# Environment and Natural Resources Trust Fund

2026 Request for Proposal

## General Information

**Proposal ID:** 2026-171

**Proposal Title:** Developing Long-Term Resilient Cropping Systems Supporting Soil Biodiversity

## Project Manager Information

**Name:** Senyu Chen

**Organization:** U of MN - Southern Research and Outreach Center

**Office Telephone:** (507) 837-5621

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## Project Basic Information

**Project Summary:** This project will investigate soil health, biodiversity, and ecological services under different long-term cropping systems through the analysis of the structure and function of nematode, fungal, bacterial, and protist communities.

**ENRTF Funds Requested:** $456,000

**Proposed Project Completion:** June 30, 2028

**LCCMR Funding Category:** Land (F)

## Project Location

**What is the best scale for describing where your work will take place?**

Statewide

**What is the best scale to describe the area impacted by your work?**

Statewide

**When will the work impact occur?**

In the Future

## Narrative

**Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.**

Over the past century, agricultural productivity has surged due to the development of genetically improved crop species and cultivars, advancements in farming equipment, and the widespread use of chemical fertilizers and pesticides. The industrialization of agriculture and the globalization of economies have driven crop production toward greater specialization, with many farmers focusing on cultivating only one or a few crops. However, these extensive and often highly intensive cropping practices have led to a decline in soil fertility and soil health, while increasing pathogen and pest pressures, particularly from plant-parasitic nematodes, which are becoming increasingly problematic.

Minnesota exemplifies this trend, where the predominant practice of annually rotating corn and soybeans has intensified pathogen and pest pressures on both crops. The soybean cyst nematode, a microscopic soil-dwelling roundworm, poses a particularly severe threat to soybeans and edible dry beans. Other plant-parasitic nematode species, such as root lesion nematodes and stubby-root nematodes, also not only deprive host crops of nutrients but also interact with microbial pathogens to cause root lesions and root rot diseases, significantly impacting corn, soybean, and potato plant growth and yields. Presumably, many other important plant-parasitic nematode species in Minnesota agricultural land have not been discovered and identified.

**What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.**

To address the challenges of declining soil health and increasing pest pressures, the Long-term Agricultural Research Network (LTARN) was established in 2013 at the University of Minnesota. This initiative evaluates the environmental health, sustainability, and productivity of 6-7 long-term crop rotation systems across three experimental sites located in Waseca, Lamberton, and Grand Rapids, Minnesota. Scientists from diverse fields, including agronomy, plant genetics, plant pathology, biology, microbiology, soil science, and agricultural engineering, have conducted research using this platform, including studies on nematode communities.

In this proposal, we aim to conduct a comprehensive analysis of soil biodiversity across the LTARN cropping systems. Nematodes, the most abundant animals on Earth, play a critical role in soil ecosystems. While many nematodes are beneficial to soil health, plant-parasitic nematodes pose significant threats to crops. Occupying all trophic levels of the soil food web, nematodes serve as key indicators of soil health and pest pressure due to their abundance and ease of quantification. Bacteria, fungi, and protists are three other major groups of organisms contributing to soil biodiversity. This project will analyze nematode, fungal, bacterial, and protist communities to evaluate the impact of different cropping systems on biodiversity and the ecological functions of soil ecosystems.

**What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?**

This project aims to enhance the protection, conservation, and preservation of Minnesota's natural resources by evaluating the impact of diverse cropping systems on soil health and biological functions. By analyzing nematode, fungal, bacterial, and protist communities, the study will provide critical insights into sustainable agricultural practices that mitigate pest pressures and improve soil fertility. The findings will guide farmers in adopting resilient cropping systems that reduce reliance on chemical inputs, promote biodiversity, and enhance long-term agricultural productivity. Ultimately, this research supports the conservation of soil resources, ensuring their sustainability for future generations while maintaining soil ecological balance and ecosystem services.

