Prairie Learning: Integrating the Arts and Environmental Education with Ecological Restoration in Ann Arbor, Michigan

by

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A practicum submitted

in partial fulfillment of the requirements

for the degree of

Master of Science

(Environment and Sustainability)

in the University of Michigan

April 2024

Practicum Advisor:

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Abstract

This practicum was centered around the ecological restoration of study plots located in a former athletic field of non-native turf grasses at the Freeman Environmental Education Center in the Ann Arbor Public School District in Ann Arbor, Michigan. The objectives of the project included increasing the biodiversity and ecological function of the site by creating the beginnings of an educational prairie in study plots, using ecological restoration as a tool for environmental education and fostering human-land relationships, providing a management plan for restoration expansion based upon observations of the plots, and integrating the arts as a key component of restoration and environmental education practices. Site preparation methods tested included smothering and repeated tilling to eradicate turf grass, and propagation methods included planting native seedlings and broadcasting native seed mixes. Environmental education curriculum and programming for K12 students was developed and implemented throughout the process. This included the development and implementation of an educational module which culminated in a collaborative sculpture built with students who learned about prairie ecosystems and stewardship. This educational module was developed to be place-based, interdisciplinary, exploratory, collaborative, and multi-sensory. The final component of this project was a children's book written and illustrated to tell the story of a community of humans and other animals who work together to restore a prairie. The book is a tool for people of all ages to learn about prairie restoration and stewardship, and includes an educational guide to promote further action.

Acknowledgements

As an ecologist, I am always viscerally aware of the importance of communities— of energy webs, mycelial networks, symbiotic interactions on every trophic level. My "independent" Master's Practicum would not have been possible without an entire community of wonderful beings.

Thank you to my advisor Sara Adlerstein-Gonzalez for being an effervescent source of wisdom and helping me to see the infinite possibilities that lie in connecting ecology with education and the arts. Thank you for reminding me to dream bigger whenever I forgot how to. Thank you to my mentors at the Freeman Environmental Education Center, Coert Ambrosino and Dave Szczygiel, for being such imaginative and inspiring collaborators on every step of this project, and for teaching me so much about how to be a thoughtful and kind educator. It has been an honor shaping a small part of the Freeman Center alongside you both.

Thank you to the community of people who helped build the beginnings of an educational prairie at the Freeman Center with me. Thank you to my former advisor Robert Grese, for connecting me to the Freeman Center and for igniting my passion for prairie restoration with your life's work. Thank you to Nate Hatt for co-facilitating the first iteration of *Deeply Rooted* with me, and thank you to all 48 students who participated; I hope you learned as much from me as I did from you. Thank you to the students in the Freeman Environmental Youth Council for growing alongside me, especially to Eliana, Charlie, Quinn, and Helen for assisting with the *Deeply Rooted* lessons. Thank you Bridget Quinn and Steve Panton and members of the Questions of Curating in Ecology workshop in 2020 for giving me the space to germinate the ideas behind this project. Thank you David Mindell for your guidance and insight into the science of prairie restoration. Thank you Bill Schneider of Wildtype Native Plant Nursery for so generously sharing your seedlings and wisdom with countless students and educators. Thank you Michigan Wildflower Farm for creating our prairie seed mixes with so much care, and thank you Greg Marker for lending us your tools. Thank you to all of the friends who donated their old jeans for the creation of *Deeply Rooted.* Thank you Julius, Mary, Mia, and Maria for helping me edit *We Planted a Prairie*, and Carl for encouraging me to pursue a Master's while working full-time. Thank you Chris, Fatema, Eliana, Dani, Anisha, Aidan, Akhil, Adam, Sloan, Evan, and Dominic for planting seedlings and sowing seeds for the future with me.

Thank you to my Ma and Baba for your undying support and love, for crossing oceans and building bridges for my entire life for me, for raising me to listen to our Earth. Thank you to my brother Ishan for being a constant source of comfort and joy, for being my best friend for life. Thank you Dominic, for loving me and loving this Earth so deeply alongside me. Thank you to all of my friends who I consider to be my family, for the relentless encouragement and care you have offered me over this journey. As Robin Wall Kimmerer writes, "All flourishing is mutual," and I could not flourish without each and every one of you: Rima, Titi, Deniz, Kiki, Trina, Rashmi, Khanh San, Evan, Cam, Skyler, Sahana, Ian, Kara, Logan, Ava, Cassandra, Jenny, Adam, Eric, Shane, Mishi, Mishka, all of my Mashis and Kakus, the Field St. house, and so many others. Thank you to the students of all ages I've gotten to learn with over the last several years. Thank you to my ancestors. Thank you to Chicory for giving me the kind of companionship only a cat could give.

Thank you to you, who care enough about the state of our world to be reading this. Thank you for caring about the past, present, and future of our native grasslands. Thank you to the generations of Indigenous people of Turtle Island who have stewarded the land that has raised me. I am forever grateful to the Great Lakes, the peninsulas, the forests, the oaks, the birds, the monarchs, the milkweed, the seeds, and of course, the prairies.

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Land Acknowledgement

The entirety of this project was conceived, planned, implemented, and conducted in collaboration with lands that are the ancestral and contemporary homelands of the Anishinaabe peoples, or the peoples of the three fires: the Ojibwe, Odawa, and Potawatomi nations, as well as the Fox, Peoria, and Wyandot Nations, who have lived on and stewarded this land surrounding the Great Lakes for generations. This project would not be possible without the stewardship, knowledge, and contributions of Indigenous peoples. Many Indigenous groups, including the Anishinaabeg, refer to what is called North America as Turtle Island. The continent of North America is referred to as Turtle Island in this report as a reminder to readers that the site of this restoration project sits on stolen Indigenous land. The native grasslands of Turtle Island would not have existed to the extent they did for millennia before European colonization without Indigenous stewardship. The drastic decrease in remaining native grasslands is also a direct result of the theft of land from Indigenous peoples. I am grateful and honored to be a guest on this land, and also recognize the responsibility that all of us who live on stolen land bear to return land to Indigenous stewardship.

Introduction

The purpose of this project was to examine and demonstrate the benefits of integrating environmental education and the arts with the processes of ecological restoration. This was done in collaboration with the Freeman Environmental Education Center within the Ann Arbor Public School District in Ann Arbor, Michigan.

Ecological restoration is defined by the United Nations Convention on Biological Diversity as the process of managing or assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed as a means of sustaining ecosystem resilience and conserving biodiversity (CBD, 2016). In the context of this project, ecological restoration is used as a tool to convert a former athletic field of non-native turf grasses and other vegetation at the Freeman Environmental Education Center into a native prairie plant community that provides more ecological benefits and increased biodiversity. As this field is functionally similar to conventional lawns, this allowed for an exploration of the conversion of lawns to native prairies.

The origins of the modern lawn in the United States can be traced back to European gardens in the 1600s, especially in England and France. Grassy fields were neatly trimmed by hand by laborers or by grazing animals as a show of social status and wealth, and the need to control natural landscapes (Byrne, 2005). Lawn grasses were brought to Turtle Island in the 1700s by European settlers, and by the mid-1800s as railways started to expand, the green lawn was being promoted by landscape architects as an ideal aesthetic in front of suburban homes (Schroeder, 1993). The development of more efficient lawn mowers (Schroeder, 1993), the promotion of irrigation systems, fertilizers, and pesticides as necessary upkeep materials by lawn care companies (Robbins & Sharp, 2003), and the continued idealization of the lawn as a pinnacle of homeowner and community pride have led to lawns becoming a cultural norm in the United States. Laws, rules, and regulations put in by local governments and homeowner organizations further promote the idealized lawn by restricting the height of vegetation in order to maintain property values (Jenkins, 1994).

Lawns cover approximately 23% of developed land (Robbins & Birkenholtz, 2003), and as of 2005, an estimated 163,812 km^2 of lawns covered the continental US-- an area three times larger than any irrigated crop (Milesi et al., 2005). From an ecological perspective, the cultural norm of the idealized lawn has been detrimental in various ways. Lawns provide little herbaceous biodiversity compared to native grasslands, and have led to an emerging homogenization of species across urban and suburban landscapes (Wheeler et al. 2017). Kentucky bluegrass (*Poa pratensis*), Bermudagrass (*Cynodon dactylon*), and perennial ryegrass (*Lolium perenne*) are some of the most commonly used turfgrasses across the continental US, and most species found in US lawns are non-native and non place-specific, meaning they do not serve as optimal food, habitat, and nectar sources for native fauna (Wheeler et al. 2017). Lawn pesticides are applied on a scale to rival agricultural toxins; in the US, almost 80 million pounds of pesticides are used annually on lawns (Grube et al., 2011). These pesticides have been linked to global insect decline (Forister et al., 2019) and are leading to watershed pollution (Milesi et al., 2005). Lawns are also highly water-intensive developments, especially in arid and semi-arid regions where lawns can account for 75% of total household water consumption (Mayer et al., 1999).

However, lawns also hold potential as sites for ecological restoration and community engagement. A large percentage of lawns are under private ownership by homeowners and business owners, and there have been recently emerging movements towards creating more ecologically sustainable alternatives to the idealized lawn. For example, No Mow May emerged in 2019 in the UK as a way to increase food sources and shelter for pollinators in the spring, and gained popularity as an initiative in the US in 2020 (Del Toro, 2020). Homeowners and communities can now apply to the National Wildlife Federation (NWF) for NWF Wildlife Certified Habitat status if they provide food, water, cover, and places to raise young for wildlife (Cubino et al., 2020). Certified participants can elect to install signs that aim to raise awareness and encourage others to also participate in a movement towards more ecologically friendly practices. Schools and public institutions are also increasingly incorporating pollinator gardens, rain gardens, and other native plantings into their landscapes.

At the FEEC, the field of turf grasses or conventional lawn grasses was seen as an opportunity to demonstrate grassland restoration practices to increase biodiversity and ecological functioning in a historically relevant way. According to General Land Office surveys conducted between 1816 and 1856, the site of the FEEC was predominantly a Black Oak Barren ecosystem prior to being converted to agricultural land use after 1820 (FEEC, 2020). Oak barrens, also called oak savannas, are a type of grassland dominated by oaks, having 5-60% tree cover, sometimes with a shrub layer (Cohen, 2001). The ground layer of oak barrens consist of mostly grasses and forbs, as in prairies, which have few to no trees. Oak barrens historically covered 719,042 acres, or an estimated 1.9% of Michigan in the 1800s. 9% of Washtenaw County was historically covered by oak barrens. Today, only a few hundred acres of oak barrens remain, constituting less than 0.00005% of Michigan's present land cover (Cohen, 2001). Native grasslands of Turtle Island, including prairies and savannas, are critically endangered ecosystems on a broader scale as well. Once covering approximately 162 million hectares of the continent, less than 1% of native prairies remain today, making the prairies of Turtle Island a globally endangered ecosystem (Sampson & Knopf, 1994). Oak barrens and prairies have been cleared for sand mining, agriculture, and urban and residential development. Especially when compared to traditional lawns, native grasslands hold immense capabilities for water absorption and flooding control, erosion control, and carbon sequestration. Native grasslands are also highly fire-dependent ecosystems; although lightning strikes are one of the catalysts for fires in prairies, historically, oak barrens and savannas were maintained through the intentional use of fire by Indigenous peoples (Day, 1953; Chapman, 1984). As Indigenous stewardship was replaced by European settlers on the land, and fire suppression policies and further suburban development in the 1920s led to a decrease in the frequency and intensity of fire in the landscapes across Turtle Island, most of the remaining oak barrens that were not cleared for the purposes listed above went through ecological succession and turned into shrubland or forests (Abrams 1992, Chapman et al. 1995). Intentional burning has emerged more as a stewardship practice in recent years in Washtenaw

County, with prescribed burns taking place in various county and city-managed natural areas.

This project aimed to not only demonstrate grassland restoration practices, but also incorporate environmental education into the process of restoration for students of all ages. As this project is a collaboration with the Freeman Environmental Education Center, this presented various opportunities to develop and integrate curriculum and teaching opportunities for K12 students. Engaging youth in environmental education has been shown to lead to increased pro-environmental behaviors as well as a more ecologically informed sense of place (Kudryavtsev et al, 2012). When youth participate in environmental education programs, the link between their awareness of community and connection with their environment is strengthened, especially in place-based education (Tuntivivat, 2018). Furthermore, environmental education that is specifically hands-on and interactive has been found to be more engaging and effective in increasing youth pro-environmental behaviors (Ison & Bramwell-Lalor, 2023). These principles influenced the approaches used in developing curriculum and ecological restoration programming throughout the course of this project.

The integration of the arts in ecological restoration and environmental education has also been an important underlying approach throughout the course of this project's completion. Integrating the arts is an extremely beneficial component of all educational initiatives, but in the context of environmental education, the arts can be a powerful way to connect with youth's creativity which is required for solving modern complex environmental problems (Wojciehowski & Ernst, 2018). The arts also play an important role in connecting humans with the environment, which is one of the most fundamental goals of environmental education (Ison & Bramwell-Lalor, 2023). Environmental art, sometimes also called "eco-art," can be defined as "any artwork that aims to stimulate awareness of people's relationship with nature as well as art which prompts discussion and/or action around environmental issues" (Marks et al., 2016). This principle of using the arts as a tool of environmental stewardship and engagement was a core element of this project.

Goals

This project was conducted over the span of 2020-2024 in collaboration with the Freeman Environmental Education Center, and had several ecological and educational objectives, which can be summarized as the following:

1. Increasing the biodiversity and ecological functioning of the site at the Freeman Environmental Education Center (FEEC) through demonstrating methods of ecological restoration in study plots
2. Utilizing ecological restoration as a tool for place-based interdisciplinary environmental education of K12 students and the public, fostering human-land relationships and increasing pro-environmental behaviors
3. Providing a management plan for future restoration expansion at the FEEC based upon observations of the study plots to continue making ecological enhancements that improve environmental education programming opportunities on site
4. Integrating the arts as a part of ecological restoration and environmental education practices

To accomplish these goals, this project consists of three main interdisciplinary components: an ecological restoration management plan and implementation, environmental education curriculum development and implementation, and the integration of the arts in various stages of all of these processes, including through creating a children's book and building a collaborative outdoor sculpture with students.

History of the Freeman Environmental Education Center

The Ann Arbor Public Schools (AAPS) Environmental Education program was launched in 1959 as an initiative to support and enhance classroom curriculum through experiential environmental learning. Bill Stapp, a graduate of the University of Michigan's School of Natural Resources and the Environment (now known as the School for Environment and Sustainability), was the first hire in the AAPS Environmental Education department, and his graduate thesis laid the framework for the AAPS Environmental Education programming that continues today (Stapp, 1965). Stapp's work in the field of Environmental Education sparked inspiration locally, nationally, and internationally. At this time, he and his colleagues defined environmental education's aims as leading to students who are "knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution." (Stapp, 1969). This included the principle that humans are inseparable from our environment and the ecosphere, and the 5 tenets of environmental education that are still used today: Awareness, Knowledge, Attitudes, Skills, and Participation (Stapp, 1969).

The current Freeman Environmental Education Center (FEEC) site was rededicated as such in 2018, and this site now houses the school district's Environmental Education program office. The site is used for environmental education field trips, professional development, and other educational activities. As of the 2023-2024 school year, approximately 10,000 students participate in AAPS Environmental Education programming every year, with a portion of those programs conducted at FEEC (over 100 classes). Some of the environmental education field trips that take place on site include "Plant Communities" studies for 2nd graders, "Winter Survival" for 5th graders, Forestry trips for high schoolers, Freeman Environmental Youth Council meetings and programming, service learning events, and the Ann Arbor Recreation and Education "A2 Nature Guardians" summer day camp.

Ecological Restoration Plan

Land History and Site Selection

The Freeman Environmental Education Center (FEEC) is a 40-acre site owned by Ann Arbor Public Schools located in Superior Township, Washtenaw County, Michigan. The building was originally built and functioned as a school, then leased to an outside organization for several years, and finally rededicated as the FEEC in 2018. Today, the site is used for Ann Arbor Public Schools Environmental Education field trips and other educational activities.

According to General Land Office surveys conducted between 1816 and 1856, the site of the FEEC was predominantly a Black Oak Barren ecosystem prior to being converted to agricultural land use after 1820 (FEEC, 2020). Since being converted to agricultural use, aerial footage shows that between 1944-1966, the FEEC site consisted of mostly agricultural fields. 1979 aerial imagery shows the main building of the current FEEC which was built throughout the 1950s and 1970s, and the emergence of old fields and scrub-shrub ecosystems (FEEC, 2020). Today, the site of the FEEC consists of a combination of paved areas, lawn, old field, early successional areas, disturbed Oak-Hickory forest, scrub-shrub, and wetland areas (FEEC, 2020).

When selecting a site for the FEEC educational prairie plots for this project, various factors were considered. After considering multiple options, the site chosen had lawn cover, has a 0-5% topographical slope, is located in full sun exposure, and has Fox sandy loam, till plain soil type. The Fox series of soils are well-drained, slightly droughty, with slow runoff (Soil Survey Staff, 2011), and formed in areas of sandy outwash, outwash plains, and glacial moraines. Oak barren communities are generally found on sandy soils derived from glacial outwash and moraines (Curtis 1959), and the soils in them vary from sand to sandy loam to loamy sand (Haney & Apfelbaum, 1993). Therefore, the soil and sun conditions on site were aligned with what is typically found in Oak Barrens and prairies, and the existing lawn cover provided a basis to test the conversion of lawn to native prairie.

The restoration area for this project was created in April 2021 as five square-shaped study plots, each measuring 25 ft. by 25 ft. The study plots are located within a large field that was formerly used as an athletic field when the site of the FEEC functioned as an elementary school. The entire field has been under a no-mow protocol since 2019 (aside from a few mowed pathways to allow for access for the public as well as students and staff members of the FEEC), and covers approximately 10 acres. The no-mow protocol was established in order to create additional cover for insects, birds, amphibians, and mammals, and to enrich learning opportunities for students. The field was mowed once in Summer 2021 with a "brush hog," with the goal of keeping invasive plants such as spotted knapweed (*Centaurea stoebe*) from self-seeding. The site of the restoration study plots within the field was also chosen for being adjacent to the established mowing pathway. The location of the plots provides visibility and proximity to the FEEC building, has various options of expansion for the future, and is accessible for environmental education programs and field trips hosted at the FEEC. The plots are also located in close proximity to the pergola on site that was used for the Deeply Rooted environmental sculpture created in 2021, and detailed further in the section titled "Deeply Rooted Educational Module and Environmental Sculpture." The layout of the study plots in relation to the pergola, main FEEC building, and larger field is shown in Figure 1.

For the purpose of this project, the decision was made to emulate a native prairie ecosystem in the study plots, since no trees or shrubs were incorporated into the restoration plan, and the herbaceous plant species found in oak barrens are also found in mesic prairies (Curtis, 1959). Specifically, prairie forbs and grasses are more abundant in high light areas of oak barrens, and forest forbs and woody species occur more commonly in the areas of low light (Curtis, 1959). Since all of the study plots for this project were located in full sun exposure, prairie forbs and grasses were the primary focus of this restoration project. The "Future Recommendations" section includes some visions for the future of this site to eventually transition from restored prairie to oak barrens.

Figure 1: Location and layout of Prairie Restoration Study Plots, pergola, and main building at the Freeman Environmental Education Center at 3540 Dixboro Ln, Ann Arbor, MI.

Site Preparation Methods

Site preparation is important for the success of any restoration effort. In the context of prairie restoration, site preparation may involve altering existing vegetation and soil structure, increasing opportunity for soil-to-seed contact, and reducing non-native weeds (Smith, 2010)

Two different methods were utilized in the test plots at the FEEC in order to prepare the site for restoration: smothering and tilling. Both methods were tested in order to compare their effectiveness, to demonstrate different methods to visitors to the site, and to gather information to present to school district administrators about preparation methods that could be used at other sites. Both smothering and tilling aimed to kill the non-native cool season turf grasses for the highest possible success rate of planted native species. Since few to no native prairie plants were observed growing in the study plots prior to treatment, all existing vegetation was aimed to be removed in order to establish a community of native plants, a process known broadly as stand replacement (Shirley, 1994). All plots were mowed to the shortest height possible before all treatments took place. Both smothering and tilling methods were chosen as a way to test their effectiveness at the site as well as an opportunity to demonstrate different methods to members of the public and the Ann Arbor Public School District.

Smothering turf grass involves using a semi or non-permeable material such as cardboard, plastic tarp, or other opaque materials to prevent sunlight and/or water from reaching the plants underneath, leading to eventual death. Another variation of this method, known as solarization, is usually executed with plastic tarp that is either black or transparent and traps enough heat from the sun to kill the seed bank in the soil as well as existing vegetation (Smith, 2010; Lind, 1999). Smothering as a method of site preparation can be labor-intensive as it involves gathering and laying down material that is large enough to cover the intended area, and very large areas can be impractical and expensive to smother altogether. However, smothering can be effective at killing the target plants with minimal disturbance of the soil and the seed bank (Smith, 2010).

