

Green Fund Student Research Grant

Contact Information

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Date:	11/11/25
Expected Graduation Date:	May 2027
Project Title:	Linking Vermicompost Inputs to Microbiome Function: Effects of Diet and Worm Species on Microbial Community Structure and Campus Composting Sustainability

Department / Advisor Information	
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Funding Information for Transfer

Local Speedchart:	G2424304
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Project Title

Linking Vermicompost Inputs to Microbiome Function: Effects of Diet and Worm Species on Microbial Community Structure and Campus Composting Sustainability

Student Researchers

Brooke Lercher, Undergraduate Researcher, Department of Biological Sciences
Andrew Grusenmeyer, Undergraduate Researcher, Department of Environmental Sciences
Northern Arizona University

Faculty Advisor

Dr. Meilander, Department of Biological Sciences

Abstract

This student-led project investigates how worm species and diet shape microbial communities in vermicomposting systems. Building on the Green Fund–supported vermicompost site established at NAU, the study will test two worm species—*Eisenia fetida* (red wigglers) and *Lumbricus terrestris* (earthworms)—across three feedstock types representative of campus food waste: mixed vegetarian, pre-consumer, and post-consumer diets. Over four weeks, students will collect weekly samples of castings and bedding for 16S rRNA gene sequencing to characterize microbial community composition. By linking worm biology, diet, and microbial structure, this work will provide new insights into nutrient cycling and compost microbiome optimization. **The project directly informs NAU's compost management practices by identifying combinations of species and feedstocks that enhance organic matter degradation and beneficial microbial activity.** It also expands undergraduate research and sustainability engagement through collaboration with the SSLUG Garden and outreach workshops. In doing so, the project exemplifies the Green Fund's mission to empower students to advance applied research and education in sustainable waste management.

Project Proposal

Introduction and Background

NAU currently diverts food waste to on-campus compost piles at the South Campus compost facility. However, the system faces operational limitations due to inconsistent pile management, lack of dedicated staffing, and inputs containing meat and oils that are unsuitable for aerobic composting below 55°C. These inputs also present challenges for vermicomposting systems, as worms do not feed on these materials. As a result, decomposition is often uneven, piles attract pests (e.g., coyotes and ravens), and nutrient recovery is underutilized. Vermicomposting—the biological breakdown of organic matter by earthworms—offers a low-energy, small-footprint alternative that produces stable, microbially enriched soil amendments. *Eisenia fetida* and *Lumbricus terrestris* were selected for this study because they are among the most effective species for decomposing organic matter and stimulating microbial activity. Schaefer et al. (2005)¹ demonstrated that these worms, along with *Aporrectodea chlorotica*, enhance microbial degradation of oils and hydrocarbons, indicating their resilience and potential applicability to food waste streams that may contain residual oils or complex organic compounds.

Vermicomposting provides a low-cost, biologically driven strategy for organic waste reduction and soil amendment production. Despite its growing popularity in sustainable agriculture, little is known about how worm diet or species shapes the gut microbiome and the downstream effects on the microbial structure of vermicompost systems². Microbiomes influence nutrient cycling, pathogen suppression, and soil health, and optimizing microbial activity is essential for developing efficient composting strategies at scale³.

This student-led project directly builds upon the Green Fund–supported vermicompost site established under the supervision of Dr. Jeff Meilander and managed by undergraduate student Charlotte Hurley. That project was designed not only to reduce campus food waste but also to serve as a foundation for future student-led research. This proposal fulfills that vision: it integrates with the existing vermicompost site as both an educational resource and a collaborative research platform.

Charlotte's ongoing work managing the vermicomposting system and studying worm biology provides valuable guidance for this new project. She will collaborate with student researchers Brooke Lercher and Andrew Grusenmeyer to help refine experimental design, support system maintenance, and co-lead outreach workshops.

Together, this team will advance both the scientific understanding of vermicomposting microbiomes and NAU's broader sustainability education mission.

In this research, six vermicompost bins will be constructed using 10-gallon containers, with paired treatments of *Eisenia fetida* (red wigglers) and *Lumbricus terrestris* (earthworms) across three diet conditions representative of common campus food waste streams: (1) a mixed vegetarian diet typical of a U.S. diet high in carbohydrates⁴, (2) pre-consumer vegetarian food waste, and (3) post-consumer vegetarian food waste. These two worm species are widely recognized as standards in vermiculture due to their efficiency in organic matter degradation and strong associations with beneficial microbial activity⁵.

