Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2016 Work Plan

Date of Report: January 27, 2016

Date of Next Status Update Report: January 1, 2017

Date of Work Plan Approval:

Project Completion Date: June 30, 2019

Does this submission include an amendment request? No

PROJECT TITLE: Measuring Pollen and Seed Dispersal for Prairie Fragment Connectivity

Project Manager: Lauren Sullivan

Organization: University of Minnesota

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Location: Clay County, Minnesota

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$556,000**
	Amount Spent:	**$0**
	Balance:	**$556,000**

Legal Citation: M.L. 2016, Chp. xx, Sec. xx, Subd. xx

Appropriation Language:

I. PROJECT TITLE: Measuring Pollen and Seed Dispersal for Prairie Fragment Connectivity

II. PROJECT STATEMENT:

WHY: Connections among habitat fragments are changing across Minnesota. These changes help some plant species while impairing others. Unfortunately, it is not always desirable species that benefit and undesirable species that are harmed. The **GOALS** of this project are to measure prairie plant connectivity to 1) promote the movement of desirable (e.g.: native) species by natural processes, or proper corridor creation, by 2) providing essential information about movement to the Minnesota Prairie Conservation Plan (MPCP).

This project will achieve the following **OUTCOMES:**

1. Measure the pollen and seed dispersal distances for 8 representative native Minnesota prairie species.
2. Determine connectivity of prairie fragments, which informs:
    a. Restoration practices for Minnesota conservation agencies.
    b. Decisions about the appropriate distances for sources of local-ecotype seed.
3. Provide conservation agencies and the MPCP with tools that they can use to determine the degree of habitat connectivity and the necessary size of corridors, to promote the spread of desirable species.

HOW: By measuring plant pollen and seed movement among habitat fragments, we can quantify habitat connectivity. This project will increase the success of the MPCP and other Minnesota restoration projects by understanding how well habitat corridors, and prairie fragments function to move species.

Background: Since 1908, Minnesota has lost 99% of its 18 million acres of remnant prairie. In addition to the overall loss in area, the prairie habitat has also become fragmented into increasingly smaller pieces. Prairie habitat can only persist as long as prairie plant and animal species are able to move among fragments, ensuring their connectivity. Having sufficient connectivity is important for maintaining important ecological and human services including habitat for pollinators and other wildlife, soil stability, water quality, and high quality land for hunting and other recreational activities. It is necessary to know how far plant species move by pollen or seeds, in order to critically evaluate how well Minnesota conservation projects connect prairie habitats.

Minnesota is currently investing large amounts of money and effort into prairie restorations and corridor creation, through the MPCP. However, this project was created by making assumptions of how far plants and animals move down corridors and between fragments. Since it is unknown how far plants move between restored areas, it is difficult to determine how successful these restoration projects will be. Our project will supply the MPCP and other conservation agencies with crucial movement information that can be immediately implemented by the MPCP to improve the quality of prairie corridors and other restorations across the state.

Premises and Hypothesis

I. **Maintaining plant connectivity between prairie fragments depends on how far species can disperse, and is essential for increasing both species and genetic diversity in fragments.**

Connectivity can in turn have a positive effect on other members of the prairie ecosystem, including pollinators and other wildlife.

II. **Determining how far plants disperse has been difficult in the past due to the difficulty tracking tiny pollen grains and seeds. However, with advances in sequencing techniques, it is now possible to use genetics to determine how far species are moving on a large subset of species. Dispersal distances must be measured in order to understand prairie fragment connectivity.**

III. **Plants have different dispersal syndromes, or ways their pollen and seeds disperse (e.g.: pollen and seeds disperse by wind, pollen disperses by animals and seeds disperse by wind, pollen disperses by wind and seeds disperse by animals, and both pollen and seed disperse by animals). We believe these syndromes will differ in how far their pollen and seeds disperse. The literature does not provide a comprehensive test of how these syndromes differ in their pollen and seed dispersal distances, and this must be measured.**

IV. **Landscape connectivity will depend on the dispersal ability of plant species. Animal pollinated species will disperse farther and therefore be more connected than wind pollinated species. Animal dispersed seeds are more connected than wind dispersed seeds. Finally, within the wind-dispersed seeds, traits such as height, terminal velocity, morphology are important drivers of connectivity.**

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of *January 1, 2017:*
Project Status as of *July 1, 2017:*
Project Status as of *January 1, 2018:*
Project Status as of *July 1, 2018:*
Project Status as of *January 1, 2019:*
Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Measure pollen and seed dispersal distances for native prairie species

Description: We propose to determine how far plants are moving by pollen and seed using a combination of DNA paternity analysis and GPS location data (See attached Figure). In this way, we can know how far related individuals are from each other. By aggregating all measured movement distances from each species, we can create both pollen and seed dispersal kernels for all of our target species. These kernels can be compared across dispersal syndromes to determine which types of species will move farther than others. For example, we can determine if species with animal pollination and animal-dispersed seeds move farther than animal pollination and wind-dispersed seeds.

