Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 152-F**

Optimizing the Nutrition of Roadside Plants for Pollinators

Category: F. Methods to Protect, Restore, and Enhance Land, Water, and Habitat

Total Project Budget: $ 815,000

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

This research will produce site-specific recommendations for roadside plantings in Minnesota to maximize the nutritional health of native bees and monarch butterflies that rely on such habitats as conservation corridors.

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Sponsoring Organization: U of MN

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Location

Region: Central, Metro, Northwest, Southwest, Southeast

County Name: Anoka, Becker, Benton, Big Stone, Blue Earth, Brown, Carver, Cass, Chippewa, Chisago, Clay, Clearwater, Cottonwood, Crow Wing, Dakota, Dodge, Douglas, Faribault, Fillmore, Freeborn, Goodhue, Grant, Hennepin, Houston, Hubbard, Isanti, Jackson, Kandiyohi, L

City / Township:

Alternate Text for Visual:

Overview of experiment and map of road sites

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Optimizing the nutrition of roadside plants for pollinators

I. PROJECT STATEMENT

This research will result in site-specific recommendations for roadside plantings in Minnesota to maximize the health of bees and butterflies that rely on such habitats as conservation corridors. While roadsides are promising pollinator habitat, there is a concern they may act as ecological sinks, which attract pollinators, but result in declines in pollinator health. For instance, plants along roadsides can accumulate sodium from salt runoff. Sodium is a potent attractant for many animals, and while it is an important micronutrient, they can feed on it to the point of toxicity. Nitrogen also accumulates on roadsides, potentially attracting animals with protein-poor diets to areas that also suffer from heavy metal buildup from brake pads and tire residue. Pesticide spillover from adjacent agricultural fields may additionally limit the quality of roadside habitats. Because different plants accumulate chemicals to different degrees, this research aims to develop recommendations for plantings for various road use intensities that optimize the value of roadside milkweed for monarchs and flower pollen and nectar for bees. We combine roadside surveys around the state of Minnesota with controlled lab rearing experiments of pollinators and field manipulations of plants.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Survey of roadside plants and pollinators **Budget: $370,000**

The first aim of this research is to document the nutrient content of roadside plants and pollinators. Drawing from an existing network of roadside sites randomly distributed across non-forested areas of the state, we will survey 50 sites across varying degrees of road use intensity and adjacent agricultural use. Surveys will document the identity and density of roadside flowering plants and milkweeds. Plant samples will be taken of three focal native species commonly used by pollinators, including common milkweed, goldenrod and partridge pea. We will measure the nutrient and heavy metal composition of leaves, pollen and nectar of these samples, including nitrogen, phosphorus, sodium, nickel, zinc, and lead. A subset of milkweed samples will be used to measure pesticide content, comparing data to pesticide levels known to have lethal or sub-lethal effects on pollinators. Control sites at least 500 m from roadsides and agricultural fields will be used to establish baseline levels of nutrients, heavy metals and pesticides for all species. At each site we will additionally sample bumblebees (especially *Bombus impatiens, bimaculatus, griseocollis*) and a common halictid bee species with a smaller foraging range (*Halictus ligatus*) to measure the nutrient and heavy metal content of their pollen loads.

Outcome	Completion Date
Collection of roadside plants and pollinators	Aug. 2017
Nutrient, heavy metal & pesticide content of roadside plants	Dec 2017
Measurement of pollinator nutrition (dissected crops, collected pollen)	May 2018

Activity 2: Pollinator health in different nutrient conditions **Budget: $200,000**

Nutrient content of roadside plants will be used to parameterize rearing experiments to measure levels at which nutrients and heavy metals become harmful to pollinators. We will use *Bombus impatiens* as a model bumblebee system. Nutrients and heavy metals (nickel, zinc, lead) will be manipulated in pollen balls of 60 queens, mimicking concentrations measured in pollen in activity 1. We will measure development time and body size of 6 offspring per queen. We will rear monarchs on milkweed containing increasing levels of nitrogen, sodium, or heavy metals, mimicking concentrations measured in milkweed leaves in activity 1. Data on size and development time will address whether roadside nutrient levels are harmful to pollinators.