Over four weeks, students will collect weekly samples of worm castings and bedding material (n = 48 total samples). DNA will be extracted and sequenced using 16S rRNA gene sequencing on a MinION flow cell to characterize microbial community composition. Results will provide fundamental insights into how worm diet and species influence microbial dynamics in vermicomposting systems, and student researchers will present their results and project at UGRADS.

These findings have direct applications to NAU's compost management strategies by informing best practices for worm selection and feedstock composition. Students will also translate their research outcomes into hands-on workshops with the SSLUG Garden and campus sustainability groups—further strengthening NAU's circular economy and zero-waste goals. In doing so, this project demonstrates how the Green Fund's initial investment in the vermicompost site is already producing the intended impact: empowering students to lead applied research and education in sustainable waste management.

Microbial communities associated with worm gut systems and castings are essential drivers of decomposition, nitrogen cycling, and plant health. Yet little is known about how specific worm species and diet diversity influence compost microbial composition and compost performance. Understanding these relationships enables intentional design of vermicompost systems to support campus sustainability goals while improving compost quality and nutrient recycling.

Research Questions and Hypotheses

This project tests the following hypotheses:

Research Question

Hypothesis

Does worm diet influence gut microbiome composition?

Microbial diversity and composition will differ across diet treatments.

Do red wigglers (*E. fetida*) and earthworms (*L. terrestris*) host distinct gut microbiomes?

Species identity will be a significant driver of gut microbiome structure.

Do changes in gut microbiomes affect the surrounding vermicompost environment?

Differences in gut microbiome composition will correspond to shifts in bedding/environmental microbial communities.

Methods

- **Experimental Design**

Six 10-gallon vermicompost bins will be installed at three NAU locations (1 at Brooke's residence, 1 at Andrew's residence, and 1 at Dr. Meilander's office). This allows for easy access for the researchers. Each site will include:

- 1 bin (3 total) with *E. fetida*
- 1 bin (3 total) with *L. terrestris*
- Diet treatments:
 - Diet A: Mixed vegetarian diet representative of a typical U.S. diet, which includes a high content of carbohydrates
 - Diet B: Pre-consumer vegetarian diet (fruit/vegetable/grain scraps)
 - Diet C: Post-consumer vegetarian diet (cooked fruit/vegetable/grain)

- **Sampling Plan (4 weeks)**

- Worm gut output: fresh castings from 10 worms per bin collected weekly (immediate transfer to RNA/DNA Shield to preserve mRNA transcripts). Worms will be placed in a petri dish and observed until defecation, at which point the casting will be collected.
- Environmental samples: 3 homogenized samples of bedding per bin weekly.
- Total samples: 48.

- **Laboratory Analysis**

- DNA extraction
- 16S rRNA amplicon sequencing (Oxford Nanopore MinION)

- Bioinformatic analysis using QIIME2
- **Data Analysis**
 - Alpha and beta diversity measures
 - Differential abundance analysis
 - PERMANOVA for community composition differences
 - Additional analyses as needed

Broader Impacts and Campus Sustainability Relevance

This project strengthens NAU's sustainability infrastructure by:

- Supporting composting efforts at SSLUG Garden through data-driven vermicompost design.
- Providing actionable guidance on worm species and diet selection for future on-campus bins.
- Supporting food waste diversion when campus compost operations are disrupted
- Offering decentralized composting strategies for departments, dorms, and student groups.
- Building student workforce skills in microbiome science, sustainability engineering, and waste reduction.
- Contributing to NAU's Climate Action Plan by reducing landfill methane emissions from food waste ⁶.
- Student outreach through a collaborative poster presented at UGRADS.

A student-led workshop will be delivered to the SSLUG Garden and the Office of Sustainability to share results and build campus composting capacity.

Questionnaire

Please select the focus of your research project, then address the following questions.