Our work for Activity 1 takes place in Clay County, Minnesota. We chose this location as it contains large swaths of remnant prairie that have never been plowed. When determining the dispersal kernel of these species, we must be able to match parents and offspring. Thus, it is important to work in a prairie without human-caused seed additions because during a restoration many seeds

from unknown parental sources are seeded randomly at one time, making movement and paternity determination difficult. We are proposing to work within Bluestem Prairie, a remnant tallgrass prairie on the Lake Agassiz Beach Ridge (See attached Figure with map). We visited the site in early November 2015 to determine the likelihood of project success at the site, and determined it would be an ideal site.

The primary goal of Activity 1 is to create dispersal kernels for our 8 target species (Table 1) within a large, continuous remnant prairie in order to maximize our ability to detect long distance dispersal. In the first year (summer 2016) we will focus on four of our eight target species in order to refine our methodology, and finish collecting data from our remaining target species in the second year (summer 2017). Then, time and money permitting, we will sample near-by smaller remnant habitat fragments in order to detect connectivity between distant habitat patches, and to see if species' dispersal kernels are similar between large, continuous prairies and smaller, more fragmented prairies.

Species	Latin name	Dispersal syndrome
Prairie dropseed	*Sporobolus heterolepis*	**syndrome I** pollen: wind; seed: wind
Big bluestem	*Andropogon gerardii*	**syndrome I** pollen: wind; seed: wind
Blazing star	*Liatris aspera*	**syndrome III** pollen: animal; seed: wind
Sawtooth sunflower	*Helianthus grosseserratus*	**syndrome III** pollen: animal; seed: wind
Showy milkweed	*Asclepias speciosa*	**syndrome III** pollen: animal; seed: wind
Coneflower	*Echinacea angustifolia*	**syndrome III** pollen: animal; seed: wind
American licorice	*Glycyrrhiza lepidota*	**syndrome IV** pollen: animal; seed: animal
Prairie rose	*Rosa arkansana*	**syndrome IV** pollen: animal: seed: animal

Table 1: List of proposed target species we will focus on for this project and their dispersal syndromes.

In order to create our proposed dispersal kernels, we will be collecting leaf and pollen tissue and GPS location data from all individuals of our 8 target species within our sampling area at Bluestem Prairie. We will then run genetic paternity analysis on all of our samples to determine which individuals are most closely related to which other individuals. We then calculate the distance between each parent and offspring in a pair, to determine the distance that the offspring's seed must have traveled (seed dispersal distance), and combine all the seed dispersal distances for all individuals within each target species and calculate the probability of dispersing all possible dispersal distances for this species. This is the seed dispersal kernel. We use a similar method to calculate the pollen dispersal kernel. We match pollen that has landed on a mother plant to a father plant (the pollen's origin) using DNA parentage analysis. We calculate the distance between the father plant and the mother plant, to determine the distance that the father's pollen must have traveled (pollen dispersal distance). Again, we combine all the pollen dispersal distances for all individuals within each target species and calculate the probability of dispersing all possible dispersal distances, or the pollen dispersal kernel.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 426,500
Amount Spent: $ 0
Balance: $

Outcome	Completion Date
select sites and receive permits to sample	*July 2016*
collect tissue samples for first 4 target species	*November 2016*
extract DNA from first 4 target species	*June 2017*
send samples out for sequencing and receive genetic data	*November 2017*

run paternity analysis on first 4 target species	*January 2018*
create dispersal kernels for first 4 target species	*February 2018*
collect tissue samples for remaining 4 target species	*November 2017*
extract DNA from remaining 4 target species	*June 2018*
send samples out for sequencing and receive genetic data	*November 2018*
run paternity analysis on remaining 4 target species	*January 2019*
create dispersal kernels for remaining 4 target species	*February 2019*

Activity Status as of *January 1, 2017:*
Activity Status as of *July 1, 2017:*
Activity Status as of *January 1, 2018:*
Activity Status as of *July 1, 2018:*
Activity Status as of *January 1, 2019:*
Final Report Summary:

ACTIVITY 2: Determine connectivity of prairie fragments in NW Minnesota

Description: Once we know the dispersal kernels of our target species, we can determine the connectivity of the prairie fragments in Clay County for those species using connectivity network analysis. This connectivity work will span across remnant and restored prairies. We can then test our hypotheses that connectivity networks vary by dispersal syndrome and dispersal traits. We also have the ability to make estimates of dispersal kernels of non-target species that are similar to the targets, and determine connectivity of those species as well, to better characterize the community.