## Activities and Milestones

### Activity 1: Evaluate crop productivity under different cropping systems

**Activity Budget:** $50,000

**Activity Description:**
Since 2013, three large-scale coordinate field experiments have been underway in southwest, south-central, and north central Minnesota, comparing 6-7 diverse production systems, including corn-soybean, corn-soybean plus cover crop, corn-soybean-wheat, corn-alfalfa, perennial polyculture, and pasture/hay. Each phase of the crop rotations is planted every year. Yield or biomass of corn, soybean, wheat, and other crop species will be measured. The data will be entered in the LTARN database that is maintained in the University of Minnesota. The impact of the diverse cropping systems on crop productivity (biomass or yield) will be analyzed.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Crop planting and maintenance | November 30, 2027 |
| Crop yield and biomass measurement | November 30, 2027 |

### Activity 2: Assess soil health, biodiversity, and ecological services through analyses of nematode, fungal, bacterial, and protist community structures and functions

**Activity Budget:** $226,000

**Activity Description:**
Soil samples will be collected in 2026 and 2027, with a total of approximately 600 samples per year, and processed for nematode extraction. The nematodes will be morphologically identified to genus or family level, and their abundance will be determined. To evaluate nematode diversity at a finer level of taxonomic resolution following morphological identification, nematode DNA will be extracted, amplified using the 18S (NF1/18Sr2b) marker, and sequenced. Based on the morphological and DNA sequencing data, the abundances of total nematodes and different feeding groups will be determined. Nematode community indices will also be calculated. These indices are used to evaluate soil health, biodiversity, ecological function, and plant-parasitic nematode pressure.

Bacteria, fungi, and protists are indispensable components of soil ecosystems. Analyzing the communities of nematodes, fungi, bacteria, and protists together provides a powerful approach to studying soil biodiversity and ecological function. This integrated analysis will generate highly informative data for evaluating the impact of cropping systems on soil biodiversity and ecological services. Bacterial, fungal, and protist DNA will be extracted directly from soil subsamples and sequenced. The DNA sequencing data will be analyzed using established bioinformatics procedures to determine the abundances of their respective taxonomic groups.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Soil sampling and nematode extraction | August 31, 2027 |
| Nematode morphological identification | October 31, 2027 |
| Fungal, bacterial, and protist DNA extraction and sequencing | October 31, 2027 |
| Nematode DNA extraction and sequencing | December 31, 2027 |
| Fungal, bacterial, and protist DNA sequence data and their community analysis | February 28, 2028 |
| Nematode community analysis | March 31, 2028 |

## Activity 3: Identify species of major plant-parasitic nematodes

**Activity Budget:** $120,000

**Activity Description:**
In the above community study, the nematodes will be identified to genera (a group of related species) for family (a group of related genera). To assess importance of plant-parasitic nematodes under different cropping systems in Minnesota, it is necessary to identify the nematodes to species level. Based on the data collected in 2013-2014 from these three field sites, major plant genera across the three sites include Heterodera, Pratylenchus, Xiphinema, Hoplaimus, Helicotylenchus, Tylenchorrhynchus, Paratylenchus, Ditylenchus, Criconema, and Aphelenchoides. Morphological examination and DNA sequencing will be used in identifying the nematodes to species. The data will be analyzed to determine the long-term cropping systems on individual plant-parasitic nematodes.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Nematode species identification | December 31, 2027 |

## Activity 4: Study the effects of different cropping systems on soybean cyst nematode populations

**Activity Budget:** $60,000

**Activity Description:**
Cyst nematodes (Heterodera spp.) were observed at all three sites. Based on their prevalence and characteristics, these nematodes are likely the soybean cyst nematode (SCN), Heterodera glycines, which is the most economically significant plant-parasitic nematode in Minnesota. Previous studies have examined the effects of long-term corn-soybean rotations and cover crops on SCN populations. However, the impact of long-term alternative cropping systems on SCN populations remains unexplored. The Long-Term Agricultural Research Network (LTARN) presents an excellent opportunity to address this gap.