- Renewable energy/Energy efficiency
- Emissions reduction
- Environmental justice/Intersectionality
- Waste Minimization
- Understanding sustainability behavior/perspectives of NAU students

- Transportation
- Other:

1. How will your research promote the purpose of the Green Fund and further sustainability on NAU's campus?

This research project directly advances the Green Fund's mission by fostering student engagement in waste diversion and campus sustainability initiatives. By researching and analyzing the effects of worm species and diet, improvements can be made to pre-existing compost systems, and help further mitigate campus food waste. These findings will not only enhance NAU's composting systems but will also support the climate action plan of reducing emissions that result from food waste, such as methane. The promotion of student engagement in sustainable engineering will allow students to participate in outreach events such as a workshop at the SSLUG Garden and the Undergraduate Symposium, further expanding the potential for campus waste management and sustainability.

2. Will your research require the utilization of any spaces or infrastructure on campus? If so, identify the specific locations and/or infrastructure, how much of the space you require, and what each space will be used for. Please refer to the Space Committee Approval Process document to know if your research will require approval through the space committee.

Minimal on-campus space will be used for conducting this research. **Of the 6 compost bins, 2 will be located at Dr. Meilander's office on campus, and the remaining 4 will be at Brooke and Andrew's residences.** These bins will not require any special infrastructure as they will be self-contained. Further storage and preservation of collected samples may also be contained at Dr. Meilander's office. DNA extractions and sequencing may be performed at the composting site or in a wet lab, depending on availability as well as weather conditions.

3. Will other departments on campus be needed to assist in this project (i.e. Facility Services, Campus Transit)? If so, identify department partnerships.

Yes, the project will engage with the Office of Sustainability and the SSLUG Garden to coordinate outreach efforts, educational workshops, and present the findings of the project.

4. How will you monitor the impact of your research after completion? What do you plan to do with the results of your research?

The sequencing results of the worm microbiomes will quantify how worm species and diet impact compost efficiency and quality. Following the project's completion, the findings will be shared with the Office of Sustainability and the SSLUG Garden so that

they may incorporate them into future composting decisions. Workshops and a presentation at the Undergraduate Symposium will help encourage and ensure implementation and ongoing vigilance of the results.

Research Budget

Does this research have any other sources of funding, and/or have you applied for other sources of funding? If so, list all additional sources of funding, both confirmed and potential, outside of the funds being requested from the Green Fund.

This research will initially be funded through the Caporaso Lab's discretionary funds. Other funding sources such as private and governmental grants will be explored.

Line Item Budget:

Item	Item Justification	Quantity	Price per Unit
Student wages	Two undergraduate workers will be conducting around 4 hours of work/week for 15 weeks	The two undergraduate workers will be paid \$15/hr	\$1,800
MinION Flow Cell	16S rRNA sequencing using Oxford Nanopore	1 package	\$1,000
Worms and supplies	Purchase of Eisenia fetida and Lumbricus terrestris, bedding, totes	2 packages worms	\$500
Sampling & Lab Consumables	RNA/DNA Shield, Eppendorf tubes, nitrile gloves, ethanol, tweezers	misc	\$500

5% Contingency (5% of total project cost)	\$190
Total Research Cost	\$3,990

Total Funding Requested:

 \$3,990

Research Timeline:

Action	Parties Involved	Completion Month and Year
Order research supplies; purchase worms; build 6 vermicompost bins	Brooke Lercher Andrew Grusenmeyer Dr. Meilander	Week 1: January 2026
Install bins at 3 locations; establish diet regimens	Brooke Lercher Andrew Grusenmeyer Charlotte Hurley	Week 2: January 2026
Acclimation period for worms; refine sampling protocol	Brooke Lercher Andrew Grusenmeyer Dr. Meilander	Week 3: January 2026
Weekly sample collection (worm castings + bedding)	Brooke Lercher Andrew Grusenmeyer	Weeks 4-7: February 2026
Complete final sampling; DNA extraction	Brooke Lercher Andrew Grusenmeyer Dr. Meilander Dr. Jason Sahl - NAU	Week 8: March 2026
Library preparation and 16S sequencing using MinION	Brooke Lercher Andrew Grusenmeyer Dr. Meilander	Weeks 9-10: March 2026

