University of Minnesota, 1974-1980

RESEARCH AND MANAGEMENT EXPERIENCE

Donald Wyse is a Professor in the Department of Agronomy and Plant Genetics at the University of Minnesota, St. Paul, where he teaches and conducts research in weed management, cropping system development, and plant breeding and selection. His research concentrates on biological weed management, development of multifunctional agricultural systems, perennial crop breeding, and legume and grass seed production systems. He has focused his research efforts on the development of perennial cropping systems, cover crop systems, biomass prairie polycultures, and has studied their impact on soil and water quality. He has lead several multi-disciplinary research teams composed of university faculty and scientists from both state and federal agencies. He has experience in managing large multi-year grants. Dr. Wyse was the founding Director of the Minnesota Institute for Sustainable Agriculture and currently serves as Co-director of the Center for Integrated Natural Resources and Agricultural Management at the University of Minnesota. Recent activities of the Center have led to the development of the Mississippi River—Green Land, Blue Water Initiative that includes universities, state and federal agencies, and NGO's that have organized to deal with the landscape issues that impact water quality in the Mississippi River and Great Lakes Basin. He was one of the founding organizers of the Midwest Cover Crops Council and is an active member of the Executive Committee.

SELECTED PUBLICATIONS

Giltzer, P., A. C., Martin, M. Kantar, K. Kauppi, S. Dahlberg, D. Lis, J. Kurle, C. Sheaffer, and D. Wyse. 2012. Optimization of screening of native and naturalized plants from Minnesota for antimicrobial activity. *J. Medicinal Plants Res*, 66: 938-949

Giltzer, P. A., D.L. Wyse, C. C. Sheaffer, S. J. Taff, and C. C. Lehman. 2012. Biomass production potential of grasslands on the oak savanna region of Minnesota, USA. *Bioenergy Research* Doi 10.1007/s 12155-012-9233-z

Kantar, M., K. Betts, B. S. Hulke, R. M. Stupar, and D. Wyse. 2012. Breaking tuber dormancy in *Helianthus tuberosus* and interspecific hybrids of *Helianthus annuus* X *Helianthus tuberosus*. *Hort. Science* 47(9): 1342-1346.

Jordan, N.R., D.L. Wyse, B. Colombo. 2012. Linking agricultural bioscience to cross-sector Innovation: A new graduate curriculum. *Crop Science* 52:2423-2431 doi: 10.2135/cropsci 2072.01.0048