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: $4,500

Research Project Topic: A survey of crayfishes of Nachusa Grasslands with effects of tallgrass prairie restoration on burrowing crayfish presence/abundance.

Research Project Purpose:

Burrowing crayfish are one of the most understudied and threatened freshwater taxa in the world, with over 30% listed as threatened and 21% as data deficient. What little information is known on burrowing crayfish suggests that fine scale habitat variation may drive burrowing crayfish localities. The goal of this project was to determine crayfish species diversity at the Nachusa Grasslands, and to quantify the

fine-scale habitat associations that drive local biogeography of the burrowing crayfish community.

We evaluated the fine-scale habitat variables that may influence crayfish presence and abundance within 6 sites with both remnant and restored habitat. We documented quadrat specific habitat variables in locations throughout Nachusa with both established and absent burrowing crayfish populations. These quadrat specific variables have been purported to drive burrowing localities. In addition, we conducted field surveys to determine what non-burrowing crayfish species occur in permanent water bodies at Nachusa.

Research Project Outcomes to date:

To conduct the species surveys at Nachusa, 8 wetland-prairie sites and 5 stream sites were selected (Table 1). These sites consisted of wetland, prairie, and stream sites to survey all possible crayfish habitats at Nachusa. Burrow surveys and excavations were done using hand trowels at the 8 wetland-prairie sites. These sites had varied restoration progress from remnant to recent secondary succession. All wetland-prairie sites except for sites 5, 7 and 8, contained active burrowing crayfish communities. Sites 7 and 8 were not used in the subsequent fine-scale habitat association study, but site 5 was used as a control site. Mist net traps were set in a total of 19 burrows throughout the 8 wetland-prairie sites for 48 hours, no crayfish were caught using this method. The 5 stream sites were sampled with the kick seine method, using a 10' minnow seine. Within stream sites, the minnow seine was placed immediately downstream of rock substrate, woody debris and/or vegetation. Those substrates were vigorously kicked to dislodge any crayfish into the seine. In total, one invasive and three native species were found to inhabit Nachusa and identified as *Faxonius rusticus* (invasive), *Faxonius propinquus, Faxonius virilis,* and *Lacunicambarus nebrascensis* (Table 1).

To conduct the fine-scale habitat associations study at Nachusa, 6 of the wetland-prairie sites surveyed for crayfish species were selected. The variables collected at each site were documented on both a quadrat specific and burrow specific scale using a $1m^2$ PVC quadrat. Quadrat specific variables include: average water table depth, soil texture at average water table depth, canopy cover, bare ground cover, root biomass, and dominant vegetation by family. Burrow specific variables were collected using a larger $9m^2$ quadrat area, due to the limited number of burrows present in the $1m^2$ quadrat. We did this by flipping the $1m^2$quadrat around the perimeter of the initial quadrat area, summing the number of burrows within each section. Burrow specific variables include: burrow presence and abundance, and burrow opening descriptions. Within each site baselines were set along the lowest point in the site and transects were placed running on alternating sides perpendicular to the baseline. 6 quadrats were placed 20 meters apart along every transect. Data was recorded at every quadrat and analyzed at the lab.

The habitat variable data was analyzed using Generalized Linear Mixed Models (GLMM). This method was chosen to account for both the random and fixed effects encountered during field collection. A total of 21 models were created with a combination of the variables collected to determine what variables affected burrow presence and abundance. Both binomial and poisson distributions were used to account for presence and abundance data recorded for burrows.

Of the 21 models created, the top models were Model 1 for the binomial analysis and Models 5 and 6 in the poisson analysis (ΔAICc < 2.5) (Table 1). The habitat associations for burrowing crayfish presence and abundance were very similar. The habitat variable with the most influence, as indicated by Model 1 and Model 6, was the average water table depth (wt; Table 2 & 3). The average water table depth was negatively associated with both burrow presence and abundance (Table 3). Root biomass and vegetation cover were positively associated with burrow presence, though not significantly (Table 3). Model 2 was a top model for the binomial analysis, which included root biomass, vegetation cover, and average water table depth, however, the only variable of significance was the average water table depth (Table 3). Model 5 was a top model for the poisson analysis, which included restoration status of the site and average water table depth, but the average water table depth was the only significant variable (Table 3). Restoration status was positively associated with burrow abundance but not significantly (Table 3).

Based on the models and field data collected over the 2022 field season, shallow water table depth was a significant driver of burrow presence and abundance within Nachusa. These findings are consistent with observations and underlying theories purported by other burrowing crayfish studies, but this is the first study to specifically target and support this theory. This was also the first study to use root biomass as a driver for burrow presence and abundance. While root biomass and vegetation cover were not significant drivers, they did show up in the final models, indicating some level of influence but not a significant one. This is the first study to use both variables for burrowing crayfish habitat association indicators. Additionally, there was correlation with the age of restoration and positive burrow abundance, with the highest burrow abundance being recorded at sites with remnant habitat (Figure 1).

