The Friends of Nachusa Grasslands
2022 Scientific Research Project Grant Report
Due June 30, 2023

Please answer the following questions with clearly written summaries to give Nachusa Friends' science committee members, officers, and board members a good idea of what you accomplished using your grant money. Unless you object to the Friends doing so, your report will be uploaded into the science section of the Friends' website: nachusagrasslands.org. Donors and prospective researchers often read these reports after they are posted.

1. Please save this form to your desktop with a unique file name that includes "Friends 2022 Science Grant Report" and your last name.
2. Complete the form using the headings in bold as your guide.
3. Save the file as a Word document or a PDF.
4. Attach the file to an e-mail, and send it to: nachusafriendsscience@gmail.com no later than June 30, 2023.
5. The subject of the e-mail should be "2022 Scientific Research Grant Report" and your last name.
6. If you have not completed your work, please submit this form anyway by the June 30 deadline and plan to contact Friends after your project is complete so that we may learn from and publicize the outcomes as appropriate.

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2022 grant amount: $6,022

Research Project Topic: *Effects of ecological management on native ecosystem soil-climate interactions*

Research Project Purpose:

To quantify soil carbon concentrations and stocks, and greenhouse gas emissions of carbon dioxide, methane, and nitrous oxide in select Nachusa prairie, woodland, and wetland management units and explore patterns related to history of ecological management (degraded vs. restored) and associations with soil microbial community composition. These data will provide the first comprehensive insight into the role Nachusa ecosystems play in climate regulation and how this role is affected by management interventions.

Research Project Outcomes to date:

Our group's research envisions a climate-conscious conservation science (CCS) for the 21st century that folds in new data and scientific understanding of ecosystem-climate change interactions into existing ecological management decision making. We hope to begin building this CCS framework at Nachusa Grasslands (Figure 1).

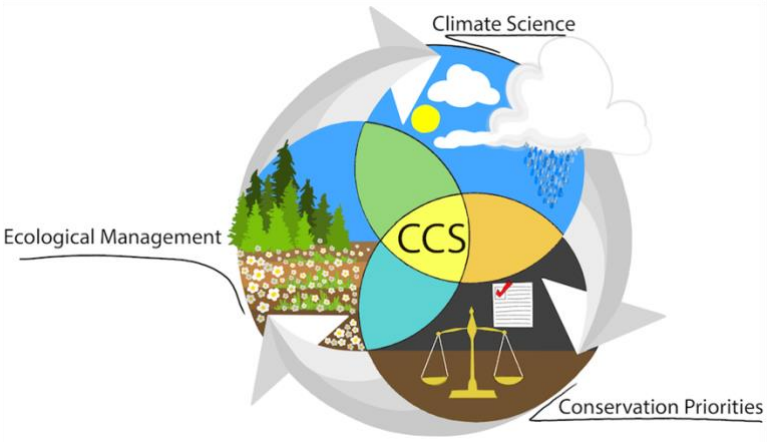


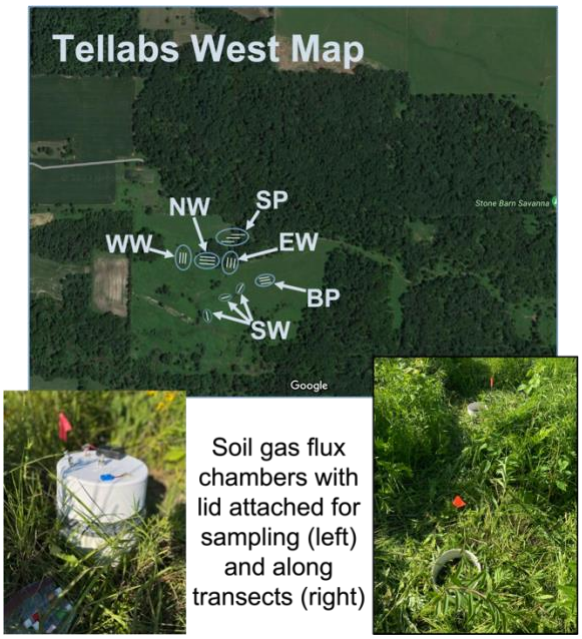
Figure 1*. Climate-conscious conservation science (CCS) informs ecological management after integrating climate knowledge with biodiversity goals.*

