Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 140-D**

Stopping Invasive Species by Attacking from Below

Category: D. Aquatic and Terrestrial Invasive Species

Total Project Budget: $ 491,515

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

Invasive plants strongly impact soil microbes, fungi, and fertility; we will evaluate innovative and potentially effective methods to manipulate these soil properties to control invasive plants in prairies and forests.

Name: Peter Tiffin

Sponsoring Organization: U of MN

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Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Invasive plants affect not only above-ground communities that we see, but also form strong associations with soil microbes. Attacking these soil microbes might control the damage caused by invasive species.

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

PROJECT TITLE: Stopping invasive species by attacking from below

I. PROJECT STATEMENT

The primary goals of the proposed work are to 1) understand the effects that invasive plant species have on soil microbial communities and soil fertility, and 2) evaluate the potential to manipulate these factors in order to control the spread of invasive species and limit their impact on native plant communities. Evaluating the effects of invasive species most often focuses on what we see aboveground and most efforts to control invasive species focus on attacking the aboveground parts of plants. However, many plant species form symbiotic associations with soil bacteria and fungi (the soil microbiota) that strongly affect plant growth and soil fertility. The spread of some invasive species, including some of those most destructive in Minnesota, has been directly linked to the presence of microbial symbionts living in plant roots. The importance of the belowground community on the establishment and growth of invasive species suggests that manipulating the soil microbiota might be an effective and under-exploited means to manage invasive plants.

We propose to further our understanding of invasive species on soil microbiota and fertility in Minnesota's prairies and forests and to evaluate the potential to manipulate soil microbes and fertility in order to reduce the negative impacts of invasive plants. Specifically, we will: i) survey the belowground microbial communities present in invaded and nearby uninvaded lands and ii) conduct manipulative field experiments to evaluate the potential for manipulating soils to limit establishment, spread, and long-term negative consequences of invasives. We focus on four species, two forest trees (Norway Maple, *Acer platanoides*, and Glossy Buckthorn, *Frangula alnus*) known to form strong associations with mycorrhizal fungi and two prairie legumes (Yellow Sweetclover, *Melilotus officinalis*, and Crown Vetch, *Coronilla varia*) known to form strong associations with rihizobial bacteria. These species are on the MN Invasive Terrestrial Plants and Pests list of prioritized species and two species (buckthorn and vetch) are on the MN DNR list of noxious weeds. Mycorrhizal fungi promote plant growth through acquisition of phosphorous and water and rhizobial bacteria greatly increase growth of certain plants by providing the plants with nitrogen. Both mycorrhizae and rhizobia are directly linked to the spread of some invasives but neither their role in the spread of invasives in Minnesota, nor the long-term effects that changes in these symbiont communities have on native communities have been investigated.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Field surveys and greenhouse experiments. **Budget: $** 200,000

To establish the extent to which the chosen invasive plants have altered the communities of plant-associated microbes present in the areas they are now present we will sample the roots of invasive and related native plants from scientific natural areas (SNAs) in southern and central MN (6 sites / species). At each site we will collect roots from the focal and related native species to measure the extent to which the plants are associated with the microbes by staining for mycorrhizae, counting "nodules" that house rhizobia, and extracting DNA in order to characterize mycorrhizal and rhizobial community composition using high throughput sequencing technology. We also will sample soil from under invaded plants and nearby uninvaded areas. We will use this soil in a greenhouse experiment in which we will grow seedlings of native and invasive plants, characterize growth and extent of symbiont colonization, and use DNA sequencing to identify both types of symbionts. These data will allow us to determine the extent to which invasive species have altered the symbiont community and also whether invasives have altered the soil environment in a way that promotes their own growth (i.e. a positive feedback).

Outcome	Completion Date
1. Complete survey of root colonists	June 2019
2. Complete greenhouse experiment of soil symbiont communities	February 2020
3. Submit manuscript on results and make all data publicly available	June 2020

Activity 2: Characterize soil fertility **Budget: $** 90,000

From each of the invaded and uninvaded soils sampled as part of Activity 1 we will characterize the effects of invasive plants on soil fertility using standard analytical methods. We will focus on the key nutrients for plant growth: nitrogen, phosphorus, and cations (calcium, potassium, magnesium). These results will allow us to determine if modification of soil nutrient availability is the dominant mechanism through which soil microbiota differentially affect success of invasive plants and will suggest possible strategies to reduce growth of invasives via soil amendments (Activity 3).