Repeated tilling is another method of site preparation for prairie restoration projects. This involves using a tiller to break up the turf grass repeatedly over at least one growing season and destroy the underground rhizomes frequently enough that eventually, the turf grass is unable to continue surviving (Shirley, 1994). This method is often used for larger sites as large machinery can be used to till soil efficiently. However, tilling must be done frequently enough that the targeted species are depleted over time. One drawback of this method is that tilling can bring weed seeds from the seed bank up to the surface of the soil and provides opportunity for germination. As this site had been under a no-mow protocol since 2019, the seed bank likely contains large amounts of the species of cool-season non-native grasses that we were aiming to eradicate for restoration. Other drawbacks of tilling include disturbance of soil communities, release of carbon dioxide into the atmosphere, and the energy required for tilling equipment.

At the site in this study, Plots 1 and 2 were smothered with salvaged cardboard that was placed on April 9 and April 17, 2021. The cardboard was weighed down with salvaged rocks and removed invasive shrub material (mostly honeysuckle, *Lonicera spp*. and glossy buckthorn, *Rhamnus cathartica* branches without any fruit present) that was placed in brush piles. The brush piles served as not only a method of keeping the cardboard in place during the summer months, but also as a demonstration to students and the public of the ecological benefits of creating brush piles. Brush piles are a relatively low-cost and low-labor method of providing shelter, nesting areas, food sources, and habitat for microorganisms, invertebrates, small mammals, birds, amphibians, and reptiles. Creating brush piles can also divert organic material from landfills. The cardboard in Plot 1 was removed on September 11, 2021 in order to cover with a layer of mulch and plant native grass and forb plugs, while the cardboard in Plot 2 was removed on December 2, 2021 in order to broadcast seed. In both Plots 1 and 2, turf grass was visibly less robust and mostly eradicated.

Plots 3, 4, and 5 were prepared for planting using repeated tilling. All three of these plots were tilled using a combination of a gas-powered rototiller and an electric handheld tiller on May 4, May 27, July 13, August 10, September 9, and October 29, 2021 to prepare for broadcasting seed on December 2, 2021. Between tills, grasses were observed growing back robustly from both leftover rhizomes and newly germinating seeds.

Informational signage was installed in Summer 2021 to inform students, educators, and the public about site preparation taking place at the restoration site. This signage can be viewed in Appendix A. Photos of site preparation methods and informational signage are shown in Figure 2.

Figure 2: Two methods of site preparation at the FEEC prairie study plots. Smothered plots were covered in salvaged cardboard and weighed down with brush piles of invasive shrub branches, and tilled plots were tilled multiple times throughout the growing season. Both methods were used in an attempt to eradicate all existing vegetation before planting native species. Installed informational signage can be seen in the bottom photo.

Planting Methods

Along with testing and demonstrating different methods of site preparation, another aim of this project was to demonstrate different methods of planting with native species that are accessible to students, school staff, and the public. Two methods were used in our study plots: planting seedlings purchased from a local nursery or grown on site, and hand-broadcasting a custom seed mix purchased from a local nursery.

In order to decide on a custom seed mix suited for the site and our restoration objectives, a lesson plan was developed for guiding high school students in the Freeman Environmental Youth Council through the process of species selection for a restoration project. The lesson was conducted virtually via Zoom on May 5, 2021, and a total of 13 students participated. Students were first given a brief presentation on different strategies of ecological restoration, oak barren ecosystems, functional diversity, and ecological niches of interest. The complete lesson plan and slides from this presentation can be viewed in Appendix B. Students were then given information about the site (such as soil conditions, sunlight, and chances of herbivory), along with a curated list (included in Appendix B) of numerous native plant species that are suited to the site conditions. Information included along with common and scientific names of each plant were height, bloom time and color, pollinators attracted by the plants (including any notable host plants for endangered species), cultural uses, and deer resistance. Students then worked in small groups to select 5 plants, including one grass species, that they wanted to be included in the seeding mix for restoration.

Functional diversity is an important component of biodiversity in restoration projects, and restored plant communities with higher functional diversity may be more adaptable to site conditions and future environmental changes (Barak et al., 2023). Functional diversity in this context may include diversity of growth forms (grasses, forbs, or non-grass herbaceous species), growth habits (plant height, flower type), phenology (blooming time within the growing season, timing of seed heads maturing, etc.), and other characteristics such as ability to fix nitrogen and resistance to deer herbivory. Students participating in the seed selection exercise were encouraged to maximize functional diversity with their choices, and shared their rationale for their selections with the large group at the end of the exercise.

The complete rationale and species presented by each group of students can be found in Table 1. As a way to use the arts to capture and present data, Esha Biswas summarized the species selections of each group of students into digital drawings, along with the rationale for their choices, shown in Figure 3. Some species that were selected by multiple groups were only depicted once to avoid redundancy. These drawings were also installed as informational signage at the restoration site in Summer 2023, which can be found in Appendix A.

All species that were selected by students were included in the final seed mix except for June grass (*Koeleria cristata*), which was not available. The final seed mix species and their percentages are included in Table 2. Additional species were chosen by Freeman staff members based on a variety of factors such as bloom color and bloom time, educational value, ecological benefits, and nursery availability. Species added to the final seed mix that were not specifically selected by students include yarrow (*Achillea millefolium*), yellow giant hyssop (*Agastache nepetoides*), nodding wild onion (*Allium cernuum*), thimbleweed (*Anemone cylindrica*), common milkweed (*Asclepias syriaca*), Joe-Pye weed (*Eutrochium maculatum*), yellow coneflower (*Ratibida pinnata*), little bluestem (*Schizachyrium scoparium*), and Indian grass (*Sorghastrum nutans*), among others.

Table 1: Plant species selected by high school students in the Freeman Environmental Youth Council to be included in the restoration seed mix

Group	Student rationale for selections	Species selected	Common Name	Included in final seed mix (Y/N)
1	The New Jersey Tea has educational purposes, can be helpful for teaching visitors at Freeman	*Ceanothus americanus*	New Jersey tea	Y
	The lead plant can be used as a deer resistant nitrogen fixer, would be beneficial to the environment.	*Amorpha canascens*	Lead plant	Y
	The Canada wild-rye would fulfill the grass part of the project and isn't aggressive and is a good establishing plant as a nurse crop.	*Elymus canadensis*	Canada wild-rye	Y
	(None given)	*Aquilegia canadensis*	Wild columbine	Y
2	We selected the Purple Lovegrass and Canadian Wild Rye so there would be a grassy component all year round.Canada Wild Rye is good for starting a prairie and then fading away allowing the rest of the selections to	*Eragrostis spectabilis*	Purple lovegrass	Y
		Elymus canadensis	Canada wild-rye	Y
		Euphorbia corollata	Flowering spurge	Y
		Amorpha canascens	Lead plant	Y
		Penstemon hirsutus	Hairy beardtongue	Y

	flourish in the future. We selected the Lead Plant because it is a nitrogen fixator as well as deer resistant making it optimal for the plot. Along with this, each of our flowers have a different blooming time that slightly overlap, making it so there are flowers and plants occupying the plot at least for the entire summer, attracting animals to the plot and establishing a prairie ecosystem.			
3	We wanted to get all edible plants because we thought it would be fun to have an activity at Freeman where kids can go out and pick the plants, learn about them, and then cook and eat them. We tried to get a diverse selection of height in terms of bloom time, pollinators attracted, and what part of the plant you can eat.	*Monarda fistulosa*	Bee balm	Y
		Helianthus occidentalis	Western sunflower	Y
		Elymus canadensis	Canada Wild-rye	Y
		Koeleria cristata	June grass	N
		Lupinus perennis	Wild lupine	Y

4	June Grass - spread throughout as to maintain a grassy floor while other plants not in bloom Early Goldenrod: attractor for many different species, edible, spreads easily. Western Sunflower: Edible, birds feed on seeds. Round Headed Bush Clover: edible, N fixer, mammals eat it. Missouri Ironweed: attracts a wide range of species (including endangered), taller than other plants	*Solidago juncea*	Early goldenrod	Y
		Helianthus occidentalis	Western sunflower	Y
		Lespedeza capitata	Round headed bush-clover	Y
		Vernonia missurica	Missouri ironweed	Y
		Koeleria cristata	June grass	N

Figure 3: Digital drawings of native plant species selected by high school students in the Freeman Environmental Youth Council for the restoration study plots, along with some of the rationale for their selections.

Table 2: Final seed mix for the restoration study plots

Forbs			
Species	**Common Name**	**Percentage of Forbs (% by weight)**	**Student selected (*)**
Achillea millefolium	Yarrow	4	
Agastache nepetoides	Yellow giant hyssop	2	
Allium cernuum	Nodding wild onion	4	
Amorpha canascens	Lead plant	1	*
Anemone cylindrica	Thimbleweed	2	
Aquilegia canadensis	Wild columbine	3	*
Asclepias syriaca	Common milkweed	1	
Asclepias tuberosa	Butterfly weed	2	
Aster oolentangiensis	Prairie heart-leaved aster	5	
Baptisia lactea	Cream wild indigo	1	
Ceanothus americanus	New Jersey tea	1	*
Coreopsis lanceolata	Sand tickseed	3	
Coreopsis tripteris	Tall tickseed	3	
Desmodium canadense	Showy tick-trefoil	3	
Euphorbia corollata	Flowering spurge	1	*
Eutrochium maculatum	Joe-Pye weed	2	
Helianthus occidentalis	Western sunflower	1	*
Lespedeza capitata	Round headed bush-clover	2	*
Liatris aspera	Rough blazing star	3	
Lobelia siphilitica	Blue lobelia	3	
Lupinus perennis	Wild lupine	1	*
Monarda fistulosa	Bee balm	3	*
Packera obovata	Round-leaved ragwort	5	

Penstemon hirsutus	Hairy beardtongue	4	*
Phlox pilosa	Prairie phlox	4	
Pycnanthemum virginianum	Virginia mountainmint	6	
Ratibida pinnata	Yellow coneflower	4	
Silphium terebinthinaceum	Prairie dock	3	
Solidago juncea	Early goldenrod	4	
Solidago rigida	Stiff goldenrod	5	
Solidago speciosa	Showy goldenrod	5	
Symphyotrichum laeve	Smooth aster	4	
Tradescantia ohiensis	Common spiderwort	2	
Vernonia missurica	Missouri ironweed	3	*
Total		**100**	
Grasses			
Species	**Common Name**	**Percentage of Grasses (% by weight)**	**Student selected (*)**
Elymus canadensis	Canada wild-rye	15	*
Eragrostis spectabilis	Purple love grass	10	*
Panicum virgatum	Switchgrass	10	
Schizachyrium scoparium	Little bluestem	30	
Sorghastrum nutans	Indian grass	10	
Sporobolus heterolepis	Prairie dropseed	15	
Carex bicknellii	Bicknell's sedge	5	
Carex muehlenbergii	Muhlenberg's sedge	5	
Total		**100**	

The final combination of seeds was purchased from Michigan Wildflower Farm in two different seed mixes: Mix A with a 50:50 ratio of forbs to grasses by weight, and Mix B with a 20:80 ratio of forbs to grasses by weight. Mix B's ratio was tested as a potential lower-cost seed mix that can be used in future restoration projects at the FEEC, since forb seeds are often more expensive than grass seed. Plots 2-5 were hand-broadcasted with seed during a workday on December 2, 2021 by FEEC staff members and high school students in the Freeman Environmental Youth Council. The workday began with an educational component in which students learned about the processes of seed collection, cleaning, processing, and stratification by observing native seeds and seed heads at various stages of processing before participating in restoration work. Cardboard and brush piles used to smother Plot 2 were removed. Seed mix was combined with sawdust in a wheelbarrow to use as a carrier. Using a carrier such as sawdust is helpful for more even seed distribution and as a visual indicator of where seed has been broadcasted. Mix A was broadcasted on Plots 2 and 3, and Mix B was broadcasted on Plots 4 and 5. Seeds were broadcasted along vertical and horizontal transects to ensure as even of a distribution as possible. 5 oz. of seeds were used to cover all four plots, equating to 0.008 oz. of seeds per square foot. Photos of this workday can be found in Figure 4.

Figure 4: Students and staff at FEEC and-broadcasting seed on the restoration study plots. The native seed mix was mixed with sawdust as a carrier to help obtain even distribution and visibility of seeds.

Plot 1 was the only plot not seeded, and was instead planted with plugs, or small seedlings grown in pots and trays. The purpose of this plot was to serve as a demonstration area for visitors to more quickly see an example of what the other study plots may eventually look like in the future, and to serve as a demonstration of smaller scale native plantings that can be installed at homes, schools, or other community spaces. Plugs, although more expensive and labor intensive to plant than broadcasted seed, often establish themselves more effectively and are often recommended for smaller-scale native plantings. The 14 species chosen for Plot 1 were a mix of species present in the seed mix used on Plots 2-5 (such as butterfly milkweed, *Asclepias tuberosa* and tall tickseed, *Coreopsis tripteris*) as well as species not included in the seed mixes used on Plots 2-5 (such as purple coneflower, *Echinacea purpurea* and spotted bee-balm, *Monarda punctata*). Species were chosen with similar criteria as the seed mix, such as bloom color and time, ecological benefits, educational value, and nursery availability. The total quantity of plugs was determined by the goal of planting each plug no more than 8-12 inches apart from each other, and the quantities of each plant were determined by nursery availability, aesthetic considerations, and overall balance of species. Two species, black-eyed susan (*Rudbeckia hirta*) and purple coneflower (*Echinacea purpurea*), were seeded into plug flats by students in the Freeman Environmental Youth Council as part of a workshop on native plants that took place on June 14, 2021. The complete list of species planted in Plot 1 can be found in Table 3.

Table 3: Plug species planted in Plot 1 of the restoration study plots

Species	Common Name	Height	Bloom color	Bloom time	Quantity of plugs planted
Asclepias tuberosa	Butterfly weed	2’	Orange	July-Aug.	38
Coreopsis lanceolata	Sand tickseed	2’	Yellow	June-July	19
Coreopsis tripteris	Tall tickseed	5’-7’	Yellow	July-Aug.	21
Echinacea purpurea	Purple coneflower	3’-4’	Purple	July-Sept.	38
Helianthus occidentalis	Western sunflower	2’-3’	Yellow	Aug.-Sept.	5
Liatris aspera	Rough blazing star	2’-3’	Purple	Aug.-Sept.	38
Monarda punctata	Spotted bee balm	2’-4’	Pink	July-Aug.	4
Packera obovata	Round-leaved ragwort	1’-2’	Yellow	Mar.-May	38
Penstemon hirsutus	Hairy beardtongue	2’	Lavender	May-June	38
Rudbeckia hirta	Black-eyed susan	1’-2’	Yellow	June-Sept.	38
Schizachyrium scoparium	Little bluestem	2’-3’	Red-brown	Warm season	38
Silphium terebinthinaceum	Prairie dock	5’-10’	Yellow	July-Sept.	8
Sporobolus heterolepis	Prairie dropseed	1’-3’	Green	Warm season	38
Symphyotrichum laeve	Smooth aster	3’	Purple	Sept.-Oct.	19

All plugs were planted in Plot 1 by Freeman Center staff, Ann Arbor Public School Teachers, students in the Freeman Environmental Youth Council, and community volunteers on September 11, 2021. A brief presentation was given on the restoration project to all attendees, and muffins made with foraged curly dock (*Rumex crispus*) and autumn olives (*Elaeagnus umbellata*) were served as an educational demonstration of the utilization of non-native invasive species as a food source during the process of ecological restoration. Photos of this workday can be found in Figure 5.

Cardboard and brush piles used to smother Plot 1 were first removed, and the entire plot was covered in approximately 4 inches of hardwood wood chips. Using some form of mulch helps to retain moisture when seedlings are establishing, and helps to prevent weeds from germinating and competing for resources (Ashworth & Harrison, 1983). A planting plan (Figure 6) was devised and used on the day of planting to direct volunteers. In naturally evolved prairies, plants of the same species are often found in bands, clusters, or “drifts,” either due to the plants’ reproductive strategies or micro-environmental differences within the prairie (Morrison, 1981). This concept of drifts was used to develop the planting plan for Plot 1, and groupings of plugs of the same species were planted together.

The path in the planting plan was sectioned off using marking flags to provide a way for visitors to enter the space and be more immersed in the plot than they would be if they only viewed it from the outer perimeters. In the planting plan, each circle represents a grouping of 3-4 plugs of the same forb species, which volunteers were able to choose the specific arrangement of when planting, as long as they were planted 8-12 inches apart from each other. Volunteers also were able to choose 1-2 plugs of either little bluestem (*Schizachyrium scoparium*) or prairie dropseed (*Sporobolus heterolepis*) to plant anywhere around or among the drift they planted, using the same spacing instructions. This allowed for random and relatively even distribution of the two grass species throughout the drifts of forbs. These loose guidelines also led to a collaborative, organic, and adaptive process of planting with a sense of shared autonomy and responsibility of the restoration effort. Plants with taller eventual heights such as prairie dock (*Silphium terebinthinaceum*) are placed in the back of the plot when viewed from the main pedestrian walking path. All plugs were planted by first brushing aside a small patch of mulch, digging using hand trowels, and planting so the soil level of the plug matched the soil level of the ground. Each grouping of plugs was also immediately watered using a hose after planting. After the initial planting, Plot 1 was watered approximately twice a week or as needed for the rest of the growing season.

Figure 5: Students, teachers, FEEC staff, and volunteers planting plugs in Plot 1 of the restoration study plots. Cardboard and brush piles used for site preparation were first removed, and the plot was covered in a layer of mulch before planting and watering.

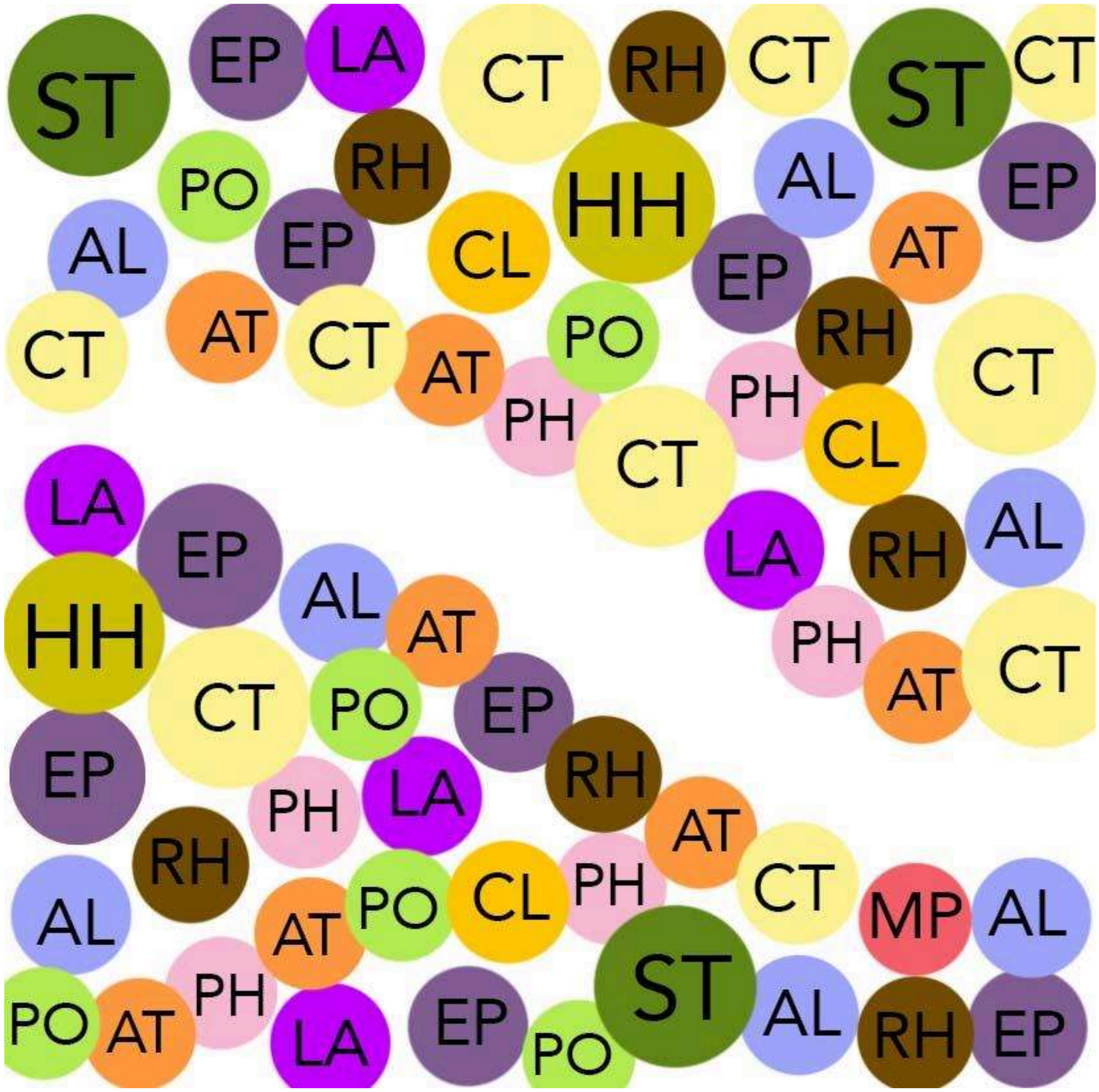


Figure 6: Planting plan for Plot 1, planted with plugs in September 2021. Each circle represents a cluster of 2-4 plugs of the same species planted approximately 8-12 inches apart from each other. AL - Smooth aster (*Symphyotrichum laeve*); AT - Butterfly weed (*Asclepias tuberosa*); CL - Sand tickseed (*Coreopsis lanceolata*); CT - Tall tickseed (*Coreopsis tripteris*); EP - Purple coneflower (*Echinacea purpurea*); HH - False sunflower (*Helianthus helianthoides*); LA - Rough blazing star (*Liatris aspera*); MP - Spotted bee balm (*Monarda punctata*); PH - Hairy beardtongue (*Penstemon hirsutus*); PO - Round-leaved ragwort (*Packera obovata*); RH - Black-eyed susan (*Rudbeckia hirta*); ST - Prairie dock (*Silphium terebinthinaceum*). Volunteers were instructed to plant 1-2 plugs of little bluestem (*Schizachyrium scoparium*) or prairie dropseed (*Sporobolus heterolepis*) among or around each cluster of forbs, with the same spacing of 8-12 inches. The space in the middle of the plot indicates a pedestrian pathway for visitors.

Results and Continued Restoration Methods

The first growing seasons after planting in all 5 study plots took place in 2022 and 2023 and included many observations, lessons learned, and continued maintenance as well as integrated educational opportunities such as the implementation of the Deeply Rooted Educational Module and environmental sculpture.

First Growing Season

Plot 1, which had been smothered in cardboard, mulched, planted with plugs, emerged in 2022 with a near 100% survival rate of the planted plugs (plugs that had not survived the winter were imperceptible). The first plants to bloom were round-leaved ragwort (*Packera obovata*) and hairy beardtongue (*Penstemon hirsutus*) in Spring 2022. Other plants observed blooming and/or producing seeds in 2022 included sand tickseed (*Coreopsis lanceolata*), spotted bee balm (*Monarda punctata*), false sunflower (*Helianthus helianthoides*), butterfly weed (*Asclepias tuberosa*), purple coneflower (*Echinacea purpurea*), rough blazing star (*Liatris aspera*), black-eyed susan (*Rudbeckia hirta*), smooth aster (*Symphyotrichum laeve*), and little bluestem (*Schizachyrium scoparium*), some of which can be seen in Figure 7. This plot was surveyed for the continued survival of planted seedlings throughout the growing season of 2022, and occasionally hand-weeded by FEEC staff, volunteers, and students participating in educational programming. The main non-native species that were hand-weeded by FEEC staff, students, and volunteers included chicory (*Cichorium intybus*), broadleaf plantain (*Plantago major*), narrowleaf plantain (*Plantago lanceolata*), and spotted knapweed (*Centaurea stoebe*). Relatively few of the former non-native turf grasses needed to be weeded in Plot 1. Deer and other mammal herbivory was noticeable in Plot 1, and two species were not able to reach a blooming stage due to herbivory: tall tickseed (*Coreopsis tripteris*) and prairie dock (*Silphium terebinthinaceum*).

Figure 7: Blooming forbs in Plot 1 in the 2022 growing season. In order from top-left to bottom-right: round-leaved ragwort (*Packera obovata*), hairy beardtongue (*Penstemon hirsutus*), sand tickseed (*Coreopsis lanceolata*), purple coneflower (*Echinacea purpurea*), spotted bee balm (*Monarda punctata*) and black-eyed susan (*Rudbeckia hirta*), butterfly weed (*Asclepias tuberosa*) with false sunflower (*Helianthus helianthoides*) in the background, smooth aster (*Symphyotrichum laeve*), little bluestem (*Schizachyrium scoparium*) and various seed heads in Fall 2022, and rough blazing star (*Liatris aspera*).

Plot 2, which had been smothered with cardboard and seeded with a seed mix of 50% grasses and 50% forbs, contained a few native species seedlings that were observed in the 2022 growing season. These species included yarrow (*Achillea millefolium*), tickseed (*Coreopsis spp.*), bee balm (*Monarda fistulosa*), stiff goldenrod (*Solidago rigida*), prairie dock (*Silphium terebinthinaceum*), Canada wild rye (*Elymus canadensis*), and hairy beardtongue (*Penstemon hirsutus*). A significant amount of the herbaceous cover in Plot 2 were weedy non-native species such as broadleaf plantain (*Plantago major*) and narrowleaf plantain (*Plantago lanceolata*), but most of the non-native turf grasses that were smothered by cardboard did not appear to have survived.

Plot 3, which was tilled and seeded with a mix of 50% grasses and 50% forbs, and Plots 4-5, which were tilled and seeded with a mix of 80% grasses and 20% forbs, were largely unsuccessful in the germination of native species. Most plants observed in these plots in the 2022 growing season were cool-season non-native turf grasses that had survived in spite of the repeated tilling treatments, along with a significantly increased amount of non-native chicory (*Cichorium intybus*).

Plot 2 was mowed to a height of 4 inches (the maximum height on the available mower) multiple times throughout the 2022 growing season. Mowing helps to establish native grassland restoration sites by restricting growth and re-seeding of non-native plants and weeds while native species germinate and establish their root systems (Rowe, 2010). Prairie restoration sites should ideally be mowed whenever the plants reach a height of 4-6 inches throughout the first 2-3 years of a restoration planting (Dillard, 2004). Although Plots 3-5 were originally planned to be mowed as well, due to the negligible amount of successful native seed germination, they were not mowed in the 2022 growing season.

Second Growing Season

The steps taken in 2023 to continue the ecological restoration process were largely based on the observations made in the study plots in 2022.

Plot 1, which had been smothered in cardboard, mulched, and planted with plugs, was evaluated as most successful in terms of plant establishment, and this plot continued to be observed for continued growth of planted seedlings, and occasionally hand-weeded. Plants were observed to be further established, clonal colonies of planted seedlings grew bigger, and some self-seeded seedlings were observed. Photos of blooming plants in the 2023 growing season can be found in Figure 8. Mammal (mainly deer) herbivory was observed again in the 2023 growing season, and the same species that did not reach their blooming stage in 2022 were again deterred by herbivory: tall tickseed (*Coreopsis tripteris*) and prairie dock (*Silphium terebinthinaceum*).

Figure 8: Blooming plants in Plot 1 in the 2023 growing season. Left: butterfly weed (*Ascelpias tuberosa*) and sand tickseed (*Coreopsis lanceolata*). Right: smooth aster (*Symphyotrichum laeve*) and little bluestem (*Schizachyrium scoparium*).

Based on the relative success of Plot 1, an additional plot, Plot A, was created to the west of Plot 1 and prepared and planted with largely the same methods as in Plot 1. This area was smothered with cardboard and layered with mulch in July 2023. The shape of the plot was not square like Plots 1-5, but expanded to fill the area up to the rounded edge of the mowed pathway in order to give a more natural, organic appearance (Figure 9). This plot was planted in September 2023 by FEEC staff and volunteers, with plugs germinated and grown on site at the FEEC by FEEC staff and students. The species planted in Plot A can be found in Table 4. These species were selected by FEEC staff based on much of the same criteria as Plot 1, such as their suitability for a prairie/oak barren ecosystem, plant heights and bloom colors/times, and also for their ability to be germinated and grown easily on site by students. The design of Plot A also included a pathway leading through the plot to allow visitors to be more immersed in the restoration. This pathway connected to the previously established pathway in Plot 1.

Figure 9: Plot A, added in 2023 and planted with plugs, in relation to the previously existing restoration study plots that were established in 2021.

Table 4: List of species germinated on site and planted in Plot A of the restoration study plots

Species	Common Name
Allium cernuum	Nodding wild onion
Asclepias syriaca	Common milkweed
Asclepias tuberosa	Butterfly milkweed
Carex vulpinoidea	Fox sedge
Echinacea purpurea	Purple coneflower
Eutrochium maculatum	Joe Pye weed
Liatris spicata	Blazing star
Lupinus perennis	Wild lupine
Panicum virgatum	Switchgrass
Penstemon digitalis	Foxglove beardtongue
Penstemon hirsutus	Hairy beardtongue
Pycnanthemum virginianum	Virginia mountainmint
Ratibida pinnata	Yellow coneflower
Rudbeckia hirta	Black-eyed susan
Schizachyrium scoparium	Little bluestem
Silphium integrifolium	Rosinweed
Silphium perfoliatum	Cup plant
Solidago juncea	Early goldenrod
Solidago speciosa	Showy goldenrod
Sporobolus heterolepis	Prairie dropseed
Symphyotrichum novae-angliae	New England aster
Thalictrum dioicum	Early meadow-rue
Vernonia missurica	Ironweed
Zizia aurea	Golden alexander

Plot 2 was left to continue growing throughout the 2023 growing season, and mowed repeatedly as in 2022. Due to the observed germination of native seeds from the seed mix broadcasted in this Plot, the decision was made to continue letting the plot develop. The first 2-3 years of prairie restoration sites often have slow visually obvious development of plants, due to many plants focusing energy on developing root systems, biennial forbs not flowering in the first year after germination, and due to competition from annual weeds (Dillard, 2004).

Plots 3-5 were evaluated as largely unsuccessful in terms of native seed germination. Based on these observations from 2022, the decision was made to smother these plots in June 2023 instead of using a repeated tilling treatment, which was evaluated as not sufficient to eradicate the non-native turf grasses. This time, recycled vinyl billboard tarp was used as opposed to cardboard, which is a relatively new practice in restoration without much local trial. Cardboard can be left in place to decompose under a layer of mulch, as was done in Plot 1 and Plot A, but billboard tarp can be ideally be reused multiple times to smother other areas, and can be obtained in larger intact pieces that cover more area than smaller pieces of cardboard. Plots 3-5 were re-mowed in June 2023 right before they were smothered with recycled billboard material in order to facilitate the smothering process. The material was weighed down with bricks and rocks instead of brush piles as in Plots 1 and 2. Plots 3-5 were monitored throughout the 2023 growing season to evaluate the effectiveness of eradicating the non-native turf grasses underneath, and the billboard tarp was deemed successful when most of the turf grass appeared to be dead by September 2023.

In December 2023, Plots 2-5 were overseeded with a mix of 60% grasses and 40% forbs. The species included were the same as the seed mix broadcasted on Plots 4 and 5 in 2022. These plots were overseeded with the hopes that the seeds would have better seed-to-soil contact after a smothering treatment than only repeated tilling as in 2022, which was not sufficient to kill a majority of the non-native turf grasses. The recycled billboard vinyl used to smother Plots 3-5 throughout the 2023 growing season were moved further east in December 2023 to expand the prairie restoration plots, as shown in Figure 10.

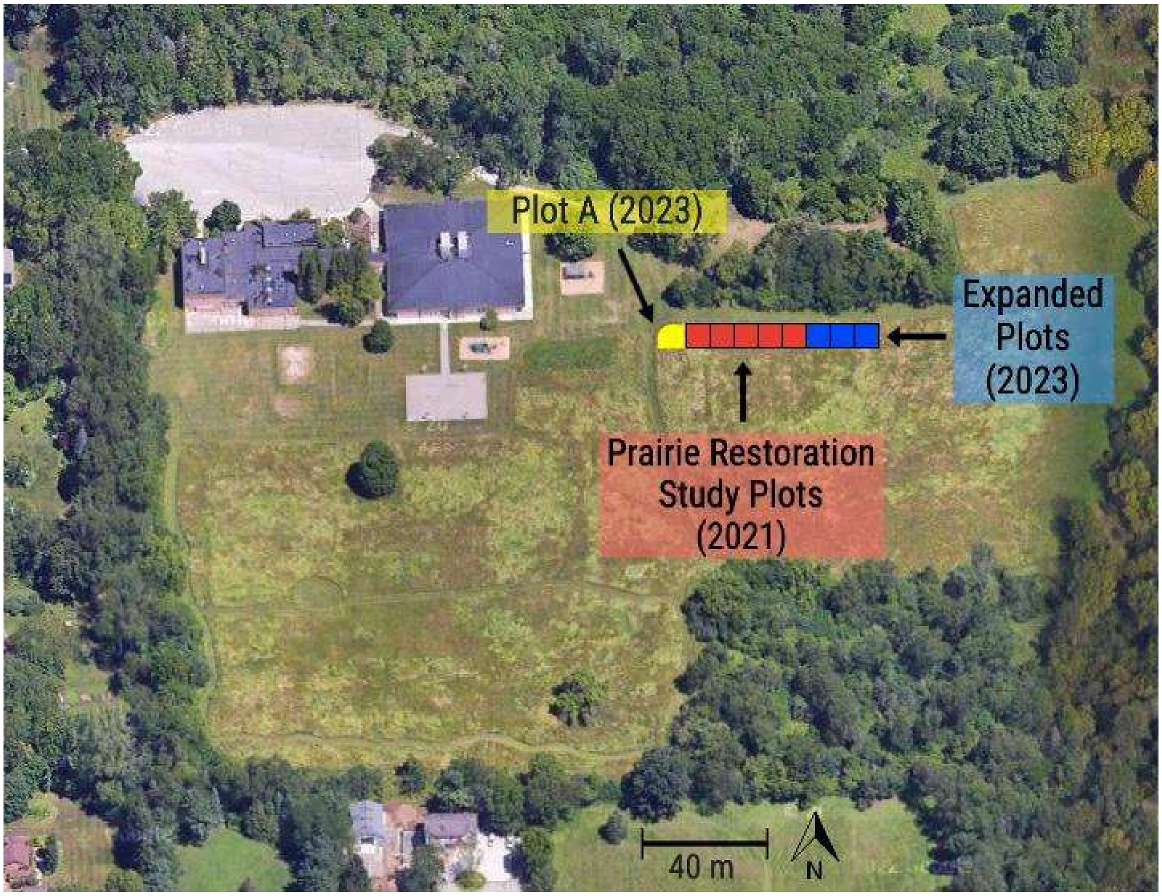


Figure 10: Expanded prairie restoration plots created in December 2023. The expanded plots were smothered with the same recycled billboard vinyl that was previously used to smother Plots 3-5 in Summer 2023.

Educational Programming

2022 included various educational programming events integrated with ecological restoration efforts. In April 2022, a workshop was conducted with the assistance of Bill Schneider from Wildtype Native Plant Nursery for high school students in the Freeman Environmental Youth Council. The workshop included sharing knowledge about native plant seed collection, seed cleaning and processing, and germination. As a result of this workshop, multiple species were germinated and grown on site at FEEC by Youth Council students and FEEC staff for planting later in the growing season as a part of other educational programming. The Freeman Environmental Youth Council shared the knowledge from this workshop with other students in Ann Arbor Public Schools by hosting an educational program as a part of an annual Earth Day event in April 2022. Volunteers and students participating in FEEC programming were involved in hand-weeding of Plot 1 throughout the 2022 growing season. Finally, the implementation of the Deeply Rooted Educational Module and installation of the Deeply Rooted environmental sculpture took place in June-July

2022. More details on this module and installation can be found in the section titled "Deeply Rooted Educational Module and Environmental Sculpture."

In 2023, seed collection and cleaning workshops were hosted for the Freeman Environmental Youth Council, and seeds were collected from established native plants in the study plots as well as other newly planted areas at the FEEC. Equipment and supplies were purchased in 2023 to create more robust seed germination and seedling nursery infrastructure. Students worked with FEEC staff to germinate 24 species for the study plots, which can be found in Table 4. As a part of the 2023 A2 Nature Guardians Summer Camp, parts of the Deeply Rooted Educational Module were implemented again to teach students about prairie ecology and root systems. Students helped to hand-pull weeds in the study plots such as dandelion (*Taraxicum officinale*), chicory (Cichorium intybus), broadleaf plantain (*Plantago major*), narrowleaf plantain (*Plantago lanceolata*), red clover (*Trifolium pratense*), and white clover (*Trifolium repens*), and studied the root systems of these plants. They also helped pull spotted knapweed (*Centaurea stoebe*) from the surrounding field. Students made prairie plant "seed balls" out of air-dry clay and native seeds and threw them into Plot 2, and helped implement the smothering treatment for Plot A by laying down cardboard and wood chips. Although the outdoor sculpture of Deeply Rooted was not built again, the arts continued to be integrated, and students who participated in 2023 collaborated on a mural at the FEEC of prairie plants and their root systems, and painted "pet rocks" of animals and insects that live in prairie ecosystems (Figure 11). The painted rocks were used to weigh down the billboard tarp that was used to smother Plots 3-5, and therefore integrated into the restoration process.

According to one FEEC staff member, "The biggest impact of the prairie plots (namely Plot 1) has been the ability for us to demonstrate a diverse group of native plants, often buzzing with pollinators! The juxtaposition of Plot 1 with the mowed trail or no-mow field provides a good opportunity to talk about species diversity, native vs. non-native plants, food webs, habitat services, habitat restoration or enhancement, and other relevant concepts" (Ambrosino, personal communication, 2024).

In Fall 2023, the restoration project was included in a presentation for the Huron High School International Baccalaureate Collaborative Science Project, which had a focus on soil conservation for the year.

Figure 11: Arts integration in the 2023 A2 Nature Guardians Summer Camp. Elements of the Deeply Rooted Educational Module were adapted, and students painted rocks with prairie animals and insects, and painted a mural of prairie plants and root systems.

Reflections and Future Recommendations

Through evaluation based on the restoration efforts in this project, various recommendations have been developed for the Freeman Environmental Education Center (FEEC). These include ecological objectives as well as recommendations for future educational programming. The recommendations outlined in this section mostly pertain to the larger field where the study plots are located. The future vision of this field, and a strategy that evolved organically over the course of this project, is that of a "patchwork prairie." In this context, a patchwork prairie is defined as a prairie restoration effort comprised of various stages, methods, and processes that evolve and mature over time and serve as: an exploration of best practices for FEEC staff in prairie restoration; demonstration of various prairie restoration techniques for students, educators, and the public; and learning experiences for environmental education students to be involved in various ecological restoration methods. A summary of future recommendations and suggested timelines of their implementations can be found in Table 5.

Based on the observations made in the 2022 growing season, repeated tilling alone was not enough to sufficiently eradicate cool season non-native turf grasses in Plots 3-5, and may have led to higher competition from non-native annual weeds. Therefore it is not recommended that repeated tilling be used as a method of future site preparation without being combined with other tactics such as smothering or the use of herbicides.

Plot 2 should be continued to be monitored and evaluated for the success of native seed germination and seedling establishment. Prairie restoration sites can have weedy appearances for 3-5 years after the first seeding due to plants focusing energy on root development, and based on some native seed germination being observed in 2022, this plot should continue to be monitored as an evaluation of the success of the initial seeding that took place in December 2021.

Plots 3-5 should be monitored for successful native seed germination and seedling establishment. This will provide information on the success of using recycled billboard vinyl as a smothering material for one growing season before broadcasting seed.

There are various methods and processes that can be explored in the future "patchwork prairie" at the FEEC as restoration continues. Two site preparation methods that can be used that were not tested in the course of this project are herbicide application and use of fire. A one-time application of herbicide such as glyphosate is often used in prairie restoration projects (Smith, 2010) to ensure complete eradication of former non-native vegetation. In order to ensure safety of students and FEEC staff, herbicide would ideally be applied only once, in the minimum amount required to eradicate turf grasses, and during a period of time when students are not on site while herbicide is still present. As prairies are fire-dependent ecosystems, fire can also be used as a site preparation strategy to remove existing vegetation and has been found to increase rates of seed germination (Alstad et al., 2018). This may be due to increased seed-to-soil contact after leaf litter is burned away, increased soil temperature, or other abiotic and biotic factors (Alstad et al., 2018).

A fire regime should also be introduced as the prairie at the FEEC establishes in the future. Fire has historically been used by Indigenous stewards of Turtle Island for various ecosystems, especially grasslands (Day 1953; Chapman 1984). Depending on restoration goals and specific site conditions, restored prairies can be burned annually or less frequently. As the patchwork prairie at FEEC expands, fire should be introduced in patches as well, so different parts of the restoration are burned in different years and the entire site is never burned all at once. Different frequencies of prescribed burns (e.g. burning annually vs. burning every three years) can also be tested experimentally. Fire as both a site preparation and management tool also serves as an important opportunity to educate students, teachers, and the public about the importance of fire in our ecosystems. Controlled burns can be observed safely by students, educators, and the public, and help to combat the view of fire as a purely destructive force in the current era of fire suppression.

Until burning is introduced, mowing should be used as a maintenance strategy to prevent non-native weed growth and to prevent woody shrubs from encroaching the patchwork prairie. A combination of mowing and fire has been shown to increase biodiversity in restored prairies, emulating historic conditions of grazing herbivores and fire regimes (Collins, 1998). As with fire, different frequencies of mowing can be tested for their effects on biodiversity and success of native plant species in the patchwork prairie.

Processes that have been used throughout the course of this project can be continued and expanded upon in the future. This includes smothering turf grass with cardboard or discarded billboard vinyl, growing plugs on site, planting plugs in patches, and broadcasting seed. Students can continue to be involved in all of these processes as they have been throughout the course of this project.

Methods that have already been implemented can also be expanded upon for further experimentation. The effectiveness of using recycled billboard vinyl should be evaluated for effectiveness and continue to be used if deemed effective for plots that are broadcasted with seeds. Billboard vinyl is less labor-intensive than collecting and smothering an area with cardboard, especially when considering the labor involved in removing packaging tape from salvaged cardboard, and ideally billboard vinyl can be reused for multiple seasons. Cardboard is an effective material for smothering if planting an area with plugs, because cardboard can be covered with mulch and directly planted into, and will eventually decompose underground. Smothering as a site preparation method can also be tested on different timelines, e.g. comparing smothering for one growing season vs. two growing seasons. Seed mixes of different ratios of grasses to forbs, different species, and broadcasted at different times can also be tested. Seed mixes can be continued to be planned with the involvement of students.

As the patchwork prairie is expanded, pathways should be continued to be intentionally expanded and designed for use by students, educators, and the public. Pathways can be an effective way for visitors to immerse themselves in the prairie restoration and feel that they can be a part of land stewardship as opposed to being passive observers. A suggestion for next steps in the prairie expansion are shown in Figure 12. The patch of field labeled A is a potential site of testing the use of fire for site preparation, as mown paths around the boundary can serve as fire breaks. Patch A can also be used to experiment with a part-shade part-sun environment. More shade-tolerant species are found in the shade of oak trees in oak barrens, so this area can be used to grow more shade-tolerant prairie species. Patch A is currently scheduled to be burned and overseeded in Spring 2024. In combination with patch A, the strip labeled B in Figure 12 can be an additional expansion of the patchwork prairie to give students a more immersive experience of walking through restored prairie on field trips hosted by FEEC. Eventually, oaks and appropriate shrub species can also be incorporated into the patchwork prairie, when FEEC wants to transition the restoration from a prairie to a habitat more similar to oak barrens.

Some oaks that have been historically found in oak savannas in Washtenaw County include white oak (*Quercus alba*), bur oak (*Quercus macrocarpa*), chinquapin oak (*Quercus muehlenbergii*), red oak (*Quercus rubra*), and black oak (*Quercus velutina*). Recommended shrubs that can be planted as seedlings in the future include leadplant (*Amorpha canescens*), New Jersey tea (*Ceanothus americanus*), gray dogwood (*Cornus foemina*), American hazelnut (*Corylus americana*), American plum (*Prunus americana*), pasture rose (*Rosa carolina*), northern dewberry (*Rubus flagellaris*), and prairie willow (*Salix humilis*). Tree and shrub species should be planted as saplings for more successful establishment, and labeled with educational signage. Saplings can also be germinated from seed, as some shrub and oak species have already been grown at FEEC in 2022 and 2023.

Figure 12: Recommended future areas of prairie restoration at FEEC. Patch A is recommended as a site to test controlled burning as a site preparation method, due to the surrounding mown pathway that can serve as a fire break. Patch B has already been partially smothered for site preparation, and can be continued to be expanded to give visitors an immersive experience while walking through both patches.

Along with these suggestions for future ecological restoration at FEEC, various educational opportunities are also present. Much of the seedling germination and growing infrastructure was created in 2023, and the continuation of these processes on site provide opportunities for more student involvement in grassland restoration. Seeds from establishing native plants have already been collected by students in 2022 and 2023, and as more plants are grown, more seeds can be continued to be collected and processed by students. This process can be incorporated into already existing field trips taking place at the FEEC, such as 2nd grade “Plant Communities” field trips. The Freeman Environmental Youth Council should continue to be involved in various restoration methods taking place on site, as well as seed collection from other local native plant communities. Planting seedlings is another step in the ecological restoration process that has already taken place with students throughout the span of this project, but can be continued and expanded upon in the future of the patchwork prairie. Future prescribed burns are also excellent learning opportunities for students and educators as observers. The Deeply Rooted Educational Module can continue to be implemented in the future in summer camp settings, or in other educational programming. This module can also be used by other educators in the Ann Arbor Public School District who collaborate with Environmental Education programming and the FEEC. Further into the future, as outlined in Table 5, K-12 and university students can use the educational grassland at the FEEC to conduct their own experiments and studies, or for programming opportunities like foraging and wildcrafting.

Table 5: Future Recommendations for the Freeman Environmental Education Center Patchwork Prairie Restoration Site

Process	**Ecological / Educational Methods**	**Suggested start year or currently in progress as a result of this project (*)**	**Notes for future experimentation and student involvement**
Site preparation	Smothering with cardboard or recycled billboard vinyl	*	Test different amounts of time that turf grass is smothered for effectiveness.
Site preparation	Repeated tilling	*	Should be used in combination with other methods, as repeated tilling was not sufficient in the course of this study.
Site preparation	Burning	2024	See Figure 12 for first burning area for site preparation.
Site preparation	One-time herbicide application	2025	Should be applied only once, in the minimum amount required to eradicate turf grasses, and during a period of time when students are not on site while herbicide is still present.
Planting	Planting plugs	*	Continue involving students
Planting	Broadcasting seed	*	Test different seed mixes of different species, different ratios of forbs to

			grasses. Continue involving students in species selection.
Planting	Overseeding	*	
Maintenance	Monitoring	*	Involve students in seedling identification programming
Maintenance	Mowing	*	Test different frequencies of mowing
Maintenance	Burning	2027	Burning should be conducted in patches, test different cycles of burns.
Maintenance	Weeding	*	Continue involving students in weeding non-native species
Seed Cycling	Collecting and cleaning seeds from restoration site and areas surrounding FEEC	*	Continue involving students
Seed Cycling	Germinating and growing seedlings in on-site nursery	*	Continue involving students
Seed Cycling	Distributing collected seeds and seedlings to teachers and schools in school district	2025	

Expansion	Creating new patches to expand prairie restoration site	*	See Figure 12 for future expansion areas. Walking pathways should continue to be incorporated throughout expanded areas.
Expansion	Incorporating shrubs and/or oak trees	2028	Transition from prairie to oak barren. Includes incorporating more shade-tolerant forbs and grasses to increase overall biodiversity.
Experimentation	Foraging programming	2026	Involve students in foraging plants from restoration site for food, dyeing, and crafting uses.
Experimentation	Deer exclosure	2027	Test effects of deer herbivory, plants least/most resistant to herbivory
Experimentation	Student-created experiments	2028	Allow K12 students and University students to use FEEC restoration site as a site of ecological experimentation

Deeply Rooted Educational Module and Environmental Sculpture

The Deeply Rooted Educational Module was taught for the first time during the A2 Nature Guardians Summer Day Camp through Ann Arbor Recreation and Education, which took place in June 2022 at the Freeman Environmental Education Center (FEEC). The module was conducted 4 times with groups of 12 students (ages 7-10) at a time, for a total of 48 participants. The module takes 4 days to complete. Each day's lesson takes 45 minutes to complete, summarized below and detailed further in Appendix C. The overall purpose of the educational module, which can be adapted to students of various ages, is to raise awareness and build knowledge in participants of the importance of prairie ecosystems and conservation, and to build an outdoor art installation that evokes the deep root systems of native prairie plants. The purpose of the art installation is to further serve as an educational tool for not only the student participants who help co-create it, but also visitors who can further their own appreciation and understanding of prairies and their root systems. This educational module was designed to share publicly to encourage others to also make similar educational art installations.

At the FEEC, the Deeply Rooted sculpture was completed on September 17, 2022 and installed under a wooden pergola that had been on site for several years. The sculpture consists of branches that were salvaged from on site-- primarily from ornamental and invasive shrubs that were removed to make way for student-led native plantings. Branches were stripped of any leaves and small twigs, and prepared into simple, visually appealing shapes prior to the start of the educational program. Salvaged denim was collected from local community members and cut into strips by student participants using scissors. Students then worked together to wrap the branches in denim strips. Due to the outdoor location of the completed sculpture, denim was chosen as a material that is often mostly cotton and therefore does not shed as many microplastics as synthetic fibers. The primarily blue shades of the denim, as pointed out by many students, also evoke the vast amounts of water that prairie plant roots are capable of absorbing. The wrapped branches were hung from the horizontal beams of the pergola at the FEEC in a formation that allows for students and visitors to sit underneath and among the "prairie roots." Picnic tables were placed under and around the sculpture, and the space continues to be used as an outdoor classroom of 2024. Field trips that are conducted on site use the space as a gathering place, and as an educational opportunity to learn about native plants and prairies in an immersive setting. Signage was installed for both adult and youth audiences to learn more about the installation (Appendix A). Laminated copies of student artwork created as a part of the Deeply Rooted Educational Module were also attached to vertical beams of the pergola as a part of the overall installation. Students and adult participants of programming were observed reading signage during field trips and during lunch breaks, and returning students who had participated in creating the sculpture often shared their accomplishments with their peers during programming.

Figure 13: Deeply Rooted Environmental Sculpture and informational signage. The sculpture was built with 48 students in the A2 Nature Guardians Summer Day Camp and installed in 2022 at the Freeman Environmental Education Center.

Deeply Rooted Educational Module Overview

Lesson 1: "Getting to the Root of it"

The purpose of the first lesson of the educational module is to introduce students to plant roots, their forms, and their functions. Students start out reflecting on what they already know about plant roots, and sampling sliced radishes and carrots. Then they use strips of paper towel to dip into water dyed with food coloring as a way to observe capillary action, and learn about how roots transport water and nutrients. In pairs, students then dig up plants from a designated area to observe and draw root systems. This exercise becomes an opportunity to introduce the concepts of tap roots, fibrous roots, and root hairs. The lesson ends with students sharing their drawings, observations, and experiences with each other.

Lesson 2: “Rooting for Native Plants”

In the second lesson, students are introduced to prairies, native plants, colonialism, and land stewardship. Standing in a circle, students are asked to close their eyes and imagine what the landscape around them looked like 500 years ago before sharing. This leads into a storytelling and drawing exercise in which students are guided through the story of prairie ecosystems in North America, their benefits, Indigenous stewardship, and the effects of colonialism and land theft on these disappearing ecosystems. Students are also given the opportunity to select the branches that they want to work with for the outdoor installation, and the visual connection is made between tree branches and plant roots. The lesson ends with a visit to the prairie restoration plots, and students learn about and witness what it takes to restore and steward a prairie.

Lesson 3: "Deeply Rooted"

The third lesson dives further into learning about prairie plant roots. Students are divided into pairs and given a card with the name and photograph of native prairie plant on it, along with the depth (in feet) that the plant has been recorded to reach with its roots. Students then measure the length of their plant's roots on pavement, mark with sidewalk chalk, and draw what they imagine the roots to look like. This lesson also includes cutting salvaged denim into strips for the outdoor installation, and learning about the benefits of using recycled materials for art. Students are also led through a movement activity in which they do stretches and poses inspired by tap roots and fibrous roots. The lesson ends with students drawing imagined roots in small groups on enlarged images of the planned site of the art installation.




Lesson 4: "Wrapping Up"

The last lesson of the module is mostly spent working on creating denim-wrapped branches for the outdoor art installation. Students work on their selected branches and are also encouraged to assist each other and work as a collective. The color blue is examined as a way to represent water being soaked up by roots, and students practice how they would share what they've learned throughout the module with people who are visiting the completed sculpture. The module ends with students visiting the prairie restoration plots, where the plant labels from Lesson 3 are used to label the living plants in the plot. Students learn more about prairie restoration, and observe pollinators and plant life cycles in the plots.

Deeply Rooted Curricular Design

The Deeply Rooted Educational Module was developed with various learning theories, pedagogies, and modes of knowledge in mind. The lesson plans are intended to include the following attributes: place-based, interdisciplinary, exploratory and play-based, collaborative, and multi-sensory.

Place-based learning is meant to recontextualize education by connecting students to their physical, social, and cultural environments (Deringer, 2017). This style of learning encourages students to solve real-world problems by examining their own communities (Deringer, 2017). In order for a curriculum to be truly place-based, it cannot be too standardized, which is why it is recommended that educators who wish to use the Deeply Rooted Educational Module with students modify it as needed to suit their local ecosystems, land, history, and environment. As this module was built with the Freeman Environmental Education Center's campus in mind, elements such as the educational prairie study plots, the outdoor classroom covered by the pergola (where the sculpture was installed), and a large basketball court were able to be used for the lessons. Educators are encouraged to be creative in their approach to using the module and using spaces that are accessible and inspiring to them. Because the Freeman Environmental Education Center sits on the traditional homelands of the Anishinaabe peoples, the Anishinaabe (including Ojibwe, Odawa, and Potawatomi) tribes' histories were included in the curriculum. Educators using the module on other ancestral territories should adapt the lessons accordingly.

Interdisciplinary learning involves combining skills and understanding of topics in typically distinct subject areas (Campbell & Henning, 2010). However, the need for intentionally interdisciplinary learning is in part due to the prevalence in Western education of separate disciplines from early childhood, reinforced throughout schooling and in higher education (Klein, 2006). Conversely, Indigenous modes of knowledge-making and sharing are more inherently transdisciplinary and holistic, featuring collective processes for facilitating dialogue between knowledge systems (Maffi, 2005). Especially in environmental education, approaching complex problems via various disciplines can often lead to more collaborative and creative solutions. The lesson plans in this module are designed with various disciplines intertwined, including ecology, botany, visual arts, sculpture, math, engineering, English, history, and anthropology.

Integrating environmental education with the arts specifically has been shown to be strongly effective for a number of reasons (Ison & Bramwell-Lalor, 2023). The arts have been shown to help evoke emotions and motivate people to care for the environment (Gray & Birrell, 2015). As the interdisciplinary nature of the arts supports cognitive, psychomotor, and affective modes of learning (Liu & Chen, 2018), this translates into also supporting the 5 tenets of environmental education-- awareness and knowledge through cognitive development, skills and participation through psychomotor development, and pro-environmental attitudes through affective modes of learning (Zylstra et al., 2014).

Based on these principles, visual arts were incorporated throughout the Deeply Rooted Educational Module-- not only with the environmental sculpture completed at the end, but throughout various interspersed activities. Students were exposed to naturalistic methods of drawing in Lesson 1 by drawing based on close observation of plant roots. Drawing based on observation allows students to examine objects with a more attentive eye, and has been used throughout history to teach and learn about the natural world. In Lesson 2, art was used in conjunction with story, as students collaboratively created a visual representation of a prairie ecosystem as they were guided through the history of prairies through storytelling. Although this exercise was scaffolded in a way that students were guided on what organisms, processes, and/or elements to draw, they also had sufficient creative freedom that all the collaborative drawings created in June 2022 were unique in style and composition (Figure 14).

Another example of structured arts integration can be found in Lesson 3 when students were able to draw imagined root systems of native plant roots that they had measured out to their full length on pavement. This allowed for students to create a visual representation of how deep prairie plant roots can reach, and also allowed for creative expression in the ways that students chose to depict their assigned plant's roots. Students also were able to explore more imaginative art generation through the activity in Lesson 3 in which they worked in small groups to draw an "imagined prairie" above the structure of the pergola where Deeply Rooted was eventually installed (Figure 14). This exercise used visual art as a way to cement and further explore learning-- students were able to use what they had already learned about native prairie plants, their root systems, and the plans for the collaborative sculpture to inform their drawings. Some of these drawings were also incorporated into the installation of Deeply Rooted alongside interpretive signage.

Figure 14: Collaborative drawings created by participants in the 2022 A2 Nature Guardians Summer Camp.

Finally, the most obvious integration of the arts into the module was in the collaborative creation of the outdoor sculpture itself. Students learned about using salvaged materials to create sculptures as an intersection of environmentalism and the arts, and gained experience building art with both raw natural materials (shrub branches) and human-manufactured materials (denim).

STEM (science, technology, engineering, and mathematics) topics are very naturally at the core of the educational module. STEM topics explored throughout the module include ecology, botany, ecosystem services, and even physics in capillary action. Students are also able to build confidence in math and engineering skills when using tape measures to measure and draw life-sized representations of native plant roots on pavement. Botany topics include learning about the structure and functions of tap roots and fibrous roots, plant life cycles, and plants' role in the greater ecosystem.

History and anthropological topics are also essential to the foundation of the module. Learning about colonialism and imperialism are core tenets of place-based education for many practitioners, since these systems are inherently connected to the environment (Deringer, 2017). The aim of the module is to be honest about the history of colonialism in the history of Turtle Island, and also to be a spark for future conversations and pro-environmental actions. The story of Indigenous land theft is essential to include when learning about environmental topics on Turtle Island, especially when the vast prairies of pre-1800s were historically maintained by Indigenous stewardship (Day 1953, Chapman 1984). Therefore, in the storytelling exercise in Lesson 2, the story includes Indigenous peoples being forced off of their homelands by European settlers, land being developed for agriculture, and the devastating effects that these actions had on native prairie ecosystems. Historical topics explored also include more recent events, such as stewardship of prairies in the current day (by both Indigenous and non-Indigenous groups) and the movement towards incorporating more native plants in gardening and landscape design.

Language skills are also incorporated in the module in various ways. Students are asked to share stories, opinions, and knowledge verbally throughout the lessons, an example being when they are asked to describe in vivid detail the landscape that they imagine existed 400 years ago where they are now standing. Towards the end of the module, students also are able to practice how they would explain the purpose of the collaborative sculpture to a visitor (such as a friend or family member) on site.

The Deeply Rooted Educational Module is based in exploratory play, which has been shown to be effective in childhood development as it increases student autonomy, facilitates cognitive and social development, and improves motor skills (Dankiw et al., 2020). For example, in Lesson 1's plant root exploration activity, students were able to explore a large area and dig up whichever plants they were able to with little restriction. The area was surveyed prior to the activity to make sure no poisonous plants or especially rare plants were present. This freedom allowed for students to make mistakes and learn from them. For example, a few students attempted to dig up small Eastern redbud (*Cercis canadensis*) saplings but were unsuccessful due to the depth of the taproot. However, this gave these students (and the rest who were able to observe this endeavor) a chance to grow a tangible appreciation for how deep tree taproots can reach even in relatively young saplings.

The module is also grounded in collaborative learning, as collaborative modes of learning have positive effects on cognitive, affective-motivational, and social aspects of learning in children (Van Leeuwen, & Janssen, 2019). One of the main purposes of the curriculum, building the Deeply Rooted environmental sculpture, was inherently collaborative as students worked together to create the final piece. Although each student had the autonomy to pick particular branches to wrap in denim, they were encouraged to help each other and work on larger branches together. Students were observed consistently assisting each other and also asking each other for help, which led to higher contentment and satisfaction in their work and abilities. Most activities in the module are designed to encourage collaboration in pairs (e.g. digging up and drawing plant roots, measuring and drawing native plant roots lengths) or small groups (e.g. drawing imagined prairies above the sculpture, observing capillary action). Individual creative expression and learning was also encouraged and observed within the context of collaboration in these group activities.

This curriculum was also designed to engage various senses and learning styles. Various pedagogical research has shown that students benefit from multi-sensory experiences in the classroom (Boardman, 2020), and engaging various senses can help keep students focused and improve memory and retention of topics (Saputra & Nugroho, 2015). Students were engaged visually in various ways including by drawing exercises, getting to see a physical prairie restoration site, and measuring and drawing the lengths of prairie plant roots. The exercise in which students are asked to close their eyes and visualize the landscape around them 400 years ago while listening to prompts is meant to engage both visual and auditory learners. The senses of taste and smell are incorporated by inviting students to sample carrots and radishes as examples of edible roots. There are various tactile and kinesthetic activities included in the module including digging up plants, doing body movements inspired by roots, physically measuring prairie root systems, and the actions of creating the Deeply Rooted collaborative sculpture which includes cutting strips of denim and wrapping branches with the strips.

The goal of creating the Deeply Rooted Educational Module was not only to engage the first participants in learning about native grasslands and stewardship, but also to be used as a tool for other educators in regions where prairies have been found historically. The lessons were developed to be easily adaptable, and educators are encouraged to modify both the curriculum and the final collaborative sculpture (or other artistic piece) to fit their own needs.

Children's Book: *We Planted a Prairie*

As a final component of this project and as a way to integrate ecological restoration, environmental education, and the arts, Esha Biswas wrote and illustrated a children's book titled *We Planted a Prairie*, which can be found in Appendix D. It tells the story of a community of humans and other animals who work together to restore a prairie. The story travels through time as the prairie develops, and includes opportunities to learn about site preparation, planting methods, prairie maintenance tools such as mowing and fire, seed collection, and foraging. The educational guide at the end of the book includes discussion questions to promote further action, a guide to the plants and animals featured in the illustrations, and recipes that can be made with foraged ingredients from a prairie.

We Planted a Prairie is a book for children and adults of all ages, and is meant to start conversations around bringing prairies back to the land. Children's books can be a powerful tool in environmental education by engaging both youth and caregivers in private and public settings. *We Planted a Prairie* will be self-published in the future, and copies will be provided to the Freeman Environmental Education Center for use in future programming. The book is also digitally available to view publicly.

Appendix A: Signage

The following signage was installed in July 2021 as a way to communicate to students, educators, and the public about the prairie restoration efforts at the Freeman Environmental Education Center.

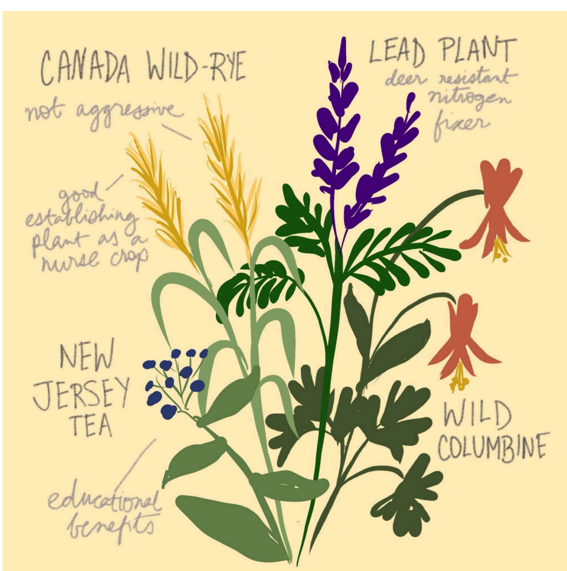
The scannable QR code on the signage above directed users to the Freeman Environmental Education website, where more information and photos were provided about restoration efforts taking place.

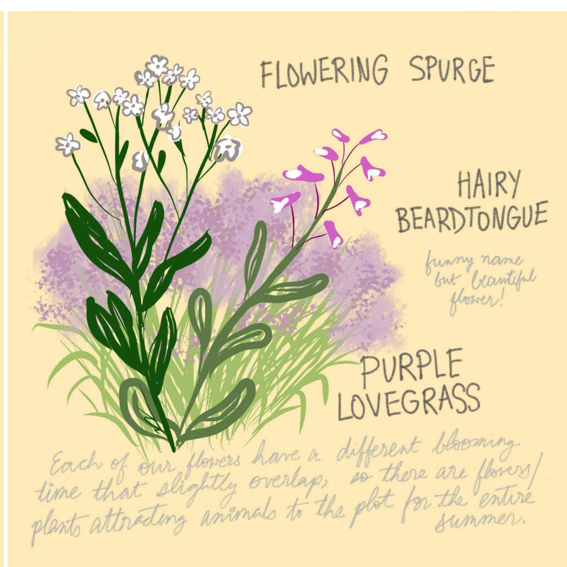
Prairie Dreaming

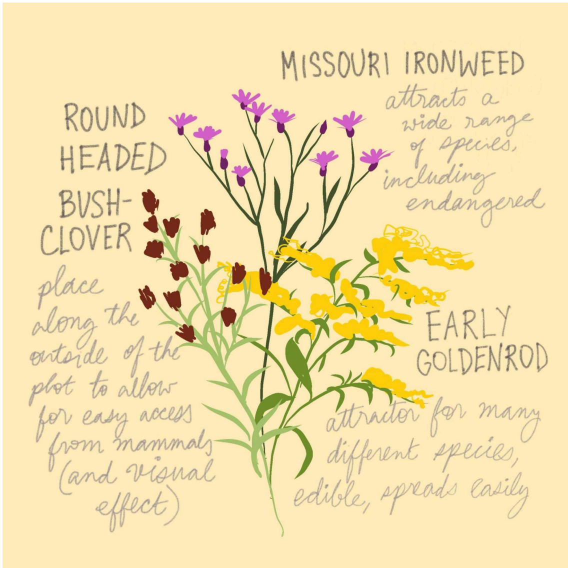
These sketches were created by University of Michigan School for Environment & Sustainability (SEAS) Master's student Esha Biswas, as part of an ongoing collaboration with the Freeman Environmental Education Center. Students in the Freeman Environmental Youth Council were given information about various native plants that are suited to the site conditions of nearby study plots that will be converted into an educational prairie. Students then selected groups of species that they would like to eventually see in this prairie, and their selections are visually summarized here along with some of the reasoning behind their choices.

Freeman Environmental Education Center

SEAS SCHOOL FOR ENVIRONMENT AND SUSTAINABILITY UNIVERSITY OF MICHIGAN



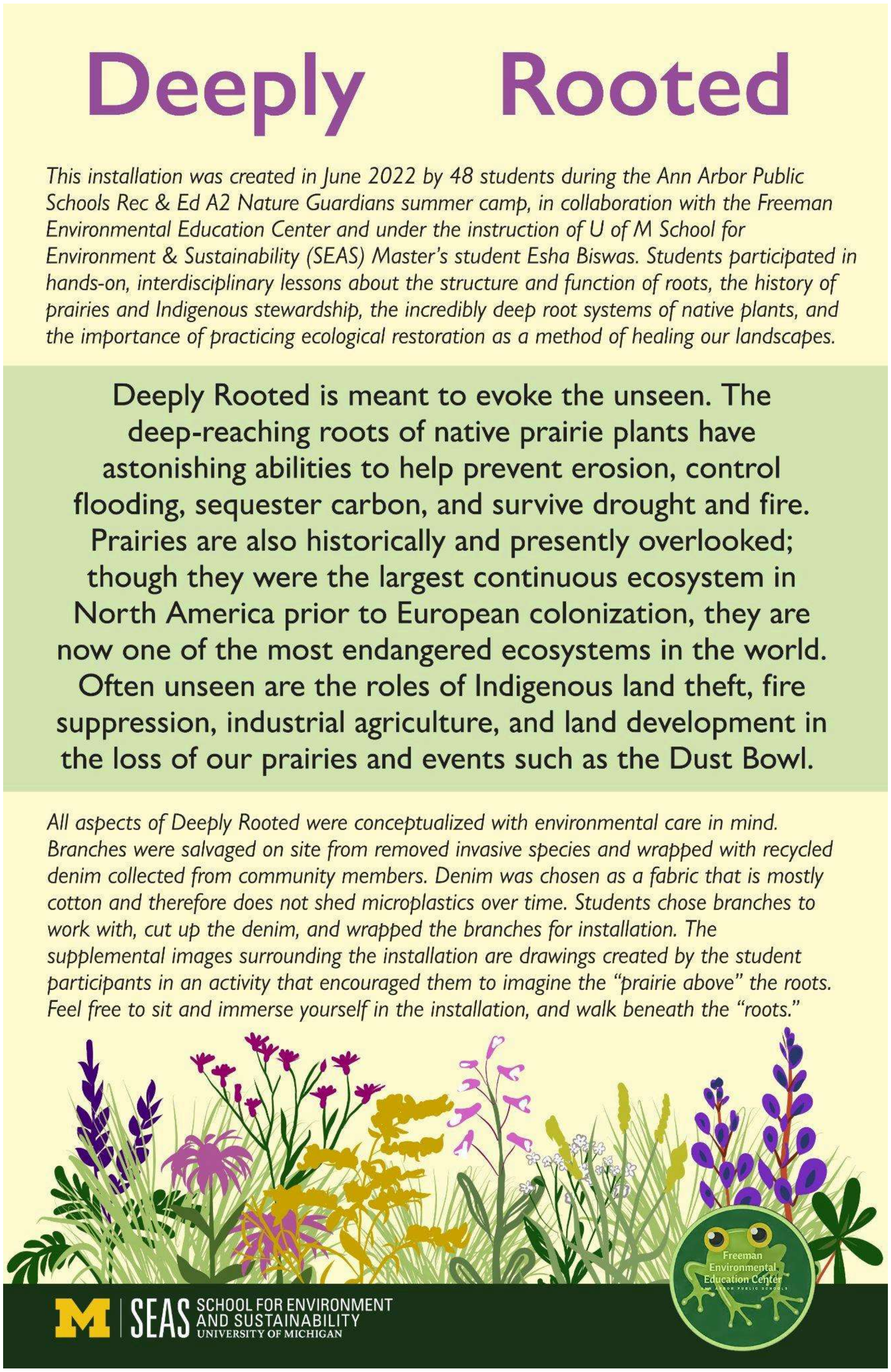



MISSOURI IRONWEED
attracts a wide range of species, including endangered
ROUND HEADED BUSH-CLOVER
place along the outside of the plot to allow for easy access from mammals (and visual effect)
EARLY GOLDENROD
attractor for many different species, edible, spreads easily


WESTERN SUNFLOWER
WILD LUPINE
JUNE GRASS
BEE BALM
We wanted to get all edible plants because we thought it would be fun to have an activity at Freeman where kids can go out, pick plants, learn about them, and then cook and eat them!


Prairie Dreaming

The signage for Deeply Rooted was installed along with laminated drawings created by students who participated in the Deeply Rooted Educational Modules. The two different informational signs were meant to engage adults and youth respectively.




Roots are everywhere!
You're looking at a sculpture that was built by a group of students during summer camp here at the Freeman EE Center.
Notice how the hanging branches look like the roots of imaginary plants.
What do roots provide for a plant and an environment?
Prairies are grasslands that used to cover a lot of our local lands.
Imagine a prairie full of colorful wildflowers and tall grasses surrounding you where you are standing.
What kind of animals and insects would you see in the prairie?
Prairie plants have really deep roots!
Some native plant roots reach 20 feet into the ground! These deep roots help hold soil together, soak up lots of water to prevent floods, and store carbon in the ground, which helps to slow down climate change.
Can you think of a place in your community where you could add native plants to help our environment?
M | SEAS SCHOOL FOR ENVIRONMENT AND SUSTAINABILITY UNIVERSITY OF MICHIGAN
Freeman Environmental Education Center


Deeply Rooted
Roots are everywhere!

Appendix B: Presentation and Lesson Plan for Species Selection Activity

In order to create a custom seed mix suited for the site and our restoration objectives, a lesson plan was developed for guiding high school students in the Freeman Environmental Youth Council through the process of species selection for a restoration project. The lesson was conducted virtually via Zoom on May 5, 2021, and a total of 13 students participated. Students were first given a brief presentation on different strategies of ecological restoration, oak barren ecosystems, functional diversity, and ecological niches of interest. The slides from this presentation are included in this Appendix. Students were then given information about the site (such as soil conditions, sunlight, and chances of herbivory), along with a curated list of numerous native plant species that are suited to the site conditions. Information included along with common and scientific names of each plant were height, bloom time and color, pollinators attracted by the plants (including any notable host plants for endangered species), cultural uses, and deer resistance. This curated list of plant species is also included in this appendix. Students then worked in small groups to select 5 plants, including one grass species, that they wanted to be included in the seeding mix for restoration, and presented their selections to the entire group at the end of the activity.

This lesson plan can be adapted and modified to guide any group through the process of species selection for ecological restoration, and educators are encouraged to use the lesson plan for their own projects.

Welcome!

Icebreaker: Share in the chat one native Michigan plant that you are drawn to (it's okay if you're not sure if it's native). What draws you to this plant?

Freeman Prairie Project - Seed Mix Planning

5 study plots set up, each with different treatments

4 out of 5 of the plots are going to be seeded with a diverse native plant mix in the fall, which YOU will be helping us plan today!

Different Approaches to Ecological Restoration

- **PAST**: restoring to a historical point in time (e.g. before development, European colonization, etc.)
- **PRESENT**: restoring based on current needs (e.g. endangered species, cultural uses, etc.)
- **FUTURE**: restoring for a resilient future (long-term sustainability, climate change, etc.)

PAST: Freeman Center used to be an Oak Barren!

- Prairies and oak barrens are both types of savannas or grasslands
  - Prairies have 0-10% tree cover, oak barrens 10-50%
- Really important for supporting wildlife, filtering water, nutrient cycling, preventing erosion and flooding, sequestering carbon, cultural benefits
- Fire-dependent: prairies in North America have been maintained by Indigenous people for millennia
- Savannas are threatened ecosystems now due to agriculture, development, fire suppression, and colonialism

Maximizing Functional Diversity

We want our mix of plants* to inhabit a variety of **NICHES** - or fulfill as many different roles as possible

- Ex: if we only plant species that bloom in early summer, we're not supporting pollinators later in the summer, because we haven't filled that niche.

*We'll be using plants native to Michigan to maximize our support for native pollinators, which often have specific native plants that they need to survive

Niches to fill in a prairie planting

Forbs (wildflowers)

Warm-season and **cool-season** grasses, **sedges**

Blooming time for forbs

Legume forbs (nitrogen fixers, important for soil health)

Additional factors (that you don't have to worry about today):

Habitat requirements - plants have already been selected for a drought-resistant, full sun, loam soil area

Budget

Seed preparation, germination

Ratios of seeds for the mix

Plant availability at nurseries

Your task today with your group:

- **Select 5 plants (including at least one grass)** that you'd like us to include in our prairie planting at Freeman
- Try your best to maximize **functional diversity** with your selection (but no pressure to fill ALL the niches we've discussed with only 5 plants!)
- Be prepared to share your rationale for your choices

Freeman Prairie Project - Seed Mix Planning

Present the species your group selected and your rationale for selecting them.

Closing question: Share with the group one way that you dream the prairie at Freeman could be used in the future!

Table B1: Species information provided to students for seed mix species selection activity (pre-selected as species appropriate to restoration site)

FORBS									
Species	**Common Name**	**Height**	**Bloom time**	**Bloom color**	**Pollinators attracted**	**Host plant for insects (*asterisk = threatened or endangered)**	**Cultural uses**	**Deer resistant**	**Notes**
Achillea millefolium	Yarrow	2'	Jul-Aug	White	Butterflies, moths, beetles	Many moths & beetles	Medicinal	Yes	
Allium cernuum	Nodding wild onion	1'	Jul-Aug	Lavender	Bees		Edible, medicinal	Yes	
Amorpha canascens	Lead plant	3'	Jun-Aug	Violet	Bees, butterflies, moths, beetles, birds	Dog face sulphur butterfly	Medicinal	Yes	Legume - N fixer
Anemone cylindrica	Thimbleweed	2-3'	May-Jun	White				Yes	
Aquilegia canadensis	Wild columbine	3'	May-Jun	Red/ Yellow	hummingbirds, bees, butterflies	Columbine Duskywing	Edible, medicinal	Yes	Easy seed collection
*Asclepias syriaca**	Common milkweed	4'	Jun-Aug	Pink	butterflies, bees, birds	Monarch butterfly	Edible, medicinal	Yes	Easy establishment, seed collection
Asclepias tuberosa	Butterfly weed	2'	Jul-Aug	Orange	butterflies, bees, birds	Monarch butterfly	Edible, medicinal	Yes	
Aster laevis	Smooth aster	3'	Sep-Oct	Purple	butterflies, bees			Yes	
Aster novae-angliae	New England aster	3-5'	Aug-Oct	Purple	butterflies, bees			Yes	self-seeds easily, can be weedy
Aster oolentangiensis	Prairie heart-leaved aster	1-4'	Jul-Nov	Blue	butterflies, bees		Medicinal	Yes	
Aster pilosus	Hairy aster	3'	Aug-Oct	White	butterflies, bees			Yes	
Aster sagittifolius	Arrow-leaved aster	3'	Aug-Oct	Blue	butterflies, bees			Yes	
Ceanothus americanus	New Jersey tea	2-3'	Jun-Aug	White	butterflies, bees, birds	Spring azure butterfly*	Medicinal	No	Educational - can

									make tea. Deer and rabbits like young plants
Coreopsis lanceolata	Sand tickseed	2'	Jun-Jul	Yellow	butterflies, bees, birds			Yes	spreads easily
Coreopsis tripteris	Tall tickseed	5-7'	Jul-Aug	Yellow	butterflies, bees, birds			Yes	spreads easily, can be aggressive
Desmodium canadense	Showy tick-trefoil	3-5'	Jul-Aug	Purple	butterflies, bees, birds			No	Legume - N fixer. Mammals eat seeds and plant
Echinacea purpurea	Purple coneflower	3-4'	Jul-Sep	Purple	butterflies, bees, birds	Ottoe skipper*	Medicinal	Yes	Many medicinal uses
Eryngium yuccifolium	Rattlesnake-master	4-5'	Jul-Aug	White	small native bees, moths, flies	Black swallowtail butterfly	Cordage (rope/stri ng)	Yes	
Euphorbia corollata	Flowering spurge	2-4'	Jul-Aug	White	butterflies, bees, birds	Karner blue butterfly*		Yes	Seeds attract many birds
Gnaphalium obtusifolium	Catsfoot	1-3'	Jul-Sep	White				Yes	Pleasant smell like maple syrup
Helianthus occidentalis	Western sunflower	2-3'	Aug-Sep	Yellow	bees, flies, birds		edible	Yes	Birds feed on seeds
Heliopsis helianthoides	False sunflower	4-6'	July-Sep	Yellow	butterflies, bees, birds		edible	Yes	Short-lived perennial
Kuhnia eupatorioides	False boneset	2-4'	Aug-Sep	Cream	butterflies, moths			Yes	Fragrant flowers
Lespedeza capitata	Round headed bush-clover	3-4'	Aug-Sep	Green	butterflies, moths	Several butterflies and moths	edible, medicinal	No	Legume - N fixer. Mammals eat plant (deer, rabits), birds eat seeds
Liatris aspera	Rough blazing star	2-3'	Aug-Sep	Purple	butterflies, bees		medicinal	No	
Lupinus perennis	Wild lupine	1-2'	May-Jun	Lavender	butterflies, bees, birds	Karner blue butterfly*	edible, medicinal	No	Legume - N fixer. Seed pods

									explode making them fun to collect
*Monarda fistulosa**	Bee balm	2-4'	Jul-Aug	Lavender	hummingbirds, butterflies, bees	Raspberry pyrausta butterfly	edible, medicinal	Yes	Many edible uses, leaves can be used as insect repellent
Monarda punctata	Spotted bee balm	1-3'	Jul-Aug	Pink	butterflies, bees, birds	Raspberry pyrausta butterfly	edible, medicinal	Yes	
Oenothera biennis	Common evening-primrose	2-5'	Jul-Sep	Yellow	moths, butterflies, bees	Primrose moth	edible, medicinal, dye from flowers	Yes	Many edible uses
Penstemon digitalis	Foxglove beardtongue	3-5'	Jun-Jul	White	many types of bees, hummingbirds	Chalcedon checkerspot, Edith's checkerspot		No	
Penstemon hirsutus	Hairy beardtongue	2'	May-Jun	Lavender	hummingbirds, bumblebees, butterflies	Chalcedon checkerspot, Edith's checkerspot, Baltimore checkerspot		Yes	
Pycnanthemum virginianum	Virginia mountainmint	2-3'	Jul-Aug	White	many bees, wasps, flies, butterflies, beetles		edible, medicinal	Yes	Leaves are minty and fragrant
Ratibida pinnata	Yellow coneflower	3-6'	Jul-Sep	Yellow	butterflies, bees, birds		medicinal	Yes	
*Rudbeckia hirta**	Black-eyed Susan	1-2'	Jun-Sep	Yellow	butterflies, moths, bees, birds	Silvery checkerspot		Yes	Often one of the earliest prairie plants to visually appear in a new planting
Senecio obovatus	Round-leaved ragwort	2'	May-Jun	Yellow	bees			No	Forms a groundcover and prevents weeds
Silphium integrifolium	Rosin weed	4-6'	Jul-Sep	Yellow	solitary bees, butterflies		edible, medicinal	Yes	quick to mature, very

									drought resistant
Silphium laciniatum	Compass plant	5-10'	Jul-Sep	Yellow	bees, birds		edible, medicinal	Yes	Takes many years to bloom from seed, but long life expectancy. Leaves orient on a north-south axis!
Silphium terebinthinaceum	Prairie dock	5-10'	Jul-Sep	Yellow	honeybees, bumblebees, birds		edible, medicinal	Yes	drought-resistant and long-lived
Solidago juncea	Early goldenrod	3'	Aug-Oct	Yellow	many bees, wasps, flies, butterflies, beetles		edible, medicinal, dye	Yes	can become a spreader
Solidago nemoralis	Gray goldenrod	2'	Aug-Oct	Yellow	many bees, wasps, flies, butterflies, beetles		medicinal, dye	Yes	
Solidago rigida	Stiff goldenrod	3-5'	Aug-Oct	Yellow	many bees, wasps, flies, butterflies, beetles		medicinal, dye	Yes	spreads easily
*Solidago speciosa**	Showy goldenrod	2-7'	Aug-Oct	Yellow	many bees, wasps, flies, butterflies, beetles			Yes	
Tradescantia ohiensis	Common spiderwort	2-4'	May-Jul	Blue	many native bees		edible, medicinal	Yes	
Vernonia missurica	Missouri ironweed	4-6'	Aug-Sep	Purple	butterflies, bees, birds	Parthenice tiger moth, ironweed borer moth, Red groundling	medicinal	Yes	
Veronicastrum virginicum	Culver's root	4-6'	Jul-Aug	White	butterflies, bees			Yes	
Zizia aurea	Golden alexander	1-3'	May-Jun	Yellow	moths, butterflies, bees	Black swallowtail	edible, medicinal	Yes	

GRASSES							
Species	**Common Name**	**Heig ht**	**Bloom time**	**Host plant for insects (*asterisk = threatened or endangered)**	**Cultural uses**	**Deer resis tant**	**Notes**
Andropogon gerardii	Big bluestem	5-8'	Warm season	Host plant for many insects	hay, forage for cattle	Yes	can easily take over a prairie
Bouteloua curtipendula	Side-oats grama	1-2'	Warm season	Host plant for at least 5 skipper moths	crafting (baskets, brooms)	Yes	oat-like appearance, grows in clumps
Elymus canadensis	Canada wild-rye	3-5'	Cool season	leafhoppers, aphids, leaf beetles, miner moths	flour	Yes	can serve as a "nurse crop" to help establish a prairie and keep out weeds, eventually fading away to make room for other plants
Eragrostis spectabilis	Purple lovegrass	1-2'	Warm season			Yes	
Koeleria cristata	June grass	2'	Cool season		flour, crafting (brooms)	Yes	flowers earlier than many other grasses
Panicum virgatum	Switchgrass	3-5'	Warm season	birds, skippers	forage for cattle	Yes	grows in clumps, can become aggressive
Schizachyrium scoparius	Little bluestem	2-3'	Warm season	many skippers, grasshoppers, beetles		Yes	"bunch grass" - provides habitat for bees and other insects
Sorghastrum nutans	Indian grass	5-8'	Warm season	grasshoppers, many caterpillars, birds		Yes	self-seeds easily, can become aggressive
Sporobolus heterolepis	Prairie dropseed	1-3'	Warm season		flour	Yes	

Appendix C: Deeply Rooted Educational Module Lesson Plans

This appendix includes the detailed plans for each lesson in the Deeply Rooted Educational Module.

The Deeply Rooted Educational Module was taught for the first time during the A2 Nature Guardians Summer Day Camp through Ann Arbor Recreation and Education, which took place in June 2022 at the Freeman Environmental Education Center. The module was conducted a total of 4 times with groups of 12 students (ages 7-10) at a time, for a total of 48 participants. The module takes a total of 4 days to complete, with each day's lesson taking 45 minutes to complete. The overall purpose of the educational module, which can be adapted to students of various ages, is to raise awareness and build knowledge in participants of the importance of prairie ecosystems and conservation, and to build an outdoor art installation that evokes the deep root systems of native prairie plants. The purpose of the art installation is to further serve as an educational tool for not only the student participants who help co-create it, but also visitors who can further their own appreciation and understanding of prairies and their root systems. This educational module was designed to share publicly to encourage others to also make similar educational art installations.

Lesson 1: Getting to the Root of it

Goals: Introduction to structures and functions of plant roots.

Length of lesson: 1 hour

Materials needed:

- Hand trowels
- Hand lenses/magnifying glasses
- Paper and drawing utensils
- Clipboards
- Paper towel strips
- Cups of water dyed with food coloring
- Carrots, beets, and radishes for tasting

Introduction and snack tasting - 10 mins

- Taste carrots, radishes, and beets together. What do all of these vegetables have in common?
- We're going to be nature detectives today and investigate something that's all around us, in every inch of the ground we're walking on. It's a very important part of the plant that we just ate - roots!
- What do roots do? Allow students to share what they know.
    - Nutrient and water uptake
    - Anchoring in soil
    - Plant communication via mycelial network
    - Reproduction via roots
    - Habitat for organisms
    - Give us food and medicine
- HOW do they do all these things? We're going to find out today by being scientists and artists! Scientists and artists are good at observing the world around us, and today we're going to observe roots really carefully so we can learn more about them. Today we're going to be naturalists-- or students of the natural world.

Capillary Action - 10 mins

- Students should be seated in small groups at tables with a cup of dyed water and multiple paper towel strips.
- First we're going to take a look at how roots absorb water and nutrients.
- Imagine that the strip of paper towel at your table is a root. Imagine that the food coloring in the cup represents nutrients in the soil.
- Carefully dip just the very tip of your paper towel into the food coloring and observe carefully. What do you notice?
- Notice how you didn't have to dip the whole strip into the water for the nutrients to travel all the way up. This is how roots work-- through something called capillary action!
- Now we're going to observe real roots and see if we can learn more about them.

Root Investigation - 30 mins

- Divide group up into pairs.
- Make sure each pair has: trowel, hand lens, clipboard with blank paper, and drawing utensils.
- In your pair, you will find three different plants to dig up. Then you're going to try to get as much soil off as possible from the roots. You can gently shake the soil off, or use your fingers to get soil out.
- Draw the three different plants - both what you saw above ground before digging it up, and the root systems below.
- If you find any organisms in the roots as you're investigating, feel free to draw those too!
- As students are digging and drawing, encourage them to:
    - Look closer and observe fine details
    - Compare and contrast different root structures
    - Choose a variety of plants to examine
    - Share their observations with other pairs of students
- As more root structures are revealed, introduce the concept of two different types of roots: tap roots, and fibrous roots.
    - Tap roots are one main long root that reaches deep into the ground (like a carrot!)
    - Fibrous roots are thin and spread out all throughout the ground - often found in grasses.
- Encourage students to find and draw at least one example of a tap root and one example of fibrous roots before time is up.

Summarize Findings - 10 mins

- What did we notice?
- Allow students to share drawings and observations with the whole class.
- What do you think tap roots are good for?
    - Nutrient *storage* - that's what makes carrots, beets, and radishes so tasty! Many roots have been used as food and medicine for thousands of years.
    - Tap roots reach water and nutrients at deeper levels.
    - Tap roots can also help break up the soil.
- What do you think fibrous roots are good for?
    - Anchoring, creating a network in the soil to absorb nutrients and water.
    - Holds soil together, prevents erosion.
    - Creates habitat underground for organisms.
- Both types of roots are important and a part of biodiversity-- something we'll learn more about tomorrow!
- Closing: share one thing you discovered about roots today.

Lesson 2: Rooting for Native Plants

Goals: Introduce prairies, native plants, land stewardship, and art installation.

Length of lesson: 1 hour

Materials needed:
- Markers
- Flip chart paper and easel
- Scissors (enough for each student)
- Old jeans and denim
- Denim strips to show as models

Introduction and Time Travel - 15 mins
- Stand (or sit if needed) in a circle together.
- What are some things we learned about roots yesterday?
- Today we are going to learn more about different types of plants and their roots, and we're going to talk about an art sculpture that you're going to help us create!
- Close your eyes. I'm going to ask you to pretend you're a time traveler. We're going to rewind the clock 400 years and imagine the landscape around us. What does the landscape look like in your imagination? What looks different?
- Ask prompting questions while eyes are still closed: What kind of plants and trees are growing? How big are they? What kind of animals and wildlife do you see? Do you see people? What are they doing?
- If you'd like to share something about the scene you're imagining, raise your hand and I'll come high-five you so you can share what you're imagining.
- Continue until everyone has shared.
- Thank you all for sharing. Some of the things you mentioned are very close to what this land looked like 400 years ago. Pay close attention in this next activity to compare your imagination to the history of our land!

History of Prairies - 25 mins

- While narrating the following, ask students to take turns to draw *elements on flip chart paper.*
- 400 years ago, things looked very different where we are standing. This place, like many other places in Michigan, was most likely a habitat called a prairie. What do you think a prairie is?
    - Prairies are a type of grassland - a habitat with not many trees, but lots of tall grasses and beautiful wildflowers (*draw grasses and flowers*)
- These prairies were filled with native plants - native plants are plants that have been growing on this continent for thousands of years.
- These prairies were really good at doing a lot of different things!
    - They were amazing habitats for wildlife - all the tall grasses and different flowers made it a perfect home for mammals, birds, butterflies, bees, and all sorts of other creatures (*draw mouse, bird, butterfly, bee*). This is called biodiversity-- when lots of different species can live together in an ecosystem.
    - Prairie plants also had amazingly long root systems underground, reaching deep deep deep underground (*draw roots*).
    - These roots held the soil in place so it wouldn't wash away when it rained (*draw rain clouds and rain*). Prairies were like a giant sponge, soaking up all the extra water.
    - Prairie plants also took in carbon dioxide from the air and kept it all stored up in their roots (*draw arrows,* CO_2 *from air to roots*)
- But prairies didn't just exist naturally without humans-- they existed because of humans! We're standing on land that belongs to the Anishinaabe people. The Anishinaabe people are the Indigenous, or Native American people who have lived in this place for thousands of years, and still do today. (*draw stick figures*)
- 400 years ago, Anishinaabe people were the ones who were living here and taking care of the prairies. They were helping to spread seeds and plant prairie plants (*draw seeds coming from a stick person's hand*)
- They also used fire to help prairie plants grow better. Prairie plants like fire! It helps add nutrients to the soil, helps seeds sprout, and it helps plants like shrubs and trees from getting too big and taking over. (*Draw flames*)
- Anishinaabe people also used and still use a lot of different prairie plants for food and medicine (*Draw basket in hand of another stick figure*)
- When European settlers arrived in Michigan, many Anishinaabe people were forced to leave their homes and their land was stolen from them. A lot of prairies were turned into farms, because the soil was so good to grow food

on. European settlers didn't know how to use fire to take care of the land, so shrubs and trees started taking over a lot of the prairies too.

- Today, prairies are extremely endangered. What does endangered mean? There are barely any prairies left, even though as we just learned, they are so important!
- But all hope is not lost. People all over Michigan and other places that used to have a lot of prairies are helping to bring them back. YOU can help too, because prairies need people to look after them, take care of them, and bring them back. We're even building a prairie here at the Freeman Center! This is called ecological restoration.
- As we build prairies, just like we built this drawing together, we see all of these benefits also coming back. [Ask students to help summarize benefits using the drawing]. Prairies are also really beautiful-- they bring us joy! (*add smiley faces to stick figures, hearts*)

Art Installation Intro - 15 mins

- A lot of people don't know how important prairies and native plants are, and how much important work their roots do. So we're going to work together to make a giant sculpture here in this pergola that shows people what we just learned about prairies!
- Introduce art installation concept and purpose, make the connection to tree branches having similar forms as roots, and show a sample of a wrapped branch.
- We are going to be using old worn out jeans to make our sculpture. Why is this more sustainable than buying new fabric? What might the blue color of the denim represent?
- Blue denim could represent water being soaked up by roots, just like we saw on Day 1 with the water being soaked up by the paper towel.
- Students start cutting denim into strips.

Lesson 3: Deeply Rooted

Goals: Learn about depths of prairie plant roots and imagine a prairie

Length of lesson: 1 hour

Materials needed:
- 6 tape measurers
- Sidewalk chalk
- Printed and laminated plant cards with common name, photo, and root depth
- Branches prepared for wrapping (variety of shapes with smallest twigs broken off)
- Flipchart drawing from Day 2
- Trowel + dug up turf grass with roots
- Pergola printouts (or printouts of site where sculpture will be built)
- Markers

Introduction - 5 mins
- What did we learn yesterday? Have flipchart drawing from Day 2 up for reference.
- One thing we learned about prairie plants is they often have really deep roots that reach way underground. Today we're going to meet some prairie grasses and flowers and see how deep their roots go!

Root Measuring Activity - 20 mins
- Divide group up into pairs, assign each pair a plant card, measuring tape, and chalk
- Working together with your partner, use your measuring tape to mark a "path" for how long the roots of your plant are. Using your chalk, draw what you imagine the roots of your plant to look like.
- Try drawing your plant above the ground line, and label with their name.

Gallery walk - 10 mins
- What do you notice? Do any of these root lengths surprise you?

- Another plant, the Lead Plant, has even DEEPER roots at 20 feet! (Show estimation)
- Show dug up turf grass and compare root lengths to prairie plant roots.

Drawing Activity - 20 mins
- Divide into small groups. Sketch branches on poster of pergola, sketch imagined prairie above the pergola.
- Feel free to draw and add to any of the things we learned about yesterday, and any of the plants you met today
- Draw anything else you want in your imagined prairie!

Closing - 5 mins
- Share drawings with large group
- Tomorrow we will start building our prairie roots and bring your drawings to life

Little Bluestem

Root depth: 5 feet

Purple Coneflower

Root depth: 7 feet

Prairie Dock

Root depth: 14 feet

Prairie Dropseed

Root depth: 5 feet, 6 inches

Black-Eyed Susan

Root depth: 6 feet

Blazing Star

Root depth: 16 feet

Lesson 4: Wrapping Up

Goals: Learn about prairie restoration, create wrapped branches for art installation

Materials Needed:
- Laminated plant signs planted into prairie restoration site
- Labeled branches
- Denim strips
- Installed branches (samples)

Introduction - 10 mins
- What did we learn about yesterday?
- Today we're going to work on our giant prairie root sculpture. It's going to end up looking something like this, but we need your help to make it happen!
- First, we're going to visit an actual prairie restoration site to see how we're building a real prairie here on site.

Visit Prairie Restoration Area - 15 mins
- This area is being restored to a native prairie ecosystem. What do you notice?
- Explain different methods of site preparation and planting used on the site.
- Can you find the plants you met yesterday? Do they look like they're fully grown right now?
- Some prairie plants take a few years to grow and start blooming. But that doesn't mean they're just sitting there! After planting prairie plants, most of the growth is actually happening underground in their roots.
- Some of these baby plants might already have roots that are reaching really deep into the ground!
- Seed saving is a great way to plant more prairie plants for ecological restoration. Have students collect seeds if any species have gone to seed. Encourage them to scatter some on the ground as well for the future of the prairie!

Branch Wrapping - 25 mins
- Students find their labeled branches
- Demonstrate branch wrapping with denim strips
- Students wrap branches

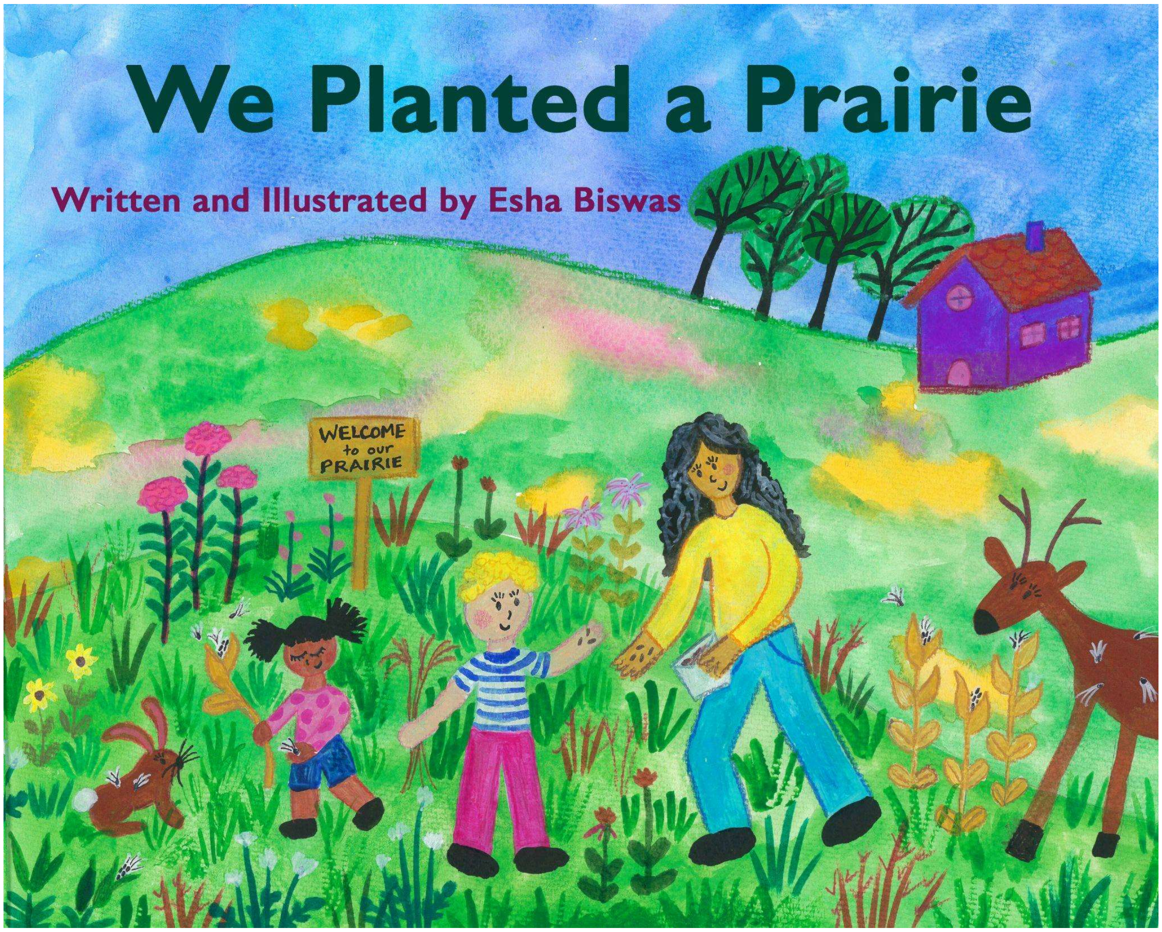
Wrap Up and Surveying - 10 mins

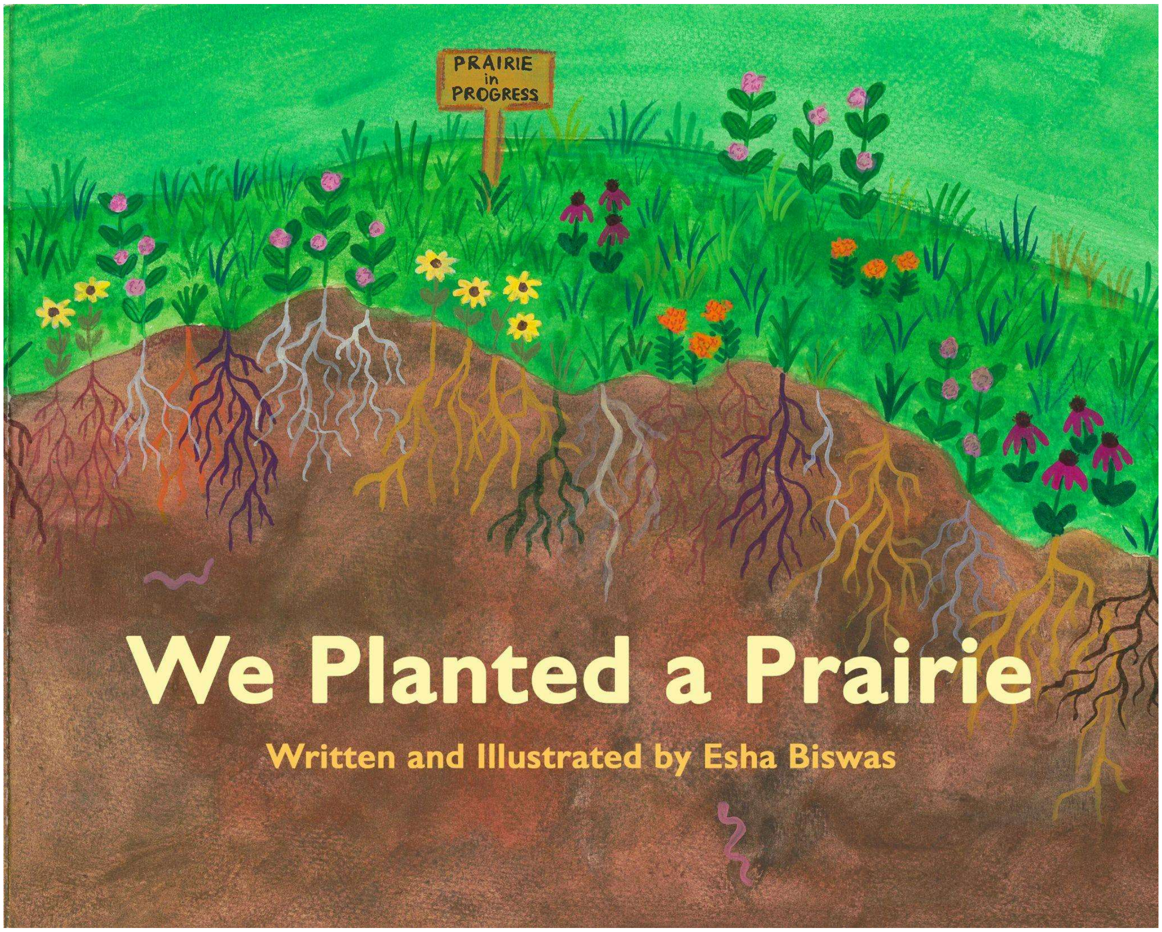
- What was your favorite part of all the things we did together this week?
- What is something you learned with me this week that you'll remember and teach someone else about?
- Come back and visit the prairie restoration and art installation with your friends and family! We'll be putting up the branches you wrapped and the art you made later, so you can bring people here and tell them about what you made and why prairies are so important.

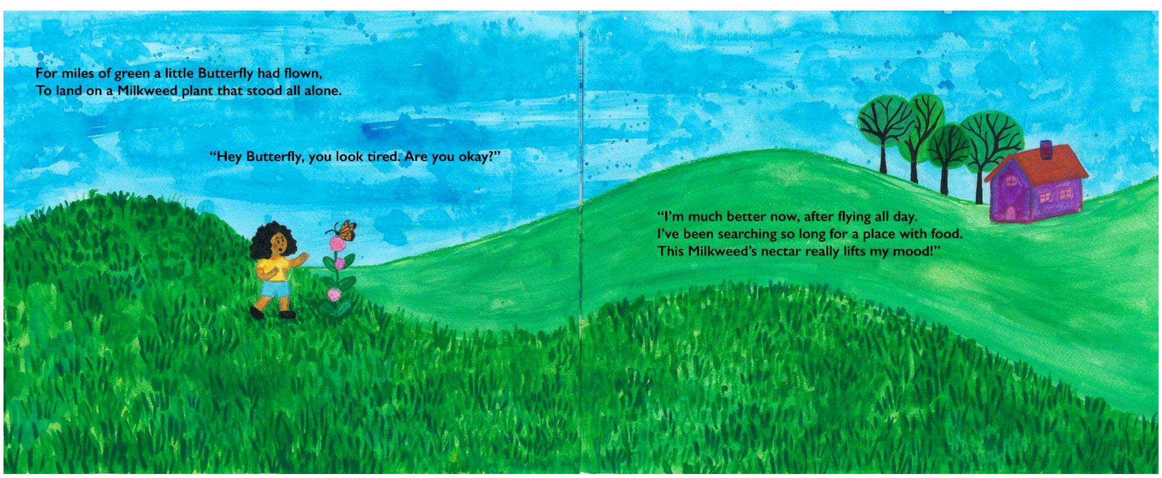
Appendix D: *We Planted a Prairie* Children's Book

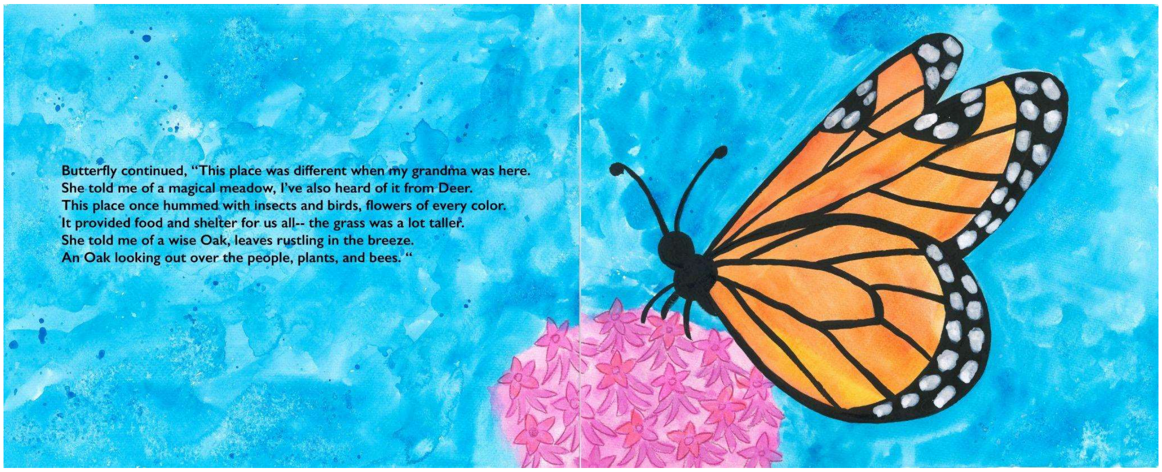
This book was written and illustrated as a component of Esha Biswas's Master's Practicum for the University of Michigan School for Environment and Sustainability. It tells the story of a community of humans and animals who work together to restore a prairie. The story travels through time as the prairie develops, and includes opportunities to learn about site preparation, planting methods, prairie maintenance tools such as mowing and fire, seed collection, and foraging. The educational guide at the end of the book includes discussion questions to promote further action, a guide to the plants and animals featured in the illustrations, and recipes that can be made with foraged ingredients from a prairie.

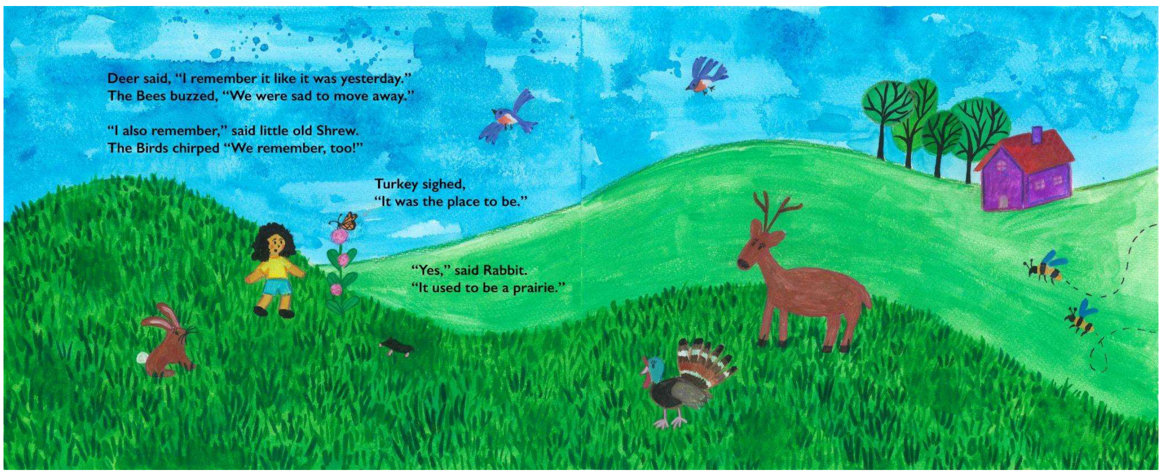
We Planted a Prairie is a book for children and adults of all ages, and is meant to start conversations around bringing prairies back to the land.

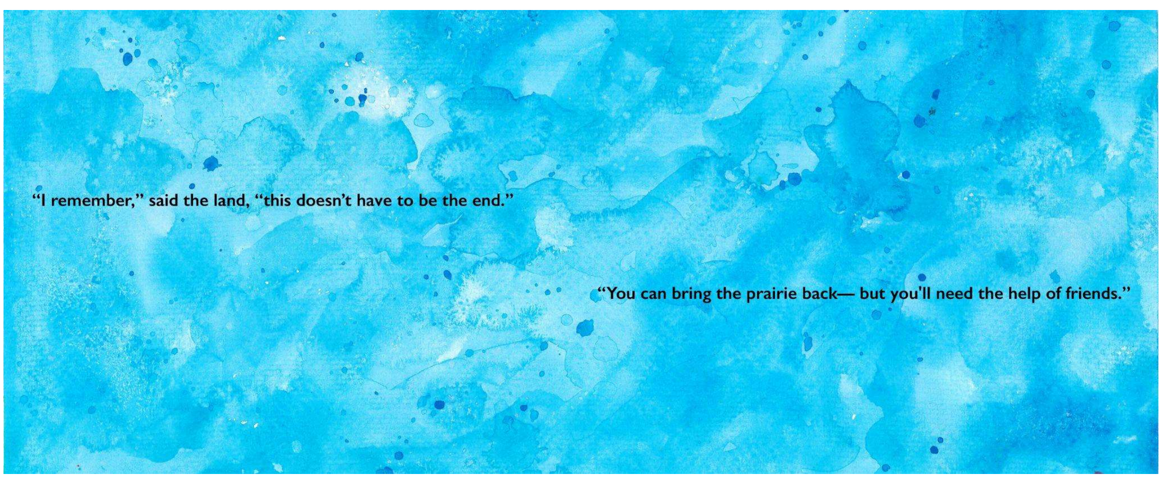

We Planted a Prairie
Written and Illustrated by Esha Biswas
WELCOME
to our
PRAIRIE

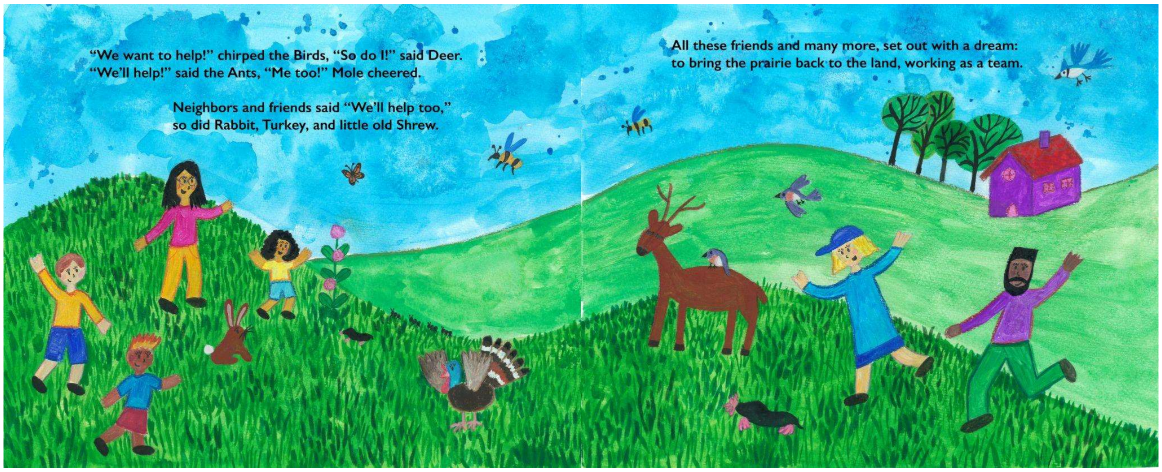

PRAIRIE
in
PROGRESS
We Planted a Prairie
Written and Illustrated by Esha Biswas

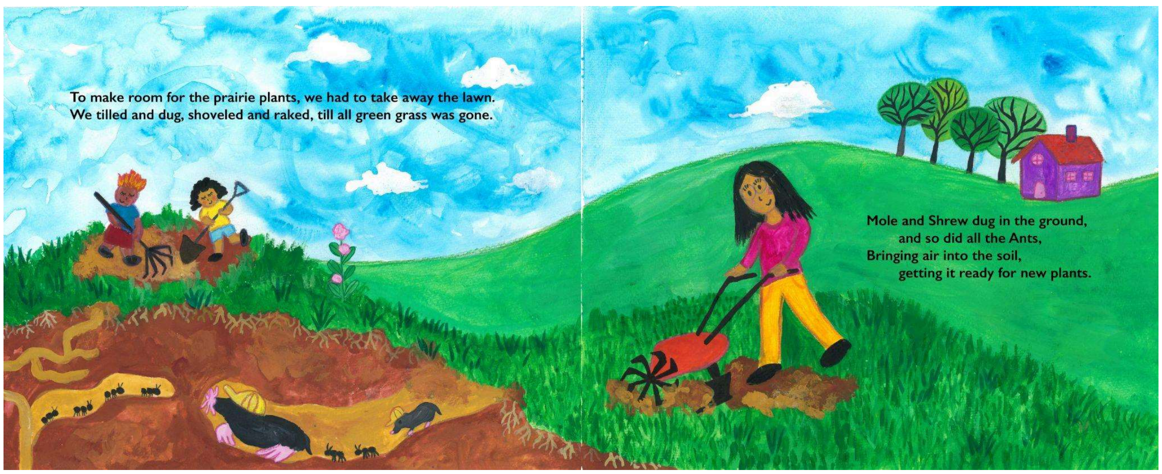

For miles of green a little Butterfly had flown,
To land on a Milkweed plant that stood all alone.
"Hey Butterfly, you look tired. Are you okay?"
"I'm much better now, after flying all day.
I've been searching so long for a place with food.
This Milkweed's nectar really lifts my mood!"

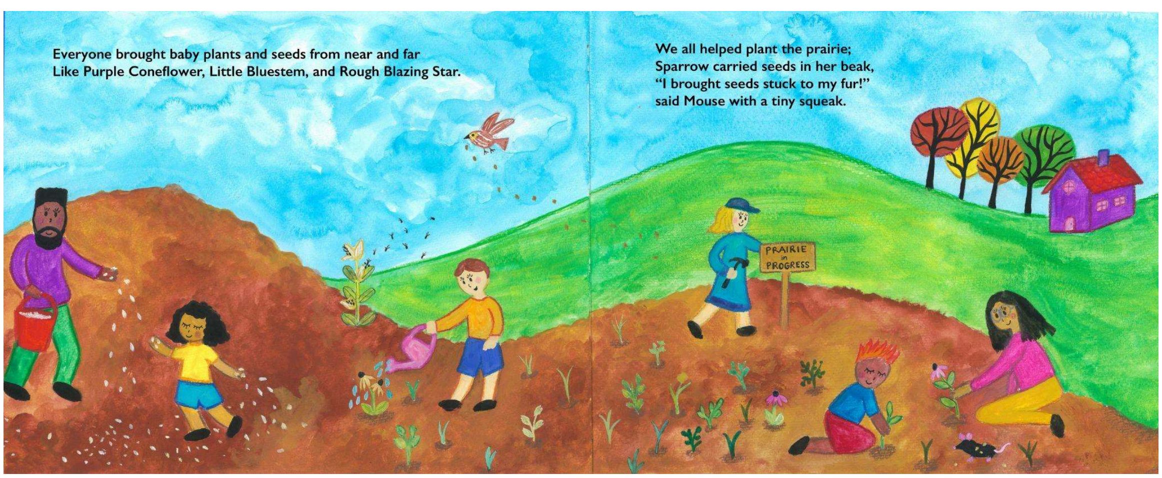

Butterfly continued, "This place was different when my grandma was here.
She told me of a magical meadow, I've also heard of it from Deer.
This place once hummed with insects and birds, flowers of every color.
It provided food and shelter for us all-- the grass was a lot taller.
She told me of a wise Oak, leaves rustling in the breeze.
An Oak looking out over the people, plants, and bees."

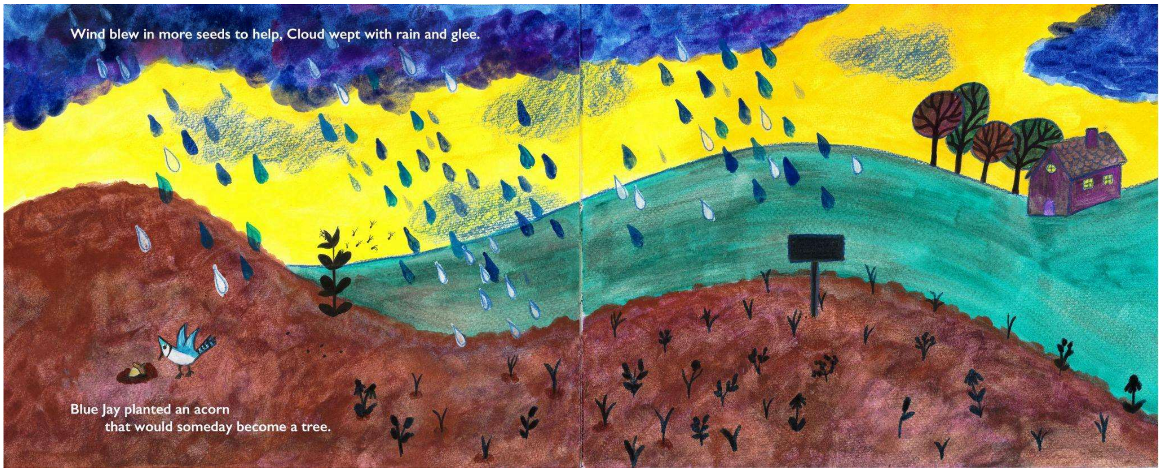

Deer said, "I remember it like it was yesterday."
The Bees buzzed, "We were sad to move away."
"I also remember," said little old Shrew.
The Birds chirped "We remember, too!"
Turkey sighed,
"It was the place to be."
"Yes," said Rabbit.
"It used to be a prairie."

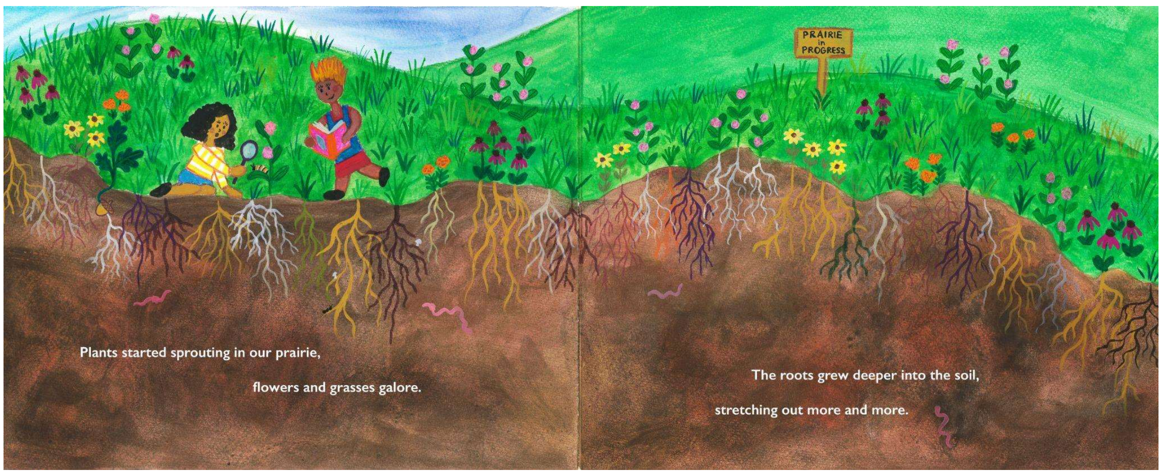

"I remember," said the land, "this doesn't have to be the end."
"You can bring the prairie back— but you'll need the help of friends."

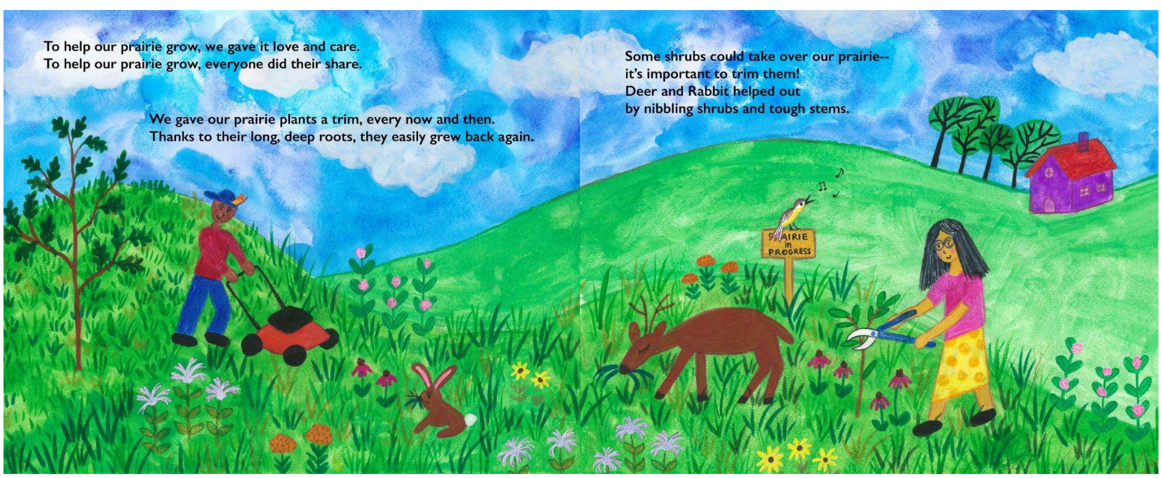

"We want to help!" chirped the Birds, "So do I!" said Deer.
"We'll help!" said the Ants, "Me too!" Mole cheered.
Neighbors and friends said "We'll help too,"
so did Rabbit, Turkey, and little old Shrew.
All these friends and many more, set out with a dream:
to bring the prairie back to the land, working as a team.

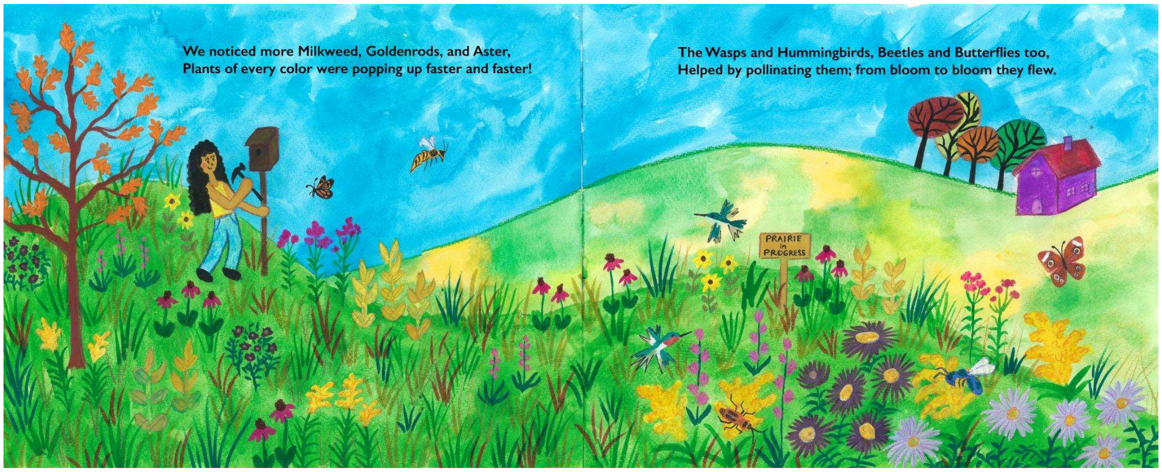

To make room for the prairie plants, we had to take away the lawn.
We tilled and dug, shoveled and raked, till all green grass was gone.
Mole and Shrew dug in the ground,
and so did all the Ants,
Bringing air into the soil,
getting it ready for new plants.

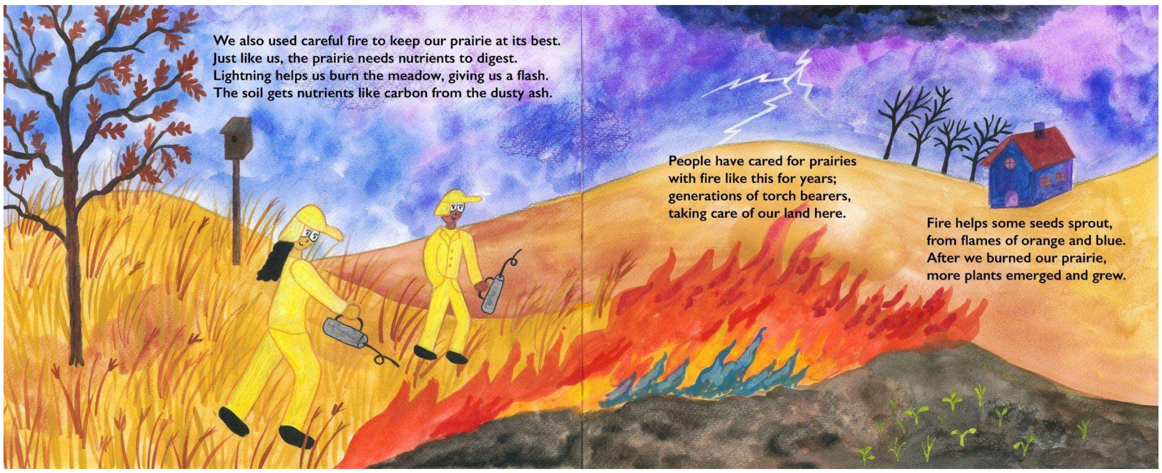

Everyone brought baby plants and seeds from near and far
Like Purple Coneflower, Little Bluestem, and Rough Blazing Star.
We all helped plant the prairie;
Sparrow carried seeds in her beak,
"I brought seeds stuck to my fur!"
said Mouse with a tiny squeak.
PRAIRIE
in
PROGRESS

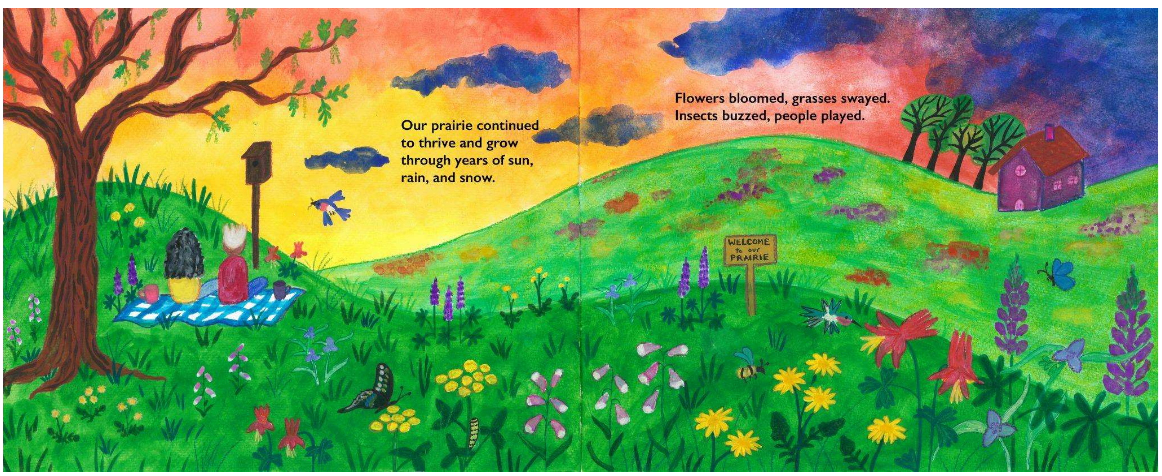

Wind blew in more seeds to help, Cloud wept with rain and glee.
Blue Jay planted an acorn
that would someday become a tree.

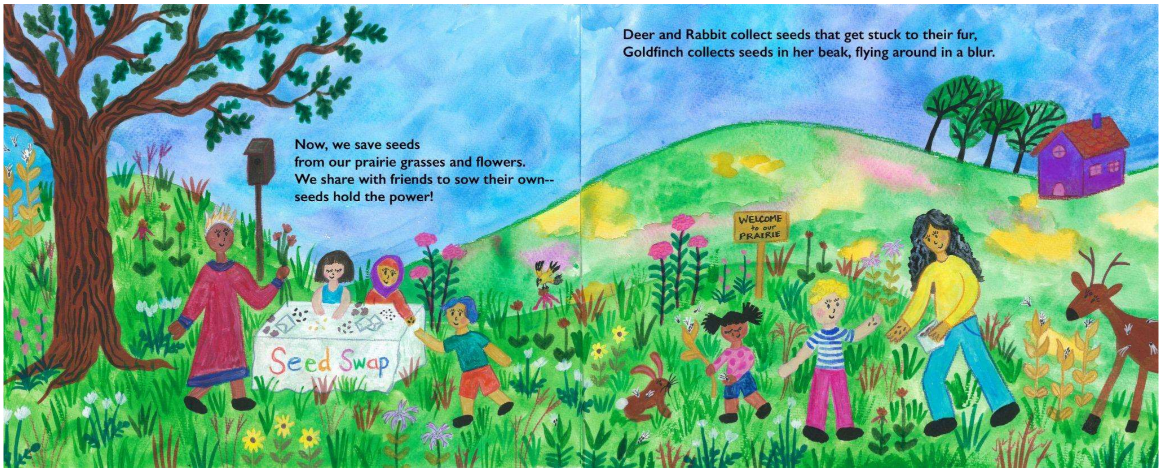

PRAIRIE in PROGRESS
Plants started sprouting in our prairie,
flowers and grasses galore.
The roots grew deeper into the soil,
stretching out more and more.

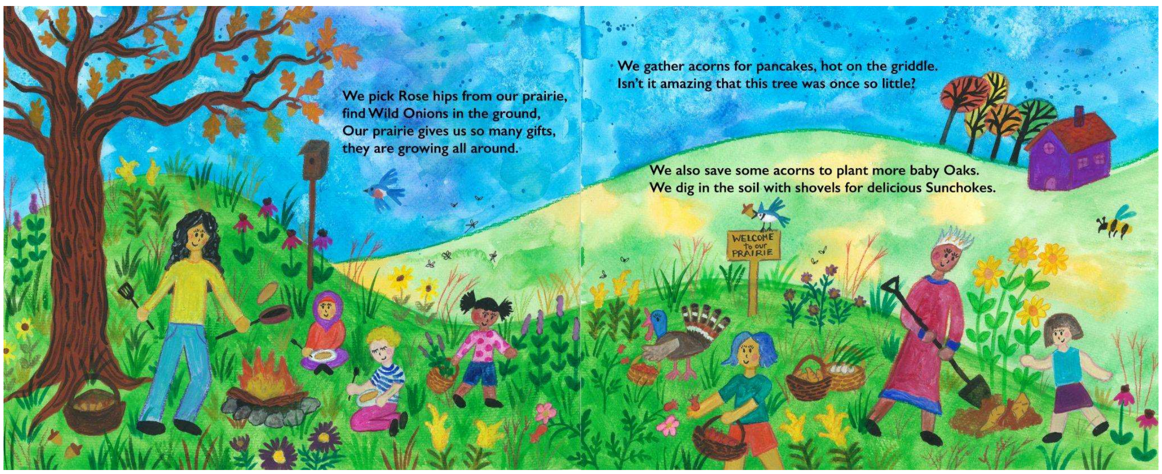

To help our prairie grow, we gave it love and care.
To help our prairie grow, everyone did their share.
We gave our prairie plants a trim, every now and then.
Thanks to their long, deep roots, they easily grew back again.
Some shrubs could take over our prairie--
it's important to trim them!
Deer and Rabbit helped out
by nibbling shrubs and tough stems.

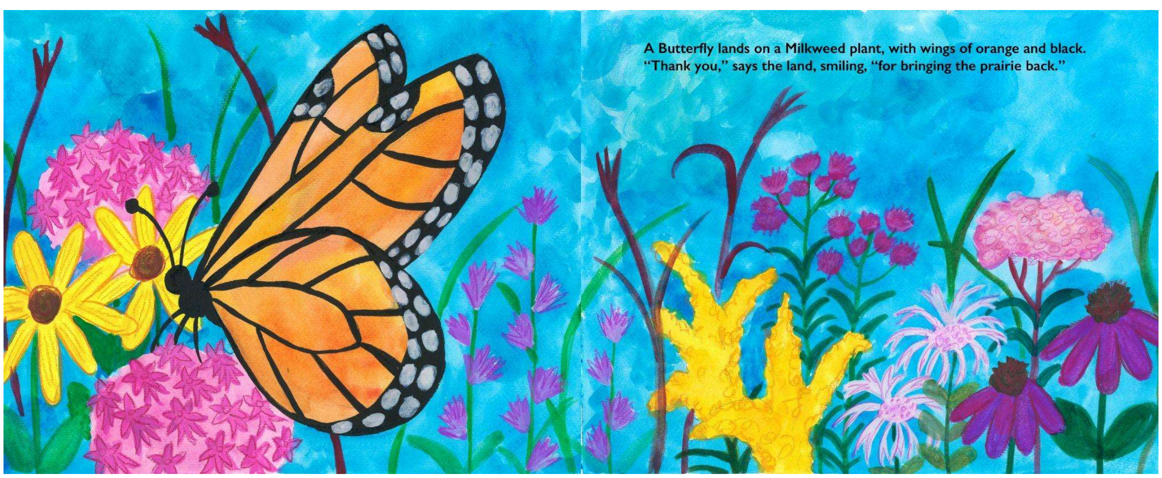

We noticed more Milkweed, Goldenrods, and Aster,
Plants of every color were popping up faster and faster!
The Wasps and Hummingbirds, Beetles and Butterflies too,
Helped by pollinating them; from bloom to bloom they flew.
PRAIRIE in PROGRESS

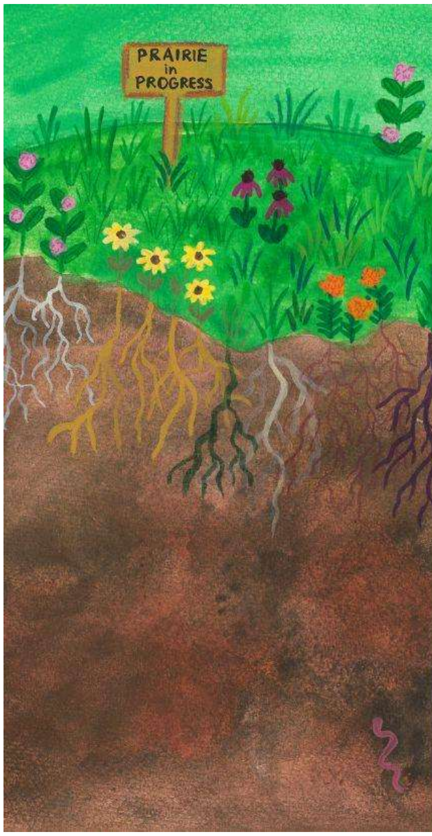

We also used careful fire to keep our prairie at its best.
Just like us, the prairie needs nutrients to digest.
Lightning helps us burn the meadow, giving us a flash.
The soil gets nutrients like carbon from the dusty ash.
People have cared for prairies with fire like this for years; generations of torch bearers, taking care of our land here.
Fire helps some seeds sprout, from flames of orange and blue. After we burned our prairie, more plants emerged and grew.


Our prairie continued to thrive and grow through years of sun, rain, and snow.
Flowers bloomed, grasses swayed.
Insects buzzed, people played.
WELCOME to our PRAIRIE


Now, we save seeds
from our prairie grasses and flowers.
We share with friends to sow their own--
seeds hold the power!
Seed Swap
WELCOME to our PRAIRIE
Deer and Rabbit collect seeds that get stuck to their fur,
Goldfinch collects seeds in her beak, flying around in a blur.


We pick Rose hips from our prairie,
find Wild Onions in the ground,
Our prairie gives us so many gifts,
they are growing all around.
We gather acorns for pancakes, hot on the griddle.
Isn't it amazing that this tree was once so little?
We also save some acorns to plant more baby Oaks.
We dig in the soil with shovels for delicious Sunchokes.
WELCOME to our PRAIRIE


A Butterfly lands on a Milkweed plant, with wings of orange and black.
"Thank you," says the land, smiling, "for bringing the prairie back."



Native plants that are found in prairies need your help!

Is there a place in your community you can think of where you can help plant a patch of prairie?

In the story, humans and lots of different creatures worked together. Whose help will you need to plant your prairie?

Prairies used to cover a lot of the North American continent. Why do you think they are so hard to find now?

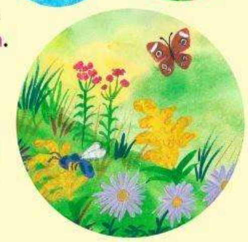
Prairie ecosystems have amazing abilities to support wildlife, help prevent erosion, control flooding, sequester carbon, and survive drought and fire. Although prairies were the largest continuous ecosystem in North America, covering an estimated 170 million acres prior to European colonization, they are now one of the most endangered ecosystems in the world, with less than 1% of original prairies remaining. Indigenous land theft, fire suppression, industrial agriculture, and land development have all contributed to the loss of our prairies and events such as the Dust Bowl.

These are only some of the animals that depend on prairie ecosystems for food, habitat, and shelter.

Mammals like deer, rabbits, and mice help transfer seeds and graze on prairie plants. Moles, shrews, and ants help aerate the soil when they make their burrows.

Birds like Eastern bluebirds, Eastern meadowlarks, blue jays, savannah sparrows, American goldfinches, and wild turkeys help spread plant prairie seeds by eating them or burying them.

Pollinators like bees, beetles, wasps, butterflies, and hummingbirds help prairie plants reproduce by spreading their pollen.




These are some of the plants that grow in a native Michigan prairie and the pollinators that rely on them!
Wild Lupine
Karner Blue Butterfly
Butterfly Milkweed
Common Milkweed
Monarch Butterfly
Purple Coneflower
Big Bluestem
Black-eyed Susan
Canada Goldenrod
Cuckoo Wasp
Goldenrod Soldier Beetle
Sunchokes
Missouri Ironweed
Prairie Rose


Hairy Beardtongue
Wild Columbine
Ruby-throated Hummingbird
Bee Balm
Prairie Ragwort
American Bumblebee
Prairie Spiderwort
Nodding Onion
Joe Pye Weed
White Oak
Notice how the plants bloom and change through different seasons in the story.
Rough Blazing Star
Golden Alexander
Eastern Black Swallowtail
Smooth Aster
New England Aster
Common Buckeye
Giant Hyssop

Prairies offer us many gifts and medicines that have been used by Indigenous people for thousands of years!

Try these recipes after harvesting prairie plants. Make sure you harvest from an area that is free from pesticides and herbicides, only consume plants that you are confident identifying as safe, leave plenty for others, and give back to the land by helping plant more prairie plants.

Prairie Tea

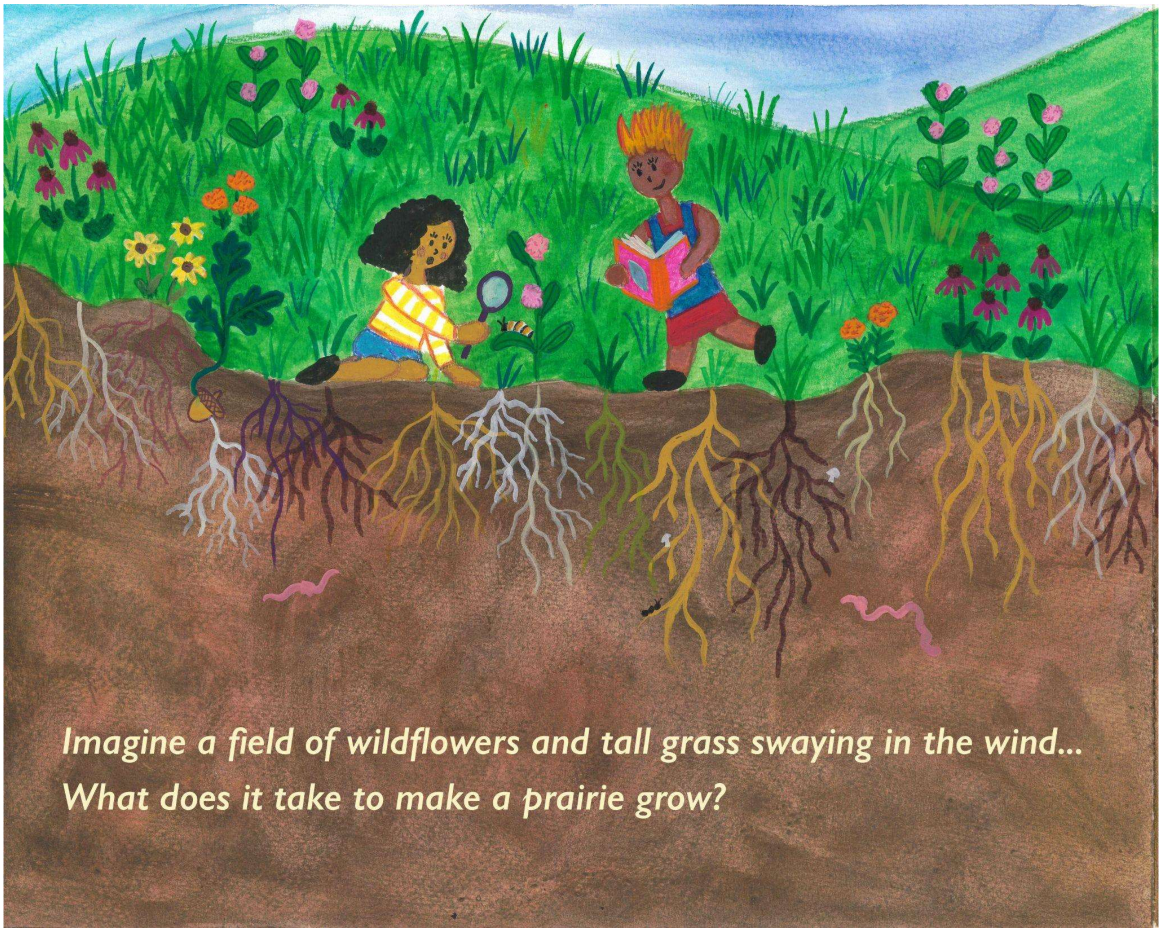
The leaves and flowers of Bee Balm, Giant Hyssop, Purple Coneflower, and Goldenrod can be used to make delicious teas by steeping them in hot water! All of these plants have valuable medicinal properties. You can use fresh or dried plants. Experiment with different blends, steeping times, and adding honey as a sweetener.

Rose Hip Syrup

Rose hips are the fruit of rose plants! Harvest rose hips after the first frost for more sweetness. Roughly chop, boil in a pot of water, strain out the solids, and add equal amounts of white sugar to your remaining liquid. Stir over low heat until all the sugar has dissolved, and cool before pouring into a glass jar. Add rose hip syrup to tea, coffee, desserts, or plain soda for a boost of Vitamin C!

Roasted Sunchokes

Sunchokes have delicious edible tubers that are similar to potatoes. After digging them up, rinse and scrub well. Chop into ½ in slices, coat in olive oil and a sprinkle of salt, and roast at 425°F for 18-22 minutes. Try seasoning your sunchokes with Bee Balm leaves or flowers!


Imagine a field of wildflowers and tall grass swaying in the wind...
What does it take to make a prairie grow?

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