We will use the dispersal kernels measured in Activity 1 to parameterize network models that can inform Clay County of the connectivity of its grasslands. Within a defined region of Clay County, we will sample all of the grassland fragments for species richness. We will likely choose the area surrounding Bluestem Prairie where we are measuring the dispersal kernels, but the decision will ultimately depend on where we can utilize previously conducted fragment richness surveys. If previous sampling methods match our methods, we will use existing data instead of collecting the data ourselves.

During the 2016 and 2017 summer field seasons, we will survey the plant species richness of the prairie fragments in Clay County. We will also use GIS to spatially locate each of the prairie fragments. Then, combining these two datasets, we will create connectivity networks where we estimate how connected the prairie fragments are based on the species richness, the pollen and seed dispersal distance of each target species, and the distance of each fragment to each other. This information is useful for planning precision prairie restorations as we can determine locations where new restorations would greatly increase connectivity on the landscape.

We may also be able to generalize our connectivity results to a broader range of prairie plant species than just the 8 target species that we measure. If, in Activity 1, we find that species with different dispersal syndromes consistently have different dispersal kernels, we can infer that non-target prairie species with the same dispersal syndromes are likely to have similar dispersal kernels as the species we measured. Thus, we will potentially be able to infer connectivity for any prairie plant species, as long as we know how its seeds and pollen are dispersed.

Summary Budget Information for Activity 2: **ENRTF Budget:** **$ 128,000**

Amount Spent: **$ 0**
Balance: **$**

Outcome	Completion Date
determine which prairie fragments to survey in Clay Co.	*August 2016*
get permission to survey selected prairies	*September 2016*
begin richness surveys in downtime from sampling tissue	*November 2016*
complete richness surveys in downtime from sampling tissue	*November 2017*
determine connectivity for first 4 target species	*May 2018*
determine connectivity for remaining 4 target species	*March 2019*

Activity Status as of *January 1, 2017:*
Activity Status as of *July 1, 2017:*
Activity Status as of *January 1, 2018:*
Activity Status as of *July 1, 2018:*
Activity Status as of *January 1, 2019:*
Final Report Summary:

ACTIVITY 3: Directly inform the MPCP and create conservation connectivity tools
Description: In order to make this project as broadly useful as possible, we will create open-source, user-friendly models that federal and state agency members can use to determine habitat connectivity of many species. We will do this by extrapolating dispersal distance measured in Activity 1 to species that are similar (in terms of dispersal syndrome) to the target species. This information will then be shared specifically with the Minnesota Prairie Conservation Plan in order to provide plant movement information for future re-evaluations of the plan. This information will help determine how big corridors need to be, and how close fragments need to be, in order to maintain plant connectivity. We will make our models available to anyone in a conservation agency that has prairie plant survey data from multiple prairie fragments, and is interested in learning how to prioritize locations for prairie restorations. We will hold virtual workshops to help agency members learn how to use these tools to analyze the connectivity of their landscape. Private land owners interested in restoring prairie can also benefit from this tool and participate in workshops.

Summary Budget Information for Activity 3: **ENRTF Budget:** **$ 1,500**
Amount Spent: **$ 0**
Balance: **$**

Outcome	Completion Date
inform Minnesota Prairie Conservation Plan of dispersal distance information	*February 2019*
develop online tools for measuring habitat connectivity	*December 2018*
hold virtual workshops to train agency members, citizens, scholars, etc on how to use the virtual tools to determine connectivity of their own prairie fragments	*May & June 2019*

Activity Status as of *January 1, 2017:*
Activity Status as of *July 1, 2017:*
Activity Status as of *January 1, 2018:*
Activity Status as of *July 1, 2018:*

Activity Status as of *January 1, 2019:*
Final Report Summary:

V. DISSEMINATION:
Description:

Findings from Activities 1 and 2 will be published in peer-reviewed journals. Important findings from these Activities will be shared with parties involved in the project and land managers in Clay County. These bodies include but are not limited to: The Nature Conservancy, The Department of Natural Resources, Fish and Wildlife Services, and Minnesota State University Moorehead. The Minnesota Prairie Conservation Plan will be specifically targeted and all results will be shared and discussed with the founders of this plan.