Outcome	Completion Date
1. Complete soil characterization	June 2019
2. Analyze data and include in manuscript from Activity 1	June 2020

Activity 3: Manipulative experiments to evaluate the effects of nutrient addition and soil microbiota manipulation on the establishment and growth of native and invasive species. **Budget: $** 201,515

To evaluate the potential for reducing the establishment and growth of invasive species by altering the soil microbiota, we propose to conduct paired greenhouse and field experiments. In the greenhouse, we will enrich soil for the fungi and rhizobia that were found with native but not the invasive species (Activity 1) as well as fertilize or modify invaded soil (e.g. change its acidity) so that it has properties of uninvaded soil (Activity 2). Into these amended soils we will plant seeds or both invasive and native species and monitor for plant growth and colonization by symbionts. The efficacy of the soil amendments will be evaluated on the basis of their negative effects on growth of invasives and positive effects on growth of natives. While greenhouse experiments provide a rapid means to assess what might be occurring in nature, manipulations under controlled conditions do not always work when implemented in the field. Therefore, we will evaluate the two most effective greenhouse manipulations in the field. This will involve experiments that include all combinations of soil amendment with and without invasive species removal. In each experimental plot, we will plant seedlings of native plants and measure the growth of these seedlings as well as plants already in the plots. These experiments will be conducted at SNA locations that the SNA management coordinator has identified as high priority for restoration.

Outcome	Completion Date
1. Establish field experiments	March 2020
2. Complete field experiments	May 2021
3. Submit manuscripts and white paper with management recommendations to SNAs	June 2021

III. PROJECT STRATEGY

A. Project Team/Partners All members of the project Team are associated with the University of Minnesota. Project Team PIs (receive funding): Dr. Peter Tiffin (Professor, UMN), Dr. Jennifer Powers (Associate Professor, UMN), Dr. Peter Kennedy (Associate Professor, UMN). One post-doctoral researcher, a half-time technician, and undergraduate students will all be hired but have not yet been identified. **Partners (no funding):** Team member Peter Kennedy has an ongoing working relationship with Mark Cleveland, state's SNA management coordinator, and we will work closely with him and other DNR employees to coordinate our sampling and experiments in order to maximize the potential benefits to the SNA management.

B. Project Impact and Long-Term Strategy. Our project is designed to be completed within the timeframe of funding. However, we anticipate that the results of our research will have long-term impacts on how invasive l are managed in Minnesota and might lead to new economical and innovative strategies to limit the establishment and spread of invasive species and promote the reestablishment of native communities.

C. Timeline Requirements. We have proposed a three year project and can complete the project objectives in that time period. That said, the field experiment we establish (activity 3) will remain in place at the end of the funding period in order to gain long-term data on the effects of soil amendments.

2018 Detailed Project Budget

Project Title: Stopping invasive species by attacking from below

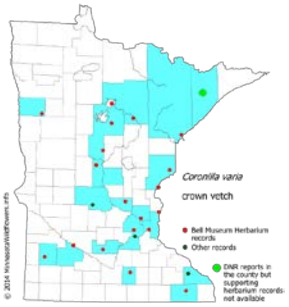
IV. TOTAL ENRTF REQUEST BUDGET *3* **years**

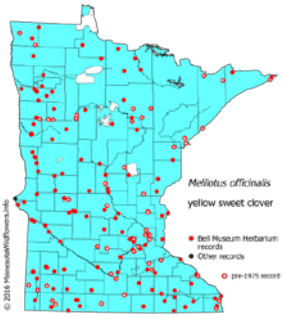
BUDGET ITEM	AMOUNT
Personnel: Peter Tiffin, PI, project ccordinator, and lead on rhizobial work (75% salary, 25% fringe) ~ 2 weeks / year increased by 3% / year	$ 49,485
Personnel: Peter Kennedy, co-PI and lead on the mycorhizae work (75% salary, 25% fringe) ~ 2 weeks / year increased by 3% / year	$ 41,250
Personnel: Jennifer Powers, co-PI and lead on soil sampling and analyses (75% salary, 25% fringe) ~ 2 weeks / year increased by 3% / year	$ 41,250
Personnel: One post-doctoral associate (82% salary, 18% fringe) three years based on an starting salary of $48,000 / year increased by 3% / year.	$ 180,100
Personnel: One Research Techniciaon (78% salary, 22% fringe), 0.5 FTE each year, starting salary $20,000 increased by 3% / year	$ 78,630
Personnel: Undergraduate student research assistants ($15 / hr, two assistants, 600 hour per year), increase by 3% per year.	$ 55,600
Professional/Technical/Service Contracts:	NA
Equipment/Tools/Supplies: Lab supplies (chemicals, extraction kits, disposables).	$ 12,000
Equipment/Tools/Supplies: Field supplies (gloves, soil samplers, flags, bags, seeds).	$ 2,000
Acquisition (Fee Title or Permanent Easements): *In this column, indicate proposed number of acres and and name of organization or entity who will hold title.*	NA
Travel: Mileage $800 dollars to support travel to conduct the field and sampling and surveys and the multiple trips that will be needed for the field experiment (activity 3)	$ 800
Additional Budget Items:laboratory services to conduct the DNA sequencing for symbiont identification, sequencing will be conducted at the University of Minnesota genomics facility. Includes charges for data generation and data storage.	$ 24,000
Additional Budget Items: Services for soil nutrient analyses, University of Minnesota Soil Testing laboratory.	$ 4,000
Additional Budget Items: Greenhous bench fees, paid to University of Minnesota	$ 2,400
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 491,515