In nematode community studies, only the motile second-stage juveniles (J2) is extracted and counted. However, SCN population density is more accurately assessed by measuring egg population density in soil, because most cyst nematodes exist as eggs within cysts, which are not included in standard community analyses. Therefore, determining egg population density is essential for evaluating the effects of cropping systems on SCN populations.

We hypothesize that alternative cropping systems with greater crop diversity and more non-host crops will have a suppressive effect on SCN populations. This research will provide valuable insights to help soybean growers manage SCN through the adoption of alternative cropping systems.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| SCN egg extraction and counting | November 30, 2027 |
| Integration of Findings | March 31, 2028 |
| Final Reporting and Dissemination | June 30, 2028 |
| Provide evidence-based recommendations for the adoption of alternative cropping systems that enhance soil health | June 30, 2028 |

## Project Partners and Collaborators

| Name | Organization | Role | Receiving Funds |
|---|---|---|---|
| Fariba Heydari | University of Minnesota | Co-Principal Investigator | No |
| Gregg Johnson | University of Minnesota | Co-Principal Investigator | No |
| Zane Grabau | University of Florida | Co-investigator | No |
| Dorota Porazinska | University of Florida | co-investigator | No |

## Long-Term Implementation and Funding

**Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?**

The results of this study will be published in scientific journals, and data will be archived in the Long-Term Agricultural Research Network (LTARN) database for long-term storage and future research. Established in 2013 at the University of Minnesota, LTARN maintains field plots using internal university resources. Ongoing efforts and additional work will be supported through continuous funding from state and national agencies sought by scientists in different fields. This ensures the sustainability of research activities and the implementation of findings beyond this project completion.

## Project Manager and Organization Qualifications

**Project Manager Name:** Senyu Chen

**Job Title:** Professor

**Provide description of the project manager's qualifications to manage the proposed project.**

Dr. Senyu Chen, a Professor in Nematology and Plant Pathology, brings over 42 years of research expertise in nematodes, microscopic worms predominantly found in soil. Since joining the University of Minnesota Department of Plant Pathology in 1995, Dr. Chen has secured over 100 grants, totaling more than $8.3 million in funding, with the majority of these projects under his leadership as principal investigator. Dr. Chen's research focuses on the biology, ecology, and management of plant-parasitic nematodes, with a primary emphasis on the soybean cyst nematode (SCN), a major pest affecting soybean and common bean crops. His work includes identifying SCN-resistant and tolerant genes and lines in soybean, common bean, and pennycress; studying SCN life cycles, population dynamics, and race composition in Minnesota; optimizing crop rotation strategies for SCN management; and exploring biological control methods for SCN and other nematodes. Additionally, he investigates soil microbial communities linked to nematodes and crop yields, evaluates commercial soybean cultivars for SCN resistance and yield potential, and assesses chemical and biological nematicides for SCN control. His research also examines the effects of tillage and soil fertility on SCN and explores nematode communities in organic and conventional farming systems. Dr. Chen has extensive leadership experience in nematode research related to crop yields in Minnesota's agricultural systems. He collaborates widely with scientists from the University of Minnesota and national and international institutions, demonstrating his ability to foster productive partnerships. With his proven track record in securing funding, managing complex research projects, and delivering impactful results, Dr. Chen is highly qualified to lead and manage the proposed project. His expertise, leadership, and collaborative approach ensure the project's success and alignment with its goals.

**Organization:** U of MN - Southern Research and Outreach Center

**Organization Description:**
University of Minnesota College of Food, Agricultural and Natural Resource Sciences, Southern Research and Outreach Center, Department of Plant Pathology, and Department of Agronomy and Plant Genetics