Bioinformatic analysis (QIIME2 pipeline)	Brooke Lercher Andrew Grusenmeyer Dr. Meilander Dr. Chloe Herman - NAU Olivia Garcia - NAU I2S student	Week 11: March 2026
Interpretation of results; statistical comparisons	Brooke Lercher Andrew Grusenmeyer Dr. Meilander Dr. Chloe Herman - NAU Olivia Garcia - NAU I2S student	Week 12: March 2026
Prepare research poster + workshop materials (UGRADS)	Brooke Lercher Andrew Grusenmeyer Dr. Meilander	Week 13: April 2026
Deliver campus workshop (SSLUG Garden + Office of Sustainability)	Brooke Lercher Andrew Grusenmeyer Charlotte Hurley Dr. Meilander SSLUG Garden	Week 14: April 2026
Submit a progress report to NAU Green Fund and clean up	Brooke Lercher Andrew Grusenmeyer Dr. Meilander	Week 15: April 2026

Expected Project Completion Date:

___ May 2026 _____

Letter of recommendation and signed commitment



The Pathogen & Microbiome Institute

To the Green Fund Committee,

I am writing in support of Brooke Lercher and Andrew Grusenmeyer's proposal to conduct research through the NAU Green Fund. Both students have demonstrated strong qualifications and a clear commitment to sustainability and environmental research.

Brooke brings a solid research background and attention to detail that will serve her well in carrying out this project. Andrew contributes a broad perspective through his experience in trail work and environmental science, which complements the practical and applied aspects of sustainability research.

Both students previously applied for the Compost Manager position for my current Green Fund-supported project. While I ultimately selected another candidate, Brooke and Andrew were both highly qualified applicants, and it was a very difficult decision. Luckily for me they were both willing to explore other options to get involved in the project. Their initiative, dependability, and enthusiasm for environmental work make them excellent candidates to carry out this research successfully. I look forward to the opportunity to work with them in the spring.

A handwritten signature in black ink, appearing to read 'Jeff Meilander', with a long horizontal flourish extending to the right.

Sincerely,
Dr. Jeff Meilander
Pathogen and Microbiome Institute
Northern Arizona University

Commitment to Present Research

If selected as a recipient of the Green Fund Student Research Grant, regardless of the outcome of my research project, I ___Brooke Lercher and Andrew Grusenmeyer___ commit to presenting the status of the research as described in this application in the form of an oral presentation to the Green Fund Committee or a poster exhibit presentation at the Undergraduate or Graduate Research Symposium, no more than 1 year after receiving notification of funding.

The oral presentation to the Green Fund Committee will consist of an approximately 10 minute long PowerPoint that includes the following aspects of your project; original goal and purpose of research, conflicts or changes to the original purpose, results/conclusion; all relevant graphical displays of data

Student Signature: _____

Brooke Lercher, Andrew Grusenmeyer

Thank you for your submission. We deeply appreciate your commitment to sustainability at NAU, and we look forward to reviewing your application. Please direct any further questions to GreenFund@nau.edu.

References

1. Schaefer, M., Petersen, S. O. & Filser, J. Effects of *Lumbricus terrestris*, *Allolobophora chlorotica* and *Eisenia fetida* on microbial community dynamics in oil-contaminated soil. *Soil Biol. Biochem.* **37**, 2065–2076 (2005).
 2. Aira, M., Olcina, J., Pérez-Losada, M. & Domínguez, J. Characterization of the bacterial communities of casts from *Eisenia andrei* fed with different substrates. *Appl. Soil Ecol.* **98**, 103–111 (2016).
 3. Domínguez, J., Aira, M., Kolbe, A. R., Gómez-Brandón, M. & Pérez-Losada, M. Changes in the composition and function of bacterial communities during vermicomposting may explain beneficial properties of vermicompost. *Sci. Rep.* **9**, (2019).
 4. Abbot, J. M. & Byrd-Bredbenner, C. The state of the American diet: How can we cope? *Top. Clin. Nutr.* **22**, 202–233 (2007).
 5. Edwards, C. A. & Arancon, N. Q. The use of earthworms in organic waste management and vermiculture. in *Biology and Ecology of Earthworms* 467–527 (Springer US, New York, NY, 2022).
 6. Lou, X. F. & Nair, J. The impact of landfilling and composting on greenhouse gas emissions--a review. *Bioresour. Technol.* **100**, 3792–3798 (2009).
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