Tables

Table 1: Sites at Nachusa that were surveyed for crayfish species. The site number, coordinates, details of the site location and the crayfish species found are listed. Sites 1-8 were wetland-prairie sites sampled during the species survey. Sites 1-6 were sampled during the habitat assessment study, sites 7 and 8 were not used after the species survey found no crayfish. Sites 9-13 were stream sites sampled.

Site Number	Coordinates	Site Description	Species Present
Site 1	41.88899, -89.35102	Rolling Thunder/Ed's Knob	*Lacunicambarus nebrascensis*
Site 2	41.88255, -89.35601	Prairie Potholes	*Lacunicambarus nebrascensis*
Site 3	41.882816, -89.35989	Fen	*Lacunicambarus nebrascensis*
Site 4	41.89319, -89.326012	New plot with deer blind, off Stone Barn Rd.	*Lacunicambarus nebrascensis*
Site 5	41.9021, -89.342553	Holland Prairie	No Crayfish Found
Site 6	41.89309, -89.37775	Tellabs West	*Lacunicambarus nebrascensis*
Site 7	41.89454, -89.324173	Wetland in new plot with deer blind off Stone Barn Rd.	No Crayfish Found
Site 8	41.8732921, -89.3499	Bivins Unit	No Crayfish Found
Site 9	41.8813, -89.35896	Tributary to Franklin Creek near Fen	*Lacunicambarus nebrascensis*
Site 10	41.92157, -89.3489	Orland East, Babbling Brook	*Faxonius rusticus* (invasive) *Faxonius propinquus* *Faxonius virilis*
Site 11	41.90465, -89.33691	Gobbler Ridge, Clear Creek	*Faxonius rusticus* (invasive) *Faxonius propinquus* *Faxonius virilis*
Site 12	41.86654, -89.36514	Franklin Creek off Naylor Rd. Bridge crossing	*Faxonius propinquus* *Faxonius virilis* *Lacunicambarus nebrascensis*
Site 13	41.89293, -89.325081	Tributary to Clear Creek next to new plot with deer blind, off Stone Barn Rd.	*Lacunicambarus nebrascensis*

Table 2: Akaike's Information Criterion adjusted for small sample size (AICc), Akaike weights (w_i), and log likelihood (LL) for the top habitat models (ΔAICc < 2.5) from a suite of variables modeled with a generalized linear mixed-model analysis for burrowing crayfish presence (Binomial Models) and abundance (Poisson Models). Average water table depth (wt), root biomass (biomass), and vegetation ground cover (vegcov). The * indicates the best predictive model from the suite.

Model Number	Model Variables	AICc	ΔAICc	LL	Wi
	Binomial GLMM				
Model #1	wt	160.1	0.00	-77.01	0.668
Model #2	biomass+vegcov+wt	162.6	2.49	-76.16	0.192
Model #3	null	190.1	30.0	-93.03	0.000
Model #4	global	172.6	12.5	-71.13	0.001
	Poisson GLMM				
Model #5	restor+wt	395.7	0.00	-191.6	0.531
Model #6	wt	396.5	0.79	-194.1	0.358
Model #7	null	421.3	24.8	-207.6	0.000
Model #8	global	408.2	13.2	-163.8	0.001

Table 3: Model-averaged parameter estimates for the top models for burrow presence and abundance within Nachusa. Models selected from a suite of variables modeled with a generalized linear mixed-model analysis for burrowing crayfish presence and abundance. The * indicates significant predictor variables.

Model Variables	Model-averaged estimate (SE)	95% CL	P(>|z|)
Binomial Model			
Average Water Table Depth	-1.658(0.380)	-2.337, -0.837	1.43e-05*
Root Biomass	0.241(0.231)	-0.211, 0.694	0.299
Vegetation Cover	0.143(0.228)	-0.304, 0.589	0.533
Intercept	-1.912(0.532)	-2.925, -0.825	0.000356*
Poisson Model			
2010's Restoration Sites	-0.236(0.643)	-1.497, 1.025	0.716
1990's Restoration Sites	0.6844(0.3805)	-0.061, 1.430	0.074
Average Water Table Depth	-1.288(0.311)	-1.884, -0.787	3.48e-05*
Intercept	-0.406(0.391)	-1.160, 0.308	0.302