## Budget Summary

| Category / Name | Subcategory or Type | Description | Purpose | Gen. Ineligible | % Benefits | # FTE | Classified Staff? | $ Amount |
|---|---|---|---|---|---|---|---|---|
| **Personnel** | | | | | | | | |
| Post-doctoral research associate | | A post-doc will work on this project at 100% of time for 2 years to identify nematodes morphological traits, data analysis, and writing reports and manuscripts | | | 25.9% | 2 | | $160,595 |
| Principal Lab technician | | A Principal Lab technician will spend 20% of her time in coordinate the lab team, and supervise junior technician and summer workers. | | | 32.3% | 0.4 | | $34,118 |
| field technician | | A field technican will work at 20% of time to maintain the field plots, take soil samples, and record crop yields. | | | 32.3% | 0.4 | | $35,697 |
| Junior technician | | A junior technician will work in 60% time to assist in taking soil samples and to process the soil samples. | | | 32.3% | 1.2 | | $78,285 |
| Temporary worker | | One summer student or temporary worker will help in field plot work | | | 7.4% | 0.4 | | $21,544 |
| | | | | | | | **Sub Total** | **$330,239** |
| **Contracts and Services** | | | | | | | | |
| Genomic Center | Service Contract | Nematode, fungal, bacterial and protisit DNA extractions, quantification, PCR amplification, and sequencing | | | | - | | $82,000 |
| Bioinformatic service | Service Contract | Nematode, fungal, bacterial and protisit meta genomic data analysis | | | | - | | $8,000 |
| | | | | | | | **Sub Total** | **$90,000** |
| **Equipment, Tools, and Supplies** | | | | | | | | |
| | Tools and Supplies | Supplies include laboratory and field supplies such as plastic tubes, plastic cups, plastic bags, pots, slides, soil sampling tools, nematode extraction tools and media, Petri dishes, microbial culture media, literature materials, lab and growth room maintenance, fertilizers etc | All the supplies are needed for field, and laboratory research activities | | | | | $11,761 |
| | | | | | | | **Sub Total** | **$11,761** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Capital Expenditures** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Acquisitions and Stewardship** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Travel In Minnesota** | | | | | | | | |
| | Other | travel to research sites Lamberton and Grand Rapids | Field plot work and taking samples | | | | | $4,000 |
| | | | | | | | **Sub Total** | **$4,000** |
| **Travel Outside Minnesota** | | | | | | | | |
| | Conference Registration Miles/ Meals/ Lodging | For the post-doc and PI to travel to professional meetings | present research results and professional development | | | | | $8,000 |
| | | | | | | | **Sub Total** | **$8,000** |
| **Printing and Publication** | | | | | | | | |
| | Publication | Journal publications | dissemination of research results | | | | | $12,000 |
| | | | | | | | **Sub Total** | **$12,000** |
| **Other Expenses** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| | | | | | | | **Grand Total** | **$456,000** |

## Classified Staff or Generally Ineligible Expenses

| Category/Name | Subcategory or Type | Description | Justification Ineligible Expense or Classified Staff Request |
|---|---|---|---|

## Non ENRTF Funds

| Category | Specific Source | Use | Status | Amount |
|---|---|---|---|---|
| **State** | | | | |
| | | | **State Sub Total** | **-** |
| **Non-State** | | | | |
| | | | **Non State Sub Total** | **-** |
| | | | **Funds Total** | **-** |

**Total Project Cost: $456,000**

**This amount accurately reflects total project cost?**

Yes

## Attachments

### Required Attachments

*Visual Component*

File: 8be79105-bc7.pdf

*Alternate Text for Visual Component*

MN Long-Term Agricultural Research Network field sites at Waseca, Lamberton, and Grand Rapids, Minnesota, that will be used for this research project...

### Supplemental Attachments

*Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other*

| Title | File |
|---|---|
| Letter file | 454ddcef-caa.pdf |

## Administrative Use

**Does your project include restoration or acquisition of land rights?**

No

**Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?**

Yes, I understand the UMN Policy on travel applies.

**Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?**

No

**Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?**

N/A

**Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?**

N/A

**Does your project include original, hypothesis-driven research?**

Yes

**Does the organization have a fiscal agent for this project?**

No

**Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?**

No

**Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?**

No

**Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:**

Senyu Chen, Southern Research and Outreach Center, University of Minnesota

**Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements**

Yes, I understand