Outcome	Completion Date
Determine optimal nutrient conditions for developing bumblebees	Dec 2018
Determine optimal nutrient conditions for developing monarchs	April 2019

Activity 3: Plant nutrient status and pollinator preferences **Budget: $245,000**

Given that different plants concentrate nutrients to different degrees, the final aim of this research is to determine which plant species would maximize pollinator health along roadsides. We will grow 30 different plant species in different nutrient treatments that simulate roadside conditions of three different use intensities (low, medium, high; informed by Activity 1). Nutrient and heavy metal content of plant leaves, pollen and nectar will be measured. Pollinator preferences will be determined through surveys of native pollinators. Plant species will be chosen based on existing recommendations for roadside plantings for pollinators (e.g., lists developed by the DNR and Xerces Society for Minnesota roadside corridors).

Outcome	Completion Date
Measure nutrients in different plant species in controlled conditions	Dec 2019
Determine pollinator preference for different plant nutrient contents	Sept 2019
Recommendations for roadside plantings to maximize pollinator health	June 2020

III. PROJECT STRATEGY

A. Project team and partners:

University of Minnesota Project Team

Personnel	Role (activity)	Financial support
Emilie Snell-Rood	Project leader (1-3)	Summer support
Dan Cariveau	Advise on bee surveys (1, 3)	None
Marla Spivak	Advise on bee rearing (2)	None
Karen Oberhauser	Advise on site selection (1) monarch rearing (2)	Summer support
Elizabeth Borer	Advise on nutrient manipulations (3)	Summer support
Clay Carter	Advise on nectar measurements (1, 3)	Summer support
Undergrad assistants	Run site surveys (1)	Summer salary
Grad student assistants	Coordinate field surveys (1) and rearing (2)	Salary + fringe
Postdoctoral Researcher	Coordinate field manipulations (3); writing (1-3)	Salary + fringe
Lab Technician	Coordinate nutrient measures (1)	Salary + fringe

We will seek input and advice from several agencies to ensure that the goals of this research are met, and that the findings are useful to, and shared with, decision-makers in Minnesota. First, we have partnered with the Department of Natural Resources (specifically Crystal Boyd, Fred Harris, Greg Hoch) to advise on site selection, survey design, plant selection in activity 3, and delineating management recommendations once results are in hand. A subset of our budget covers this consulting. Second, we will seek additional advice on plant selection from the Minnesota Board of Water and Soil Resources (specifically Dan Shaw). Finally, we will seek advice from the Minnesota Department of Transportation in site selection and management recommendations.

B. Project impact and long-term strategy

The final outcome of this project will be recommendations for roadside plantings to maximize pollinator health. For example, preliminary data show that milkweed can accumulate very high levels of sodium, suggesting plantings along less intensely used rural roads may be ideal. Datasets will be made publically available on the digital repository "DRYAD" and the DNR observation database; publications will be open access. Final management recommendations will be made in collaboration with the DNR and communicated to all relevant stakeholders.

C. Timeline

Roadside surveys of plants and pollinators will take place July-August 2017 and processed over the next 6 months. All rearing (activity 2) will take place in 2018. Plant rearing (Activity 3) will take place summer 2019. Data analysis will be complete by June 2020.