The online tutorials and connectivity tools created in Activity 3 will be made publicly available to any private citizen, state or federal agency, non-profit, or scientific body interested in the results and methods. Online workshops will be open to any interested party. Contact information will be provided in case users run into snags when using the tools.

Status as of *January 1, 2017:*
Status as of *July 1, 2017:*
Status as of *January 1, 2018:*
Status as of *July 1, 2018:*
Status as of *January 1, 2019:*
Final Report Summary:

VI. PROJECT BUDGET SUMMARY:
A. ENRTF Budget Overview:

Budget Category	**$ Amount**	**Overview Explanation**
Personnel:	$ 383,000	**Full time positions** 1) Sullivan (postdoc - *82% salary, 18% benefits. 100% FTE for 3 years*) = $159,000 2) Civil Service Lab Assistant (*78% salary, 22% benefits.100% FTE for 2 years*) = *$81,580* 3) Civil Service Bioinformatition (*78% salary, 22% benefits. 100% FTE for 1 year*) = *$46,400* **Summer salary (one month)** 1) Shaw (assistant professor - *75% salary, 25% benefits. 8.333% FTE for 3 years*) = $36,800 2) Moeller (assistant professor - *75% salary, 25% benefits. 8.333% FTE for 3 years*) = $40,500 **Part time positions**

		1) 2 student assistants for 1 year and 1 student assistant for 1 year = *$13/hour * 40hr/week * 12 weeks * 3 years = $18,720*
Professional/Technical/Service Contracts:	$ 0	
Equipment/Tools/Supplies:	$ 5,500	**Field Supplies** Pin flags, coin envelopes, bar code reader for sample labeling, GPS rental, meter tapes, stake pins ($3000) **Lab/Computing Supplies** 96 well plates, chemicals for DNA extraction, scintillation vials, super computing hours for connectivity model ($1500) **Workshop Supplies** Name tags, folders, food, coffee ($1000)
Capital Expenditures over $5,000:	$ 0	
Fee Title Acquisition:	$ 0	
Easement Acquisition:	$ 0	
Professional Services for Acquisition:	$ 0	
Printing:	$ 500	Printing materials for workshops ($500)
Travel Expenses in MN:	$ 27,000	**In-state Travel** Car rental ($722.40/month * 2.5 months * 2 years = $3612) Per Diem ($46/day * 4.5 days per week * 12 weeks * 3 people = $7452) **In-state Lodging** Hotel rooms ($83/night * 4 nights/week * 12 weeks * 4 rooms (2 rooms per year) = $15936)
Other:	$ 140,000	Lab services for genotyping plant samples to determine paternity. *(8 species * 250 samples/species the first year, and 4 species * 200 samples/species the second year = 2800 samples * $50/sample = $140,000)*
TOTAL ENRTF BUDGET:	**$ 556,000**	

Explanation of Use of Classified Staff: N/A

Explanation of Capital Expenditures Greater Than $5,000: N/A

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 7.25

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 0

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
University of Minnesota	$ 289,120	$0	In-kind support: non-summer salaries of Shaw and Moeller, office space, lab space
Shaw startup	$1,428	$0	Two weeks of field work to set up the field sight and begin collecting data before July 1. The flowering season will begin before this date, so it will be necessary to begin before July 1 to get all the appropriate data. Funds include hotel room, per diem and car rental. Details are the same as above.
State			
None			
TOTAL OTHER FUNDS:	**$**	**$**	

VII. PROJECT STRATEGY:

A. Project Partners:

Funded Partners

Lauren Sullivan (Postdoctoral Researcher - UMN) will oversee project and conduct all research, Allison Shaw (Assistant Professor – UMN) will assist with modeling and determining connectivity, and David Moeller (Assistant Professor – UMN) will assist with genetic analysis.

Non-funded Partners

Greg Hoch (MN DNR) and Steve Chaplin (The Nature Conservancy (TNC)) will assist with site selection, promote workshops, and incorporate information gathered into the Minnesota Prairie Conservation Plan to make real change for Minnesota prairies.