The first step to achieve CCS is to quantify and understand native Midwest ecosystem-atmosphere exchanges of greenhouse gases (GHG), which are the primary drivers of climate change. With this exchange data we can first compute the annual GHG balance for different native ecosystems, which is the sum of net CO2, methane (CH4), and nitrous oxide (N2O) flux (emissions or uptake) expressed in kilograms of carbon dioxide-equivalents. A positive GHG balance indicates a net release of GHG to the atmosphere, while a negative GHG balance indicates net uptake. Most ecosystem exchange research has focused on CO2, but information on all three primary GHGs are required for GHG balance calculations because CH4 and N2O exchanges have disproportionate warming/cooling effects relative to CO2 despite both fluxes being smaller in mass.

<u>Our proposed research project thus had three goals:</u>

1. To quantify soil-climate interactions across the dominant native ecosystems at Nachusa grasslands;
2. To test whether ecological management has a significant effect on soil-climate interactions;
3. To explore statistical interactions between ecological management effects, hydrological gradients, and soil microbiology.

Due to a lack of appropriate control (non-restored) units at Nachusa Grasslands, we were not able to set up an experiment to test treatment (restored) vs. control (non-restored) units (**Goal 2**).



However, we have been able to make progress on **Goal 1 and 3**. We made soil greenhouse gas flux measurements across wetland, woodland, and prairie units at Tellabs West. We also made measurements and/or collected soil samples for soil moisture, temperature, microbial community, and carbon content as both explanatory data.

Figure 2*. (Top) Map of ecosystem chamber transects at Tellabs West in woodlands (WW, EW), prairies (BP, SP), and wetlands (NW, SW).*

GOAL 1: From monthly soil flux chamber measurements (July – October) we have found that across all ecosystems, soil was a (**Figure 3**):

- Carbon dioxide (CO2) source
- Methane (CH4) sink
- Variable Nitrous oxide (N2O) source/sink

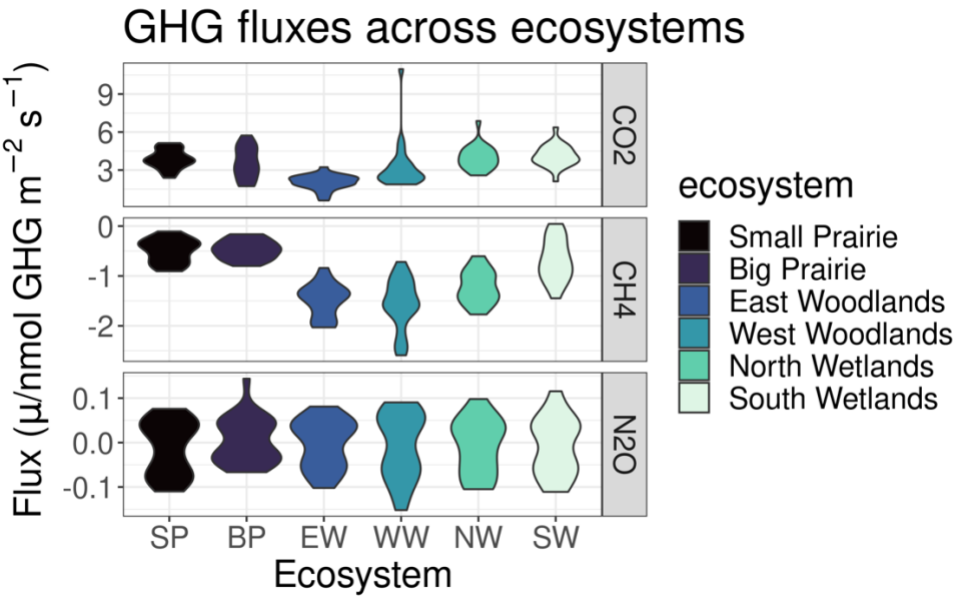


Figure 3. *CO2 fluxes are consistently positive, CH4 fluxes are consistently negative or neutral, and N2O fluxes range from slightly negative to slightly positive. One exceptionally high CO2 emission rate was observed while an ant hill was present in a chamber base. The strongest methane uptake rates were observed in the woodlands.*