2017 Detailed Project Budget

Project Title: *Optimizing the nutrition of roadside plants for pollinators*

IV. TOTAL ENRTF REQUEST BUDGET *3* **years**

BUDGET ITEM	AMOUNT
Personnel: Emilie Snell-Rood (PI) will oversee all three activities and is requesting 1.5 months of summer salary each year. (75% salary, 25% benefits)	$ 61,000
Personnel: Clay Carter is requesting 2 weeks of summer salary each year. (75% salary, 25% benefits)	$ 21,000
Personnel: Karen Oberhauser is requesting 2 weeks of summer salary each year. (75% salary, 25% benefits)	$ 23,000
Personnel: Elizabeth Borer is requesting 2 weeks of summer salary each year. (75% salary, 25% benefits)	$ 23,000
Personnel: One postdoctoral associate will direct activity 3 & data analysis. (82% salary, 18% benefits) 100% FTE for 3 years	$ 160,000
Personnel: Two graduate research assistants will direct activities 1 and 2 with the help of two undergraduate research assistants (roadside surveys) and one lab technician (rearing experiments). (52% salary, 48% benefits during the academic year and 85% salary, 15% benefits during the summer) 50% FTE for 3 years	$ 297,000
Personnel: Two undergraduate research assistants - One will work 50% time during the academic year and two will work full-time during the summer. (100% salary, 0% benefits) 92% FTE & 23% FTE for 2 years	$ 38,000
Personnel: A lab technician will help coordinate surveys and sample processing during year 1 (activity 1). (79% salary, 21% beneifts)	$ 54,000
Professional/Technical/Service Contracts: The Department of Natural Resources will provide valuable consulting and advice across 9 total meetings (3 per year, 2 hrs/meeting, 4 people/meeting)	$ 8,000
Equipment/Tools/Supplies: Supplies for rearing monarchs and bees for nutrient manipulations. Field supplies for collecting and processing plants and pollinators.	$ 15,000
Travel: Travel to roadside sites for sampling plants and pollinators (activity 1: approx 3000 miles over a 3 week period). Travel to field station for plant plot manipulations (activity 3).	$ 9,000
Additional Budget Items: Plant samples for analysis of nutrients/heavy metals ($20/sample) and pesticides ($300/sample).Activity 1: 3 species across 50 sites (nectar, pollen and leaves, N = 3/sp/site). Activity 3: 30 species in controlled plots of 4 treatments (N = 3/sp/treatment)	$ 98,000
Additional Budget Items: Costs of open-access research publications.	$ 8,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 815,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:		
Other State $ To Be Applied To Project During Project Period:	$ -	*NA*
In-kind Services To Be Applied To Project During Project Period: *Indirect costs associated with this proposal.*	$ 372,000	*Secured*
Funding History: Funds supplied from the Office of the Vice President for Research (University of Minnesota) that funded this project during its first two years (spent by 2013). Resulted in publication: Snell-Rood et al. Anthropogenic changes in sodium affect...2014 PNAS	$ 28,000	
Remaining $ From Current ENRTF Appropriation:	$ -	*NA*