We will have many non-funded partners in the Clay County area to broaden the scope of this project. We are working with Brian Wisenden and Tony Burmann at Minnesota State Moorehead (2015 LCCMR grant recipients) to discuss site selection, and outreach opportunities. We will work with them to hire undergraduate field assistants and provide these assistants with research opportunities through the University of Minnesota as well as Minnesota State. We will also provide reciprocal outreach by presenting our work through their outreach program funded by their LCCMR grant. We are working with Brian Winter at the Nature Conservancy, and Cindy Leuth at the Minnesota DNR to get the appropriate permissions to perform our work at the proposed site.

B. Project Impact and Long-term Strategy:

First, this project will provide important data that is now only possible because of cutting edge genetic sequencing technology. This will be the first set of information on the dispersal ability of a

suite of species that vary in their dispersal syndromes. This project will provide important conservation information that multiple federal agencies can incorporate into their prairie restoration programs. The connectivity information and ability to measure it will be useful, widely across the state. We have contacted the Minnesota DNR, the Board of Water and Soil Resources, and the Nature Conservancy, and they have indicated that they would be very interested in attending the trainings and that this project would provide important information that would be immediately useful to existing programs. This project is extremely timely because it will increase the success of the Minnesota Prairie Conservation Plan, and will be immediately implemented into its upcoming re-evaluation. This project complements an LCCMR proposal by Daniel Cariveau (UMN) titled "Data driven pollinator conservation" that also seeks to understand habitat connectivity and its importance for native pollinators. We will work with both Cariveau and Crystal Boyd to combine the outreach efforts of our LCCMR projects to bring information about plant movement and their insect pollinators to the general public.

This work will be long-lasting as information will be incorporated into the Minnesota Prairie Conservation Plan. It will also be pivotal for creating precision prairie conservation plans across the state that allow managers to target specific areas for restorations that will help increase prairie habitat connectivity across the state. We anticipate that the data collected in this project could provide the basis for future studies on the dispersal and connectivity of Minnesota prairie species. Where possible, we will seek out collaborations and apply for further funding sources to support this work into the future.