Preliminary finding: Nachusa prairies, wetlands, and woodlands are therefore likely to be sinks of CH4 and slight sources/sinks of N2O at an annual timescale. Due to photosynthetic uptake of CO2 in plants, Nachusa ecosystems are likely provide an overall climate cooling service.

GOAL 3 A: Elevation effects

We found variable effects of elevation within each ecosystem cover type. In most ecosystems CO2 flux decreases as one moves downslope, however, in the North Wetlands, CO2 flux increased at the bottom of the slope (Figure 4; next page).

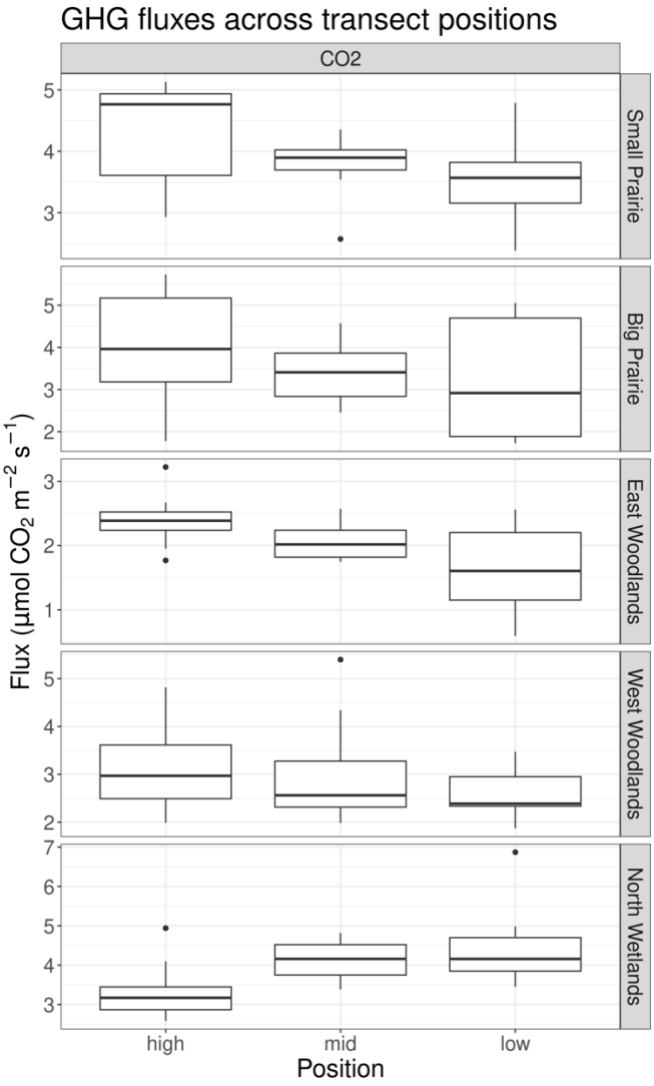


Figure 4. *CO2 flux patterns across slope elevation gradients within each ecosystem cover type. South Wetlands are not shown as there is no consistent slope.*