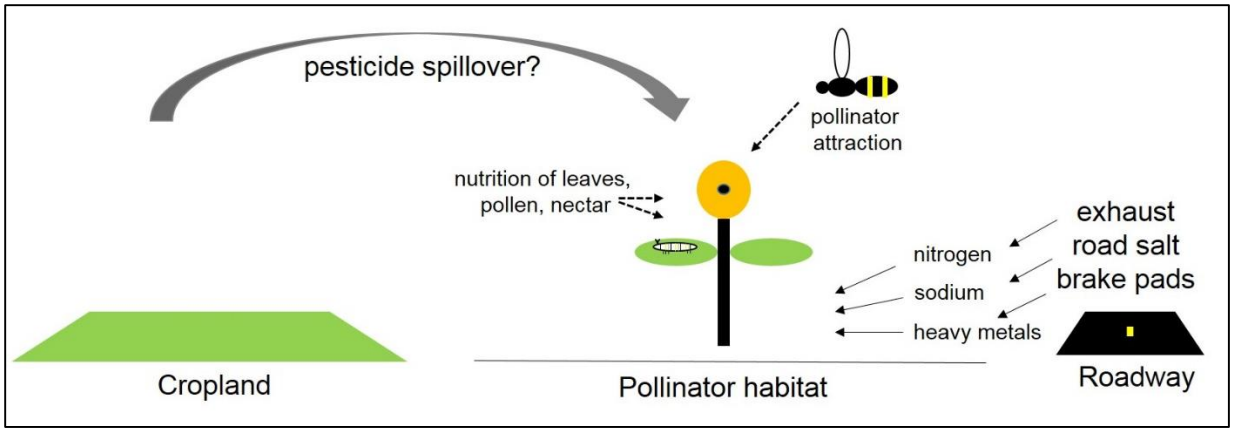

Figure 1. ***Research overview***. Some elements of road runoff such as nitrogen and sodium may attract pollinators to roadsides where toxins such as pesticides and heavy metals may additionally be present. This research addresses the nutrition of roadside plants through roadside surveys, developmental manipulations of monarchs and bumblebees, and plant trials to optimize which species to plant along roadways of different use profiles.

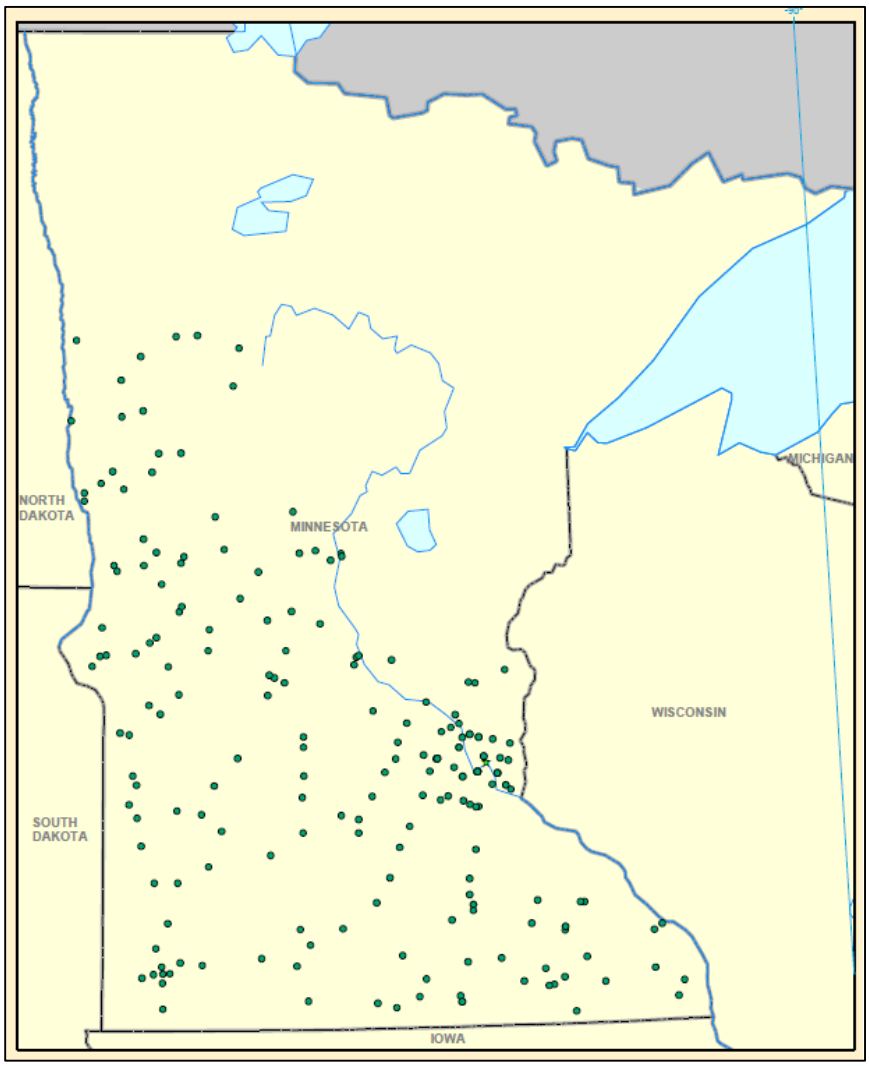

Figure 2. ***Roadside sites***. Activity 1 of this research will focus on 50 roadside sites drawn from an existing network of sites (shown here). These sites represent a random sample of sites within prairie and open habitats within 200 miles of the Twin Cities. We will build on existing data for these sites, which will include two field seasons of surveys of milkweed and monarchs. Over 50% of these sites contain milkweed. The sites include a mixture of road use intensities and adjacent land use (>50% agriculture).