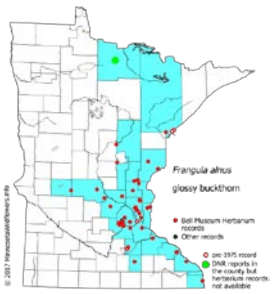
V. OTHER FUNDS

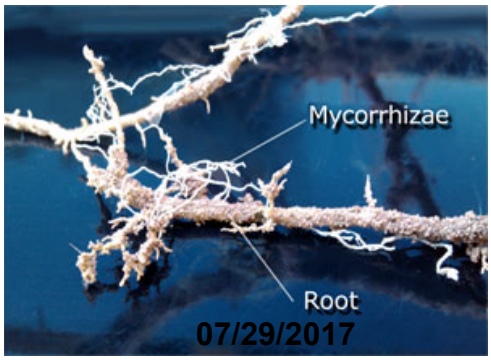
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: none	NA	
Other State $ To Be Applied To Project During Project Period: none	NA	
In-kind Services To Be Applied To Project During Project Period: *Unrecovered indirect costs @ 54% of modified total direct cost base (minus travel).*	$ 264,980	*Secured*
Past and Current ENRTF Appropriation: none	NA	
Other Funding History: none	NA	

Stopping Invasive Species by Attacking from Below









Project Title: *Stopping invasive species by attacking from below*

Project Manager: Dr. Peter Tiffin

Current Position: Professor, Department of Plant and Microbial Biology, University of Minnesota – Twin Cities

Education:

B.S.	1988	Botany	University of Wisconsin, Madison
M.S.	1994	Crop and Soil Science	Michigan State University
Ph.D.	1999	Zoology	Duke University

Experience:

As a faculty member at the University of Minnesota since 2002 I have been actively involved in research science education and in research that advances our understanding of the factors that effect plant growth, plant genetic diversity, and the response of plant populations to environmental perturbations. As an educator I have taught both undergraduate and graduate courses. In these courses I have used both lecture-based delivery and more recently have started teaching in the University's Foundations of Biology course that is based on guiding undergraduate majors in Biology through active-learning activities. I have also mentored more than a dozen graduate students and post-doctoral researchers, more than half of whom have obtained University faculty positions.

As a researcher I have published 75 articles in scientific journals (http://cbs.umn.edu/tiffin-lab/publications) on a variety of subjects including the effects of rhizobia on plant growth, the genetics and genomics of rhizobia, rhizobia effects on the spread of plant populations, factors that limit species ranges, the genetics of adaptation to climate, and the response of plants to elevated concentrations of atmospheric CO_2. While at the University of Minnesota I have been a principal investigator or co-principle investigator on grants from the National Science Foundation that have brought in more than $ 2.5 million dollars to fund research in my lab – this money has primarily gone to for stipends and salaries to graduate students and post-doctoral researchers.

Organization Description

The Department of Plant and Microbial Biology and the University of Minnesota are dedicated to supporting biological research that integrates knowledge across levels of biological complexity. This includes field research, the development of collections, and the management of ecosystems. The institution is dedicated to teaching and research, especially as it pertains to biological issues that affect society. Our team or researchers for this project (Dr. Jennifer Powers, Dr. Peter Kennedy, and myself, all faculty at the University of Minnesota) together have expertise in soil microbiota and soil fertility and how these factors affect plant growth and ecological communities.