B: Moisture Effects

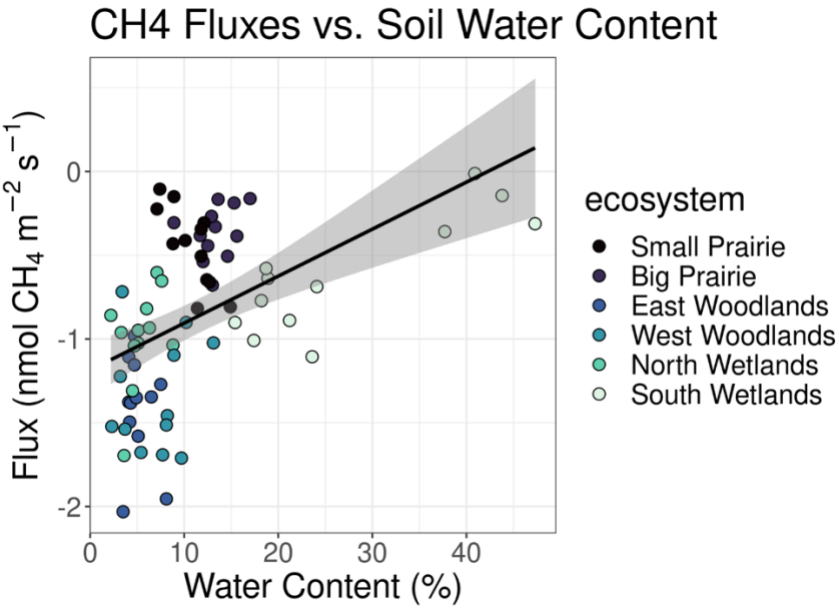
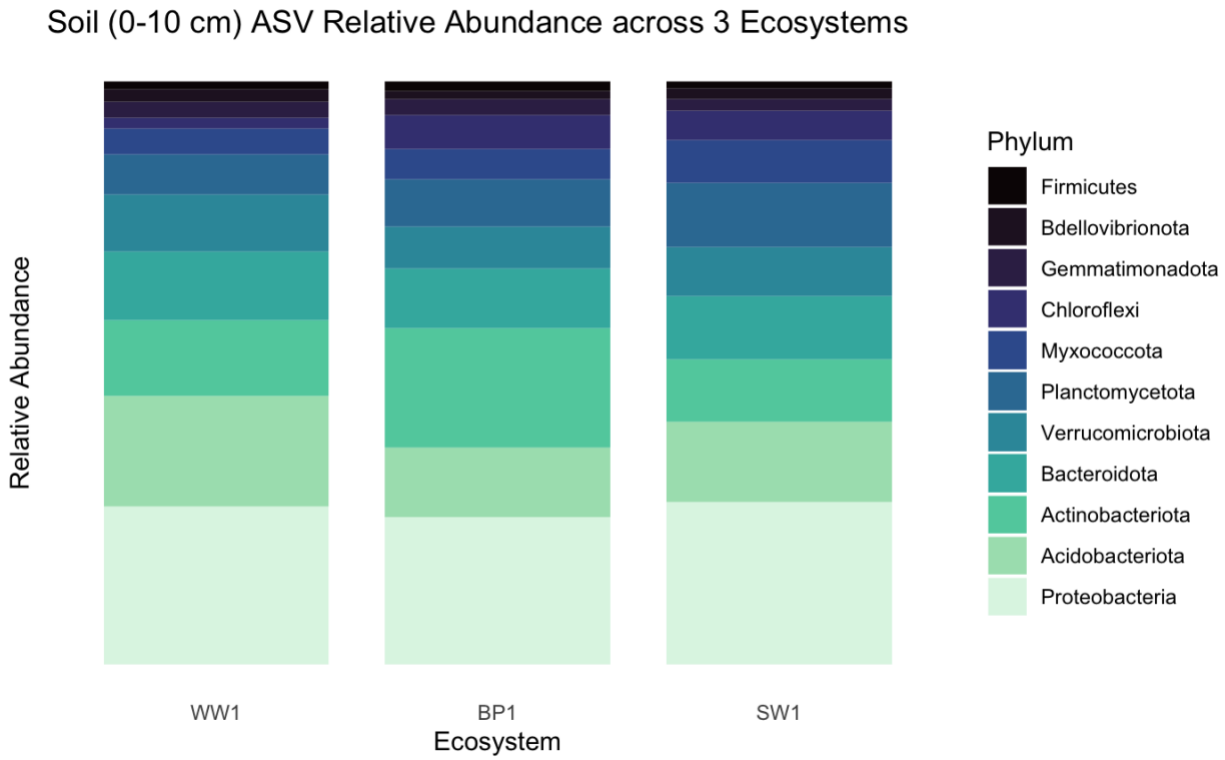


Figure 5. *Effect of soil moisture on soil CH4 flux rates.*

Preliminary findings: CH4 uptake increased (more negative fluxes) at low soil moisture (Figure 5). Surprisingly, even the wettest locations showed net uptake or zero CH4 emissions, despite saturated conditions that normally cause net CH4 emissions.