Figures

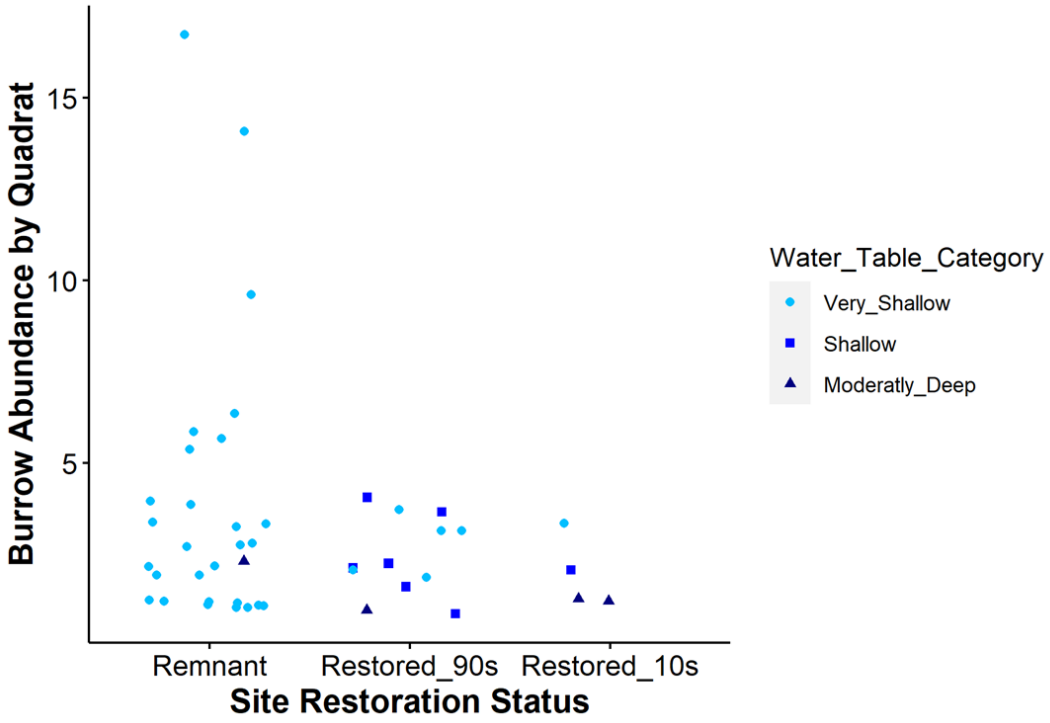

Figure 1: Quadrats with positive burrow abundance in relation to the restoration status of the site and the water table measurement taken at the quadrat. This graph shows a clear correlation with very shallow water table access (0-10 inches in depth), when compared to shallow (10-20 inches) and moderately deep (20-35 inches) water table depth. In addition, increased burrow abundance was recorded at sites of remnant habitat than those of secondary succession.

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:

Grant funds were used for study materials and to facilitate several trips to Nachusa for field sampling. In addition, funding was used to provide one month of graduate student stipend to conduct this study.

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

Burrowing crayfish species are linked to prairie and wetland habitats. However, little is known about their habitat associations which can help to inform conservation on these organisms. Understanding more about the biogeography of these prairie/wetland organisms helps to preserve, protect, and spur research collaborations to conserve species diversity found within the Nachusa Grasslands and similar endangered ecosystems.

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

While no burrowing crayfish species are listed as species of concern, they are an essential part of the prairie and wetland ecosystem, providing habitat for species of dragonflies and amphibians. They also provide ecosystem functions such as soil mixing. The continuation of research into the habitat associations of burrowing crayfish can be applied to several non-crayfish species across the Nachusa landscape and inform management for future seeding, hydrological manipulations, and mowing.

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

Carlson M. C., Swedberg D. A., & Taylor, C. A. (2023), Fine-scale habitat associations as predictive measures for a unique semi-terrestrial species. Oral Presentation. NRES Research Symposium. 03-04-2023. NRES department faculty, staff, and graduate students.

Carlson M. C., Swedberg D. A., & Taylor, C. A. (2023), Fine-scale habitat associations as predictive measures for a unique semi-terrestrial species. Poster Presentation. The Nachusa Science Symposium. 04-22-2023. Friends of Nachusa Grassland, The Nature Conservancy and Nachusa researchers.

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.**)**

No publications have been submitted to date. However, a working manuscript is being revised and will be sent for journal review in the coming months.

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

Field work is currently underway for the 2023 research grant project entitled “Predation on burrowing crayfish at Nachusa Grasslands”. This project’s goal is to determine the predation dynamics between burrowing crayfish and their predators within Nachusa. This project is being conducted at the same 6 sites selected in the 2022 grant research project described above and is a continuation of that project.

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