Project Manager Qualifications and Organization

Emilie Snell-Rood, Project Manager
Asst. Professor: Department of Ecology, Evolution and Behavior, University of Minnesota
emilies@umn.edu; http://cbs.umn.edu/snell-rood-lab/home

Organization: Emilie Snell-Rood (Asst. Prof, Dept. Ecology, Evolution & Behavior) will lead the project. Dan Cariveau (Asst. Prof, Dept Entomology) will contribute expertise on bee surveys in Activity 1 and 2. Marla Spivak (Professor, Dept Entomology) will contribute expertise with rearing bumblebees (Activity 2). Karen Oberhauser (Professor, Dept. Fisheries, Wildlife & Conservation Biology) will contribute expertise in rearing of monarchs (Activity 2) and roadside surveys of milkweed and monarchs (Activity 1). Elizabeth Borer (Assoc. Professor, Dept. Ecology, Evolution & Behavior) will offer expertise with respect to controlled nutrient manipulations of plants (Activity 3). Clay Carter (Assoc. Professor, Dept. Plant Biology) will offer guidance in measurement of nectar and pollen nutrient content. Individual aims will be carried out by graduate student research assistants, a postdoctoral fellows, and a lab technician.

Recent Awards and Grants

- Animal Behavior Society, Young Investigator Award, 2014
- McKnight Land Grant Professorship, 2015
- NSF: Stochasticity in Gene Expression as a Mechanism Underlying Developmental Plasticity (March 1, 2014-Feb. 28, 2017), $488,416

Relevant Publications

- Swanson, E., A. Espeset, I. Mikati, I. Bolduc, R. Kulhanek, W. A. White, S. Kenzie, and E. C. **Snell-Rood**. Nutrition shapes life history evolution across species: a case study in butterflies. In review, Proceedings of the Royal Society of London, B.
- **Snell-Rood**, E. C., R. Cothran, A. Espeset, P. Jeyasingh, S. Hobbie, N. Morehouse. 2015. Life history evolution in the anthropocene: effects of increasing nutrients on traits and tradeoffs. Evolutionary Applications 8: 635–649.
- **Snell-Rood**, E. C., A. Espeset, C. Boser, W. A. White, R. Smykalski. 2014. Anthropogenic changes in sodium affect neural and muscle development in butterflies. Proceedings of the National Academy of Sciences USA 111: 10221-10226.

Selected relevant publications by research team members

- **Cariveau**, DP and R Winfree. 2015. Causes of variation in wild bee responses to anthropogenic drivers. Curr Opinion in Insect Science 10:104-109
- Stevens, CJ, EM Lind… ET **Borer** et al. 2015. Anthropogenic nitrogen deposition predicts local grassland primary production worldwide. Ecology 96:1459-1465.
- **Cariveau**, DP, NM Williams, FE Benjamin, R Winfree. 2013. Response diversity to land use occurs but does not consistently stabilize ecosystem services provided by native pollinators. Ecology Letter 16:903-911.
- Pleasants, JM and KS **Oberhauser**. 2012. Milkweed loss in agricultural fields because of herbicide use: effect on the monarch butterfly population. Insect Conservation and Diversity 6:135-144.
- Bender, R, P. Klinkenberg… CJ **Carter**. 2012. Functional genomics of nectar production in the Brassicaceae. Flora 207:491-496.
- Mader, E. M **Spivak**, E. Evans. 2010. Managing alternative pollinators. SARE, ebook.
- Evans, E, I. Burns, and M. **Spivak**. 2007. Befriending bumblebees: a practical guide to raising local bumblebees. University of Minnesota Extension Service.