C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	$ Amount
none		$

VIII. FEE TITLE ACQUISITION/CONSERVATION EASEMENT/RESTORATION REQUIREMENTS:

A. Parcel List:

B. Acquisition/Restoration Information:

Fee Title Acquisition

NONE

Conservation Easement Acquisition

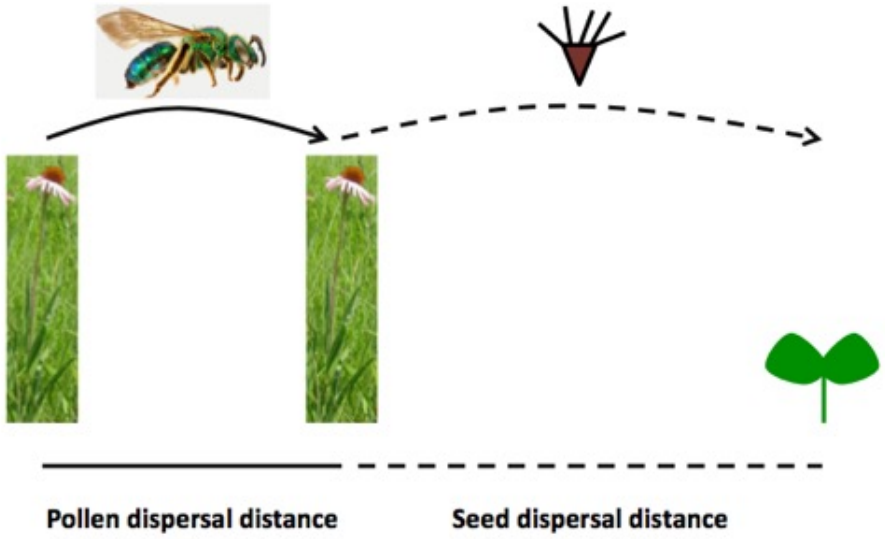
NONE

Restoration

NONE

IX. VISUAL COMPONENT or MAP(S):

How to measure pollen and seed dispersal distance



Research Area

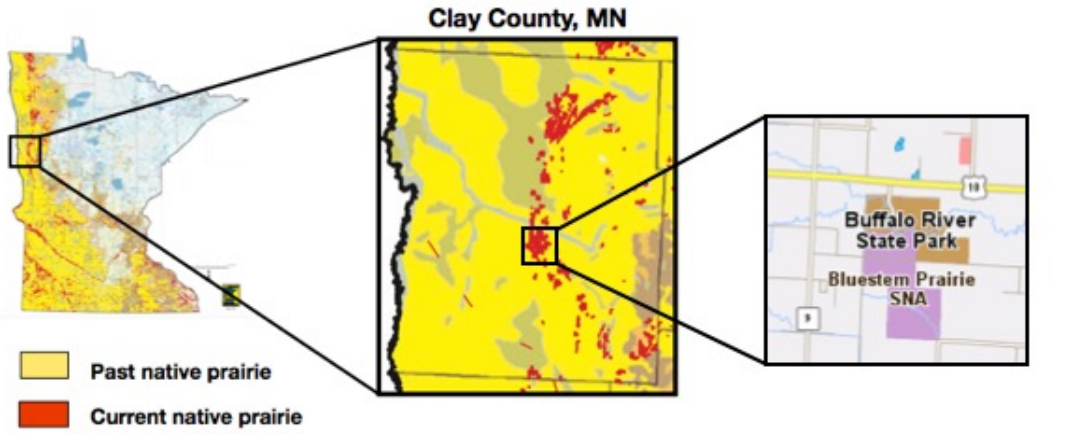


*Image from the Minnesota Prairie Conservation Plan

*image from the MN DNR website

X. RESEARCH ADDENDUM:
See attached at the end.

XI. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted no later than January 1 2017, July 1 2017, January 1 2018, July 1 2018, and January 1 2019. A final report and associated products will be submitted between June 30 and August 15, 2019.

Environment and Natural Resources Trust Fund
M.L. 2016 Project Budget

Project Title: Measuring Pollen and Seed Dispersal for Prairie Fragment Connectivity
Legal Citation: *Fill in your project's legal citation from the appropriation language - this will occur after the 2016 legislative session.*
Project Manager: *Lauren Sullivan*
Organization: University of Minnesota
M.L. 2016 ENRTF Appropriation: $ *556,000*
Project Length and Completion Date: 3 *Years, June 30, 2019*
Date of Report: January 27, 2016

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	***Measure pollen and seed dispersal distances for native prairie species***			***Determine connectivity of prairie fragments in NW Minnesota***			***Directly inform the MCPC and create conservation connectivity tools***				
Personnel (Wages and Benefits)	$244,674	$0	$244,674	$138,326	$0	$138,326	$0	$0	$0	$383,000	$383,000
Lauren Sullivan *UMN postdoc - supervise and participate in the research project full time. 82% salary, 18% benefits. 100% FTE for 3 years ($159,000)*											
Allison Shaw *UMN assistant professor - participate in sampling and develop connectivity models. 75% salary, 25% benefits. 8.333% FTE for 3 years ($36,800)*											
Dave Moeller *UMN assistant professor - participate in sampling and parentage analysis 75% salary, 25% benefits. 8.333% FTE for 3 years ($40,500)*											
*Student field assistants (3 total). 100% salary. 25% FTE for 3 years ($13/hour * 40hr/week * 12 weeks * 3 years = $18,720)*											
Civil Service Tech 1 lab assistant, civil service employee - help with lab work and extractions. 78% salary, 22% benefits.100% FTE for 2 years ($81,580)											
Civil service employee Bioinformatician - assist in data analysis of parentage analysis. 78% salary, 22% benefits. 100% FTE for 1 year ($46,400)											
Equipment/Tools/Supplies											
Field and Lab Supplies (flags, coin envelopes, bar code reader, GPS rental, 96 well plates, chemicals, vials, etc)	$3,000	$0	$3,000	$1,500	$0	$1,500				$4,500	$4,500
Supplies to conduct workshops (food, name tags, etc)							$1,000	$0	$1,000	$1,000	$1,000
Printing											
printing materials for workshops							$500	$0	$500	$500	$500
Travel expenses in Minnesota											
Travel for field work *(LODGING: $83/night * 4 nights/week * 12 weeks * 4 rooms (2 rooms per year) = $15936; CAR RENTAL: $722.40/month * 2.5 months * 2 years = $3612; PER DIEM: $46/day * 4.5 days per week * 12 weeks * 3 people = $7452)*	$27,000	$0	$27,000	$0	$0	$0				$27,000	$27,000

Other											
*Lab services for genotyping plant samples to determine paternity (8 species * 250 samples/species the first year, and 4 species * 200 samples/species the second year = 2800 samples @ $50/sample = $140,000*	$140,000	$0	$140,000							$140,000	$140,000
COLUMN TOTAL	**$414,674**	**$0**	**$414,674**	**$139,826**	**$0**	**$139,826**	**$1,500**	**$0**	**$1,500**	**$556,000**	**$556,000**