C: Microbial community relationships



Preliminary findings: Microbial communities were dominated by **oxygen-loving Proteobacteria and Acidobacteria** that can break down organic matter and fix and cycle soil nitrogen. **Verrucomicrobiota**, a phylum including newly-discovered soil methane consumers, was identified.

We have not yet conducted the statistical analyses required to determine differences across ecosystem cover types.

Describe how the grant funds you have received from the Friends of Nachusa Grasslands have been used in regard to the above topic, purpose, and/or outcomes:

The funds we received supported the building of soil flux measurement chambers, monthly travel to and from Nachusa Grasslands from UIC for the lab manager Jack Brieter (who used his personal vehicle) and several undergraduates, including two who identify as students of color and for whom this was their first field research experience. Michael Yonker led the analysis of these data and presented a poster on the study for his Honors College capstone presentation at the UIC Undergraduate Research Forum.

Describe how your project has benefited the work and goals of Nachusa Grasslands:

Thus far, we have only acquired flux data for Nachusa grasslands, woodlands, and wetlands with a consistent and long-term management history. Our preliminary finding that these cover types under current management are functioning as net greenhouse gas sinks is encouraging. We are interested to explore whether TNC management practices that favor high biodiversity and ecosystem health may be helping to limit excess GHG production, perhaps via a tight nutrient cycle (i.e., a lack of eutrophication). With further work, we hope to able to identify the mechanistic basis of these favorable GHG fluxes.

Describe how your findings can be applied to challenges in management practices for restoration effectiveness and species of concern:

Our preliminary study hopes to contribute to questions of these sort in the future, however, our baseline work to date does not provide any specific management recommendations. One other direction we hope to pursue is to understand the specific effects of faunal communities (ants, crayfish, bison, etc.) which may appear to be hot spots of emissions at the scale of individuals/communities, however, at an ecosystem scale may help sustain high ecosystem carbon and tight nutrient cycling.

Please list presentations/posters you have given on your research:

Yonker, M. McNicol, G. Effects of ecosystem type and environmental gradients on native Midwest ecosystem-climate interactions. **University of Illinois Chicago Undergraduate Research Forum.** *April 18, 2023 (Honors College)*

Yonker, M. et al. Effects of ecosystem type and environmental gradients on native Midwest ecosystem-climate interactions. **2023 Nachusa Science Symposium.** *April 22, 2023*

Have you submitted manuscripts to scientific journals? If so, which ones? If not, do you anticipate doing so? (Please send digital copies of published articles to the Friends so that we can learn from your work.**)**

Not yet. These data will form the basis of a proposal to the Walder Foundation Biota Award in October 2023, and the National Science Foundation CAREER award in 2024.

In addition, after 2-3 years of gas flux measurements, we aim to publish these data in a manuscript in a journal such as *Plant and Soil, Ecosystems,* or *the Journal of Geophysical Research: Biogeosciences.*

What follow-up research work related to this project do you anticipate (if any)?

We are currently supported by Friends of Nachusa Grasslands to continue gas flux measurements into 2023. We are developing and testing the measurement of plant photosynthesis rates to understand the overall CO2 balance, rather than focusing only on soil respiration as we did in 2022. Due to the height of the forest canopy, we may explore additional funding to acquire tower-based eddy covariance flux measurements in the future.

<u>Optional</u>: Suggestions for improving the application and award process for future Friends of Nachusa Grasslands Scientific Research Grants: