College of Food, Agricultural, and Environmental Sciences

First Energy Pollinator Plots Surveys and Management

Ohio State University-Mansfield Ecolab and Ohio Woodlands Stewards Report

The Ohio State University

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Background and Context

As pollinators lose vital habitat and their populations continue to decline, it is necessary to create effective and economically sound opportunities for their conservation. Some of these opportunities arise from the compatible goals of industry and conservation; one such opportunity lies in vegetation management for utility right-of-ways (ROWs). Partnering with utility companies could be a powerful opportunity for conservation, as Ohio ROWs run upwards of 10 thousand miles of managed vegetation (Goodfellow 2018). By tailoring ROW vegetation to the specific utility type (e.g., overhead powerlines or underground gas lines), the pollinator plots provide examples of how the intentional establishment of pollinator habitat can reduce the burden of managing ROW vegetation to meet utility regulatory standards (Goodfellow 2018).

To demonstrate this potential from different pollinator seed mixes, we developed four research plots in a quarter-acre area under a 138-kilovolt FirstEnergy transmission line that intersects the Ohio State-Mansfield campus (Figure 1). The four plots were created in the shape of a butterfly's wings (Figure 2), and the antennae of said butterfly represented two rows of viburnum shrubs, also planted for their pollinator value (*see report titled "Viburnum Leaf Beetle Surveys and Management" for more information on those plots*). The focus of this report are the forewings and hindwings of the butterfly – the four different pollinator seed mixes.

Figure 1. Location of the study site and pollinator plots, relative to The Ohio State University – Mansfield (Source: Google Earth imagery).

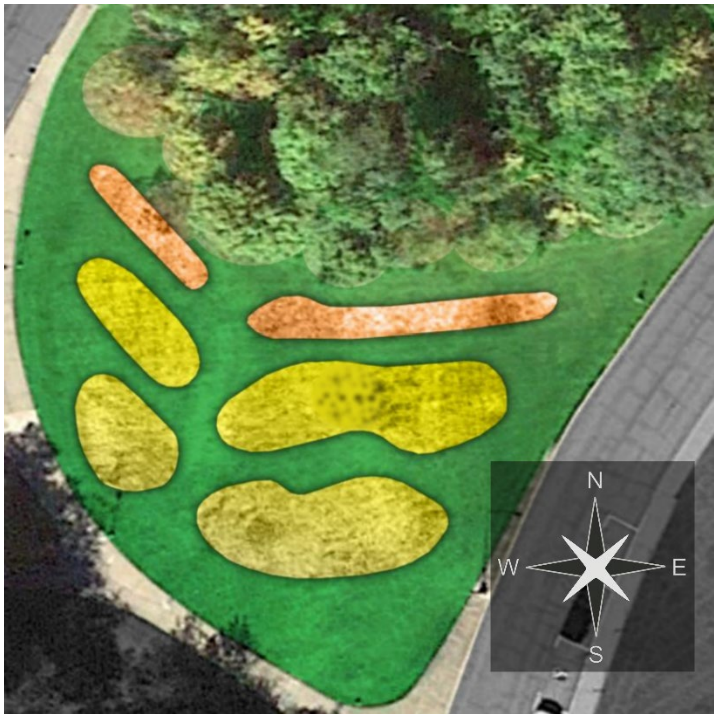

Figure 2. Zoomed in location and aerial view of survey site (Adapted from Appendix A).

Each of the four pollinator demonstration plots was established with different native seed mixes and native plant plugs (Table 1). The native species used were selected for pollinator benefit and matched to specific site conditions (Appendix A). Specifically, the Northeast plot was seeded with Xeres Pollinator Mix II, which included a mix of species that would provide pollinator resources all growing season. The Northwest plot was seeded with Rain Garden Mix III, which included native plants that tolerate wet soils. The Southeast plot was seeded with Fall Pollinator Fuel Mix, which emphasized late summer nectar for monarch migration. Lastly, the Southwest plot was seeded with the Ohio Pollinator Oasis Mix, which included species well suited to small sites in urban and suburban areas and was developed with help from the Ohio Bee Keepers Association.

Table 1. Species from seed mixes used in 2015 to seed each of the four pollinator plots. The species are separated by plant type. Species' scientific and common names are taken directly from the mixes.

		NE	NW	SE	SW
Grasses					
Schizachyrium scoparium	Little Bluestem	x			
Elymus canadensis	Nodding Wild Rye	x			
Elymus virginicus	Virginia Wild Rye		x		
Glyceria grandis	Reed/American Manna Grass		x		
Bouteloua curtipendula	Side-Oats Grama	x			
Sedges					
Carex lurida	Shallow/Lurid Sedge		x		
Carex comosa	Bristly Sedge		x		
Carex crinita	Fringed Sedge		x		
Carex vulpinoidea	Brown Fox Sedge		x		
Carex grayi	Gray's Sedge		x		
Scirpus atrovirens	Dark Green Bulrush		x		
Scirpus validus (Schoenoplectus tabernaemontani)	Great/Soft-Stemmed Bulrush		x		
Forbs					
Asclepias incarnata	Rose (Swamp) Milkweed				x
Asclepias syriaca	Common Milkweed	x			x
Monarda citriodora	Lemon Mint	x			x
Pycnanthemum virginianum	Virginia Mountain Mint				x
Echinacea purpurea	Purple Coneflower	x	x		x
Orbexilum pedunculatum	Sampson's Snakeroot	x			
Tradescantia ohiensis	Ohio Spiderwort	x			
Gaillardia pulchella	Indian Blanket	x			x
Zizia aurea	Golden Alexander	x			
Asclepias tuberosa	Butterfly Weed	x			x
Dalea purpurea	Purple Prairie Clover	x			
Dalea candida	White Prairie Clover	x			
Liatris spicata	Dense Blazingstar	x	x		
Iris virginica (var. shrevei)	Southern Blue Flag		x		
Iris versicolor	Northern Blue Flag		x		
Coreopsis tripteris	Tall Coreopsis	x			
Coreopsis lanceolata	Lanceleaf Coreopsis	x			x
Silphium terebinthinaceum	Prairie Dock	x			
Vernonia altissima	Tall Ironweed	x		x	
Baptisa alba (var. macrophylla)	White Wild Indigo	x			
Penstemon digitalis	Foxglove Beardtongue	x			x
Ratibida pinnata	Yellow/Gray-Headed Coneflower	x			x
Monarda fistulosa	Wild Bergamot	x	x		x
Solidago rigida	Stiff Goldenrod	x		x	x
Solidago speciosa	Showy Goldenrod			x	x
Solidago graminifolia (Euthamia graminifolia)	Grass-Leaved Goldenrod			x	x
Solidago nemoralis	Dwarf Goldenrod			x	x
Rudbeckia hirta	Black-Eyed Susan	x			x
Rudbeckia laciniata	Green-Headed Coneflower		x		
Physostegia virginiana	Purple Obedient Plant		x		
Lobelia siphilitica	Great Lobelia		x		x
Lobelia cardinalis	Cardinal Flower		x		
Chamaecrista fasciculata	Partridge Pea			x	x
Vernonia fasciculata	Western Ironweed			x	
Veronicastrum virginicum	Culver's Root		x		
Mimulus ringens	Monkey Flower		x		
Heliopsis helianthoides	Ox-Eye Susan				x
Eryngium yuccifolium	Rattlesnake Master				x
Astragalus canadensis	Canadian Milk Vetch				x
Aster umbellatus	Flat-Topped White Aster			x	x
Aster azureus	Sky Blue Aster			x	x
Aster laevis	Smooth Aster	x		x	x
Aster novae-angliae	New England Aster	x	x	x	x
Aster pilosus	Frost Aster				x

All four plots were seeded during the dormant season in December of 2015. The southeast (SE), southwest (SW), and northwest (NW) plots were supplemented in or after the initial establishment year with plugs (see Appendix B for list). The following list of species established successfully in their respective plots by means of plug planting and little to no follow-up care (e.g., watering): common milkweed (*Asclepias syriaca*), swamp milkweed (*Asclepias incarnata*), Ohio goldenrod (*Solidago ohioensis*), Ohio spiderwort (*Tradescantia ohioensis*), golden alexander (*Zizia aurea*), great lobelia (*Lobelia siphilitica)*, obedient plant (*Physostegia virginiana*), and blue vervain (*Verbena hastata*).

Of note are great lobelia, obedient plant, and blue vervain. These species seem to have established initially but did not reappear in the following growing season. This is to be expected, as all three of these perennials are short-lived species that establish quickly but do not compete well with other perennials in maturing pollinator habitat. Although they do well earlier in a planting, they usually phase out, being replaced by species that may have taken longer to establish but are more long-lived.

In the ten years since seeding, most of the pollinator plots have required minimal management. One stubborn invader, cattails (*Typha* spp.), was controlled in the NW and SW plots via mechanical treatment (e.g., digging) in 2021 and herbicide early in the 2022 growing season. Cattails were densest in the SW plot and had to be mechanically removed again in 2023 followed by a cut-stem treatment in 2024 using an 8% glyphosate (Roundup Custom) and dye application. A few multiflora rose (*Rosa multiflora*) bushes and majority of the brambles (*Rubus* spp.) were uprooted and mechanically removed from the NW planting plot in summer 2022. Brambles were mechanically removed in the NW plot again in 2024. Invasive thistles (*Cirsium arvense* and *Cirsium vulgare*) were dug up or clipped off several times before they were able to seed, particularly in the NW and SE plots in 2023 and 2024. Overall, the northeast (NE) plot needed the least management. In both the NE and SW plots in 2024, poison ivy (*Toxicodendron radicans*) was spot-sprayed and the few encroaching seedlings (commonly *Fraxinus* spp., *Populus* spp., and *Ulmus* spp.) were spaded out. The hemp dogbane (*Apocynum cannabinum*) dominating the SW plot was hand thinned in 2024 as well. Future management of hemp dogbane might involve resetting the SW plot if it continues to be aggressively dominant and begins to suppress the diversity of other forbs.

As exemplified in three out of the four plots, the lack of intensive management that was needed demonstrated the minimal maintenance requirements after site appropriate native plant establishment, so long as the site is monitored and potential issues are identified early and treated before they get out of hand (e.g., thistle infestation). The largest management undertaking was in autumn 2025, when we decided to reset the NW demonstration plot, which had been originally seeded with the Rain Garden Mix III seed mix. After seven years of increased sedge and bulrush dominance, we made repeated glyphosate treatments to kill off the plot. A few sedge species showed evidence of glyphosate-resistance; therefore, a 2026 application of halosulfuron-methyl (Sedgehammer) was conducted to gain full control of the plot before re-establishment.

Ultimately, this project has served multiple key purposes and demonstrates how a fruitful partnership between landowners and utilities can create quality habitat for native pollinators. The plots showcase the long-term stability of native vegetation and the ability to meet ROW safety and regulatory standards. The pollinator plots are under the First Energy powerline and represent compatible vegetation, but theoretically the same pollinator plots could also be established above an underground utility and remain firmly within the bounds of those standards as well. Additionally, the four different plots facilitate a case study by which various questions related to native pollinator habitat can be asked – the intersection with ROWs vegetation management notwithstanding. For instance, of the many native species contained in a diverse seed mix, how many establish and persist in a planting, and how does this vary based on initial site conditions and soil properties?

Furthermore, the pollinator plots function as year-round exhibits for landowners, community members, in-service professionals, faculty, and students. Whether interacting with the permanent signage as passerbys (Appendix A) or attending a workshop or event, the community can interact with the demonstration plots to learn more about native pollinator conservation, as well as be invited to pursue alternative management options for utility ROWs on their properties. The site regularly hosts multiple outreach events and workshops, with the annual Pollinators and Pancakes event being a highlight that helps kick off each autumn semester (Figure 3).

Figure 3. Students attending community event at pollinator demonstration site, August 2022.

Methodology

To collect our data, we sampled each pollinator plot by establishing two intersecting transects and surveying subplots along each transect at regular intervals (Figure 4). Each subplot was a Daubenmire frame (D-frame), which are 1 m by 0.5 m rectangles made of white PVC pipe, and each plot contained nine subplots. With reel tape extended, the frames were placed flush with the right side of the tape (starting at 0% and moving towards 100% distance along each axis) such that the long side of the D-frame was parallel to the reel tape and the distance marks the middle of the long side.

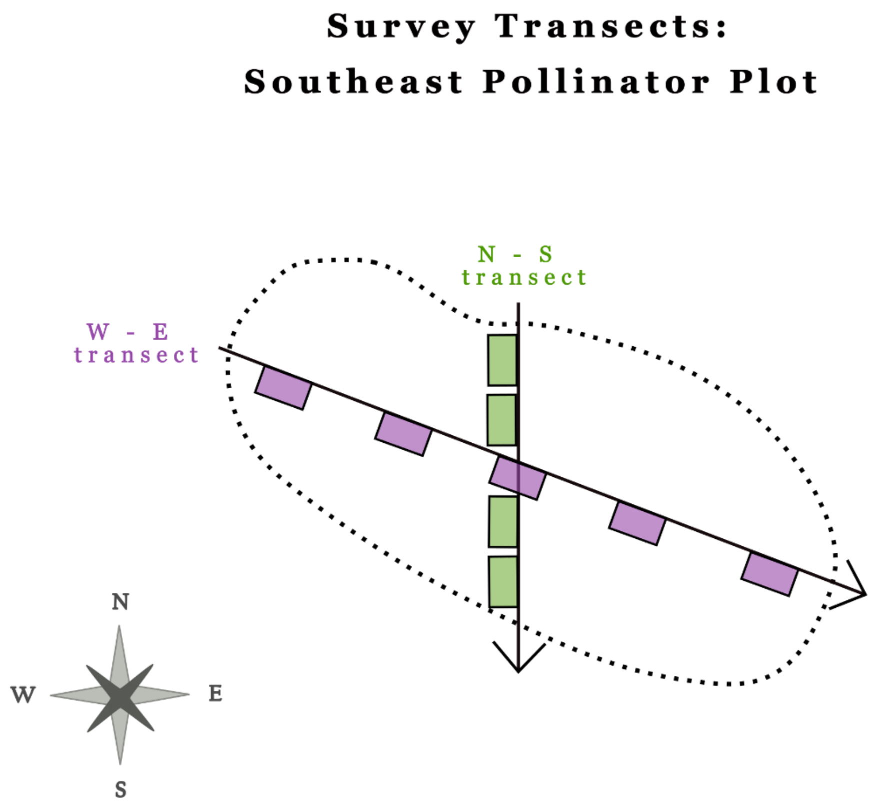

Figure 4. Illustration of southeast (SE) plot survey transects and subplots. Each subplot represents systematic intervals at the 0, 25%, 50%, 75%, and 100% distance mark of each axis. The 50% interval was omitted from the N-S transect to prevent pseudoreplication due to overlap. The N-S transect was 9 m 42 cm long and the W-E transect was 19m and 86 cm long. The start and end point of each transect was monumented with a wooden stake for repeatability between time periods and years. Sampling points at the 0 (W & N endpoints, respectively) and 100% (E & S endpoints, respectively) distance were positioned such that the short side of the D-frame was 50 cm interior from the mowed perimeter of each plot.

Examining only plants rooted within the D-frames, each subplot was evaluated for percent vegetation cover, seedling/sapling abundance, height of visual obstruction by plant density, height of tallest plant species, flowering species, and bloom abundance (Figure 5). With this information, we sought to evaluate plot vegetation density and composition, vegetation vertical structure, and pollinator resource availability.

Figure 5. A community partner and an Ecolab student technician collecting vegetation data using a D-frame in the Northwest plot, May 2018.

Percent plant cover was recorded for bare ground, leaf-litter, mulch/rocks, moss, ferns, sod-forming grasses, clump-forming grasses, sedges, wetland plant types (e.g., bulrush), clovers, native forbs, and non-native forbs. Cover was evaluated visually, using integer-based cover classes from 1 to 6. The integers indicate ranges of coverage classes represented by the following percentages: 1: 0-5%, 2: 5-25%, 3: 25-50%, 4: 50-75%, 5: 75-95%, and 6: 95-100%. These ranges were converted to percentage midpoints for analysis. Individuals of the *Rubus* genus (i.e., blackberry), invasive shrub species, and other tree seedlings/saplings were counted to evaluate woody encroachment.

Density and composition of vegetation was measured by cover class estimates. From both a habitat and utility perspective, the ratio and amount of certain cover class categories is important. For instance, too much bare ground can suggest erosion risk and lead to regulatory violations, but if interseeding is planned to enhance forb diversity, then some amount of bare ground is necessary for successful seed germination. Bare ground is also a vital resource for ground nesting bees, which make up about 70% of bees worldwide (Spring and Gardiner 2019). Thus, we sought a balance between establishing sufficient ground cover to minimize erosion while also providing adequate bare ground to function as native solitary bee habitat. We also monitored the proportions of native and non-native forbs, as well as clumping and non-clumping grasses. Native forbs and clumping grasses (e.g., most native warm-season grasses) provide the greatest benefit to native pollinators and wildlife. Overall, evaluating cover is important for planning future management, understanding species composition within the ROW, and for anticipating future problems and planning treatment accordingly.

We evaluated the vertical complexity of each plot by measuring the heights of the tallest vegetation in a subplot as well as the height of obstructing cover (Figure 6).

Vegetation heights were measured in centimeters. Vertical vegetation complexity creates habitat conditions preferred by many wildlife species. Additionally, vegetation height is an important measurement to ensure regulatory standards are met. While it is hard to imagine a pollinator habitat growing tall enough to interfere with powerlines, pipeline markers over underground utilities require line-of-sight visibility, thus tolerance thresholds are much shorter.

Figure 6. Ecolab student technicians collecting vegetation height and vertical complexity data in the Northeast plot, June 2022.

Lastly, flowering plants species and the number of individual blooms were recorded. Plants flowering outside the nine subplots were identified and recorded, but their individual blooms were not counted. Documenting what species are in bloom within the ROW is important for measuring the richness and abundance of nectar and pollen resources available to wildlife. It is also important to be able to compare that information over time to see what impacts different treatment methods have on the available resources and how quickly they rebound. Plant phenology is critical to consider when planning a pollinator plot to ensure through-season productivity and to see how different flower forms and colors are dominant at different times of year (Appendix B).

The plots took a little over two years to establish, and the first plot surveys were conducted in May of 2018. The plots were then surveyed again in 2022, 2024, and most recently, in 2025. All four plots were surveyed throughout the growing season to document bloom phenology. The entire site (all 36 total subplots across the four plots) was surveyed once a period. The sampling periods are as follows: period 1 - late May; 2 - June; 3 - July; 4 - early August; 5 - late August; 6 - late September/early October (Figure 7).

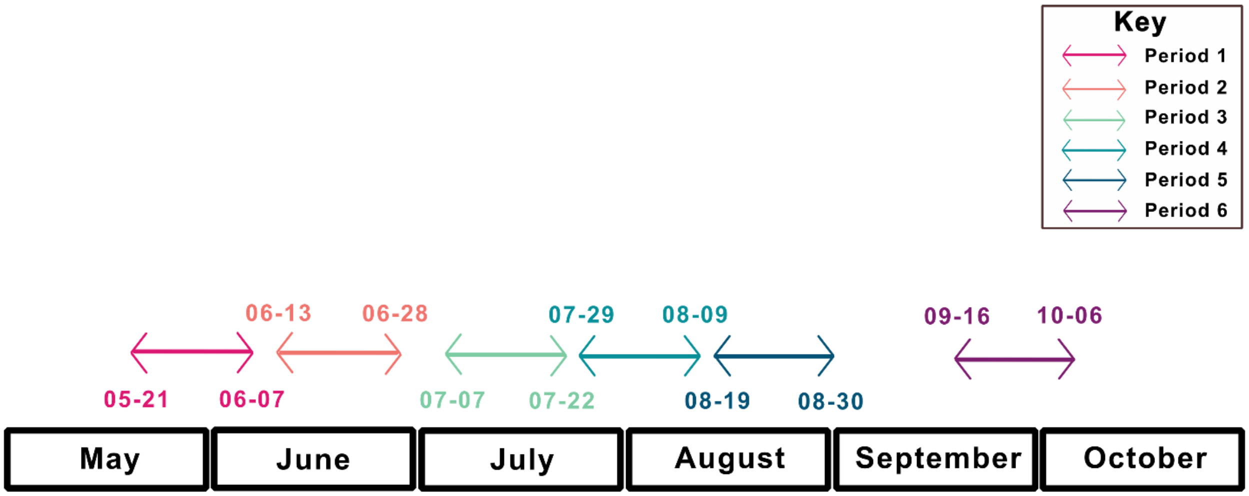

Figure 7. Sampling periods defined by earliest and latest dates of data collection over study's duration.

Results and Discussion

<u>Vegetation Cover</u>

While native forbs dominate the SE plot, grass cover has persisted past early establishment (Figure 8). Almost all of the grass cover is non-target grass vegetation, with almost half being sod-forming grasses (Appendix D). Although bare ground had increased since 2018, it remained stable, at 12.2% (SE = 1.7%) average cover.

Over the years, forb cover has remained relatively stable across all six sampling periods in the SE plot (Figure 9). This is ideal for pollinator plantings, indicating that there are abundant resources for pollinators throughout the growing season.

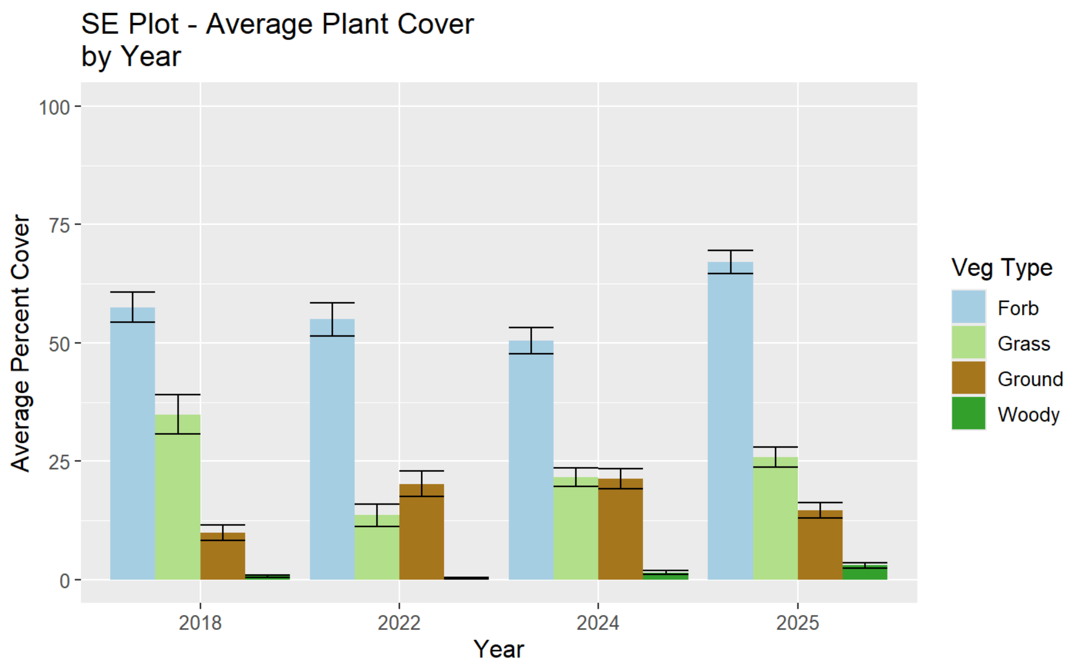

Figure 8. Plant cover averages (in percents) by vegetation type over the sampling years for the Southeast plot. In 2018, the SE plot was not sampled during periods 4 and 6, thus they are not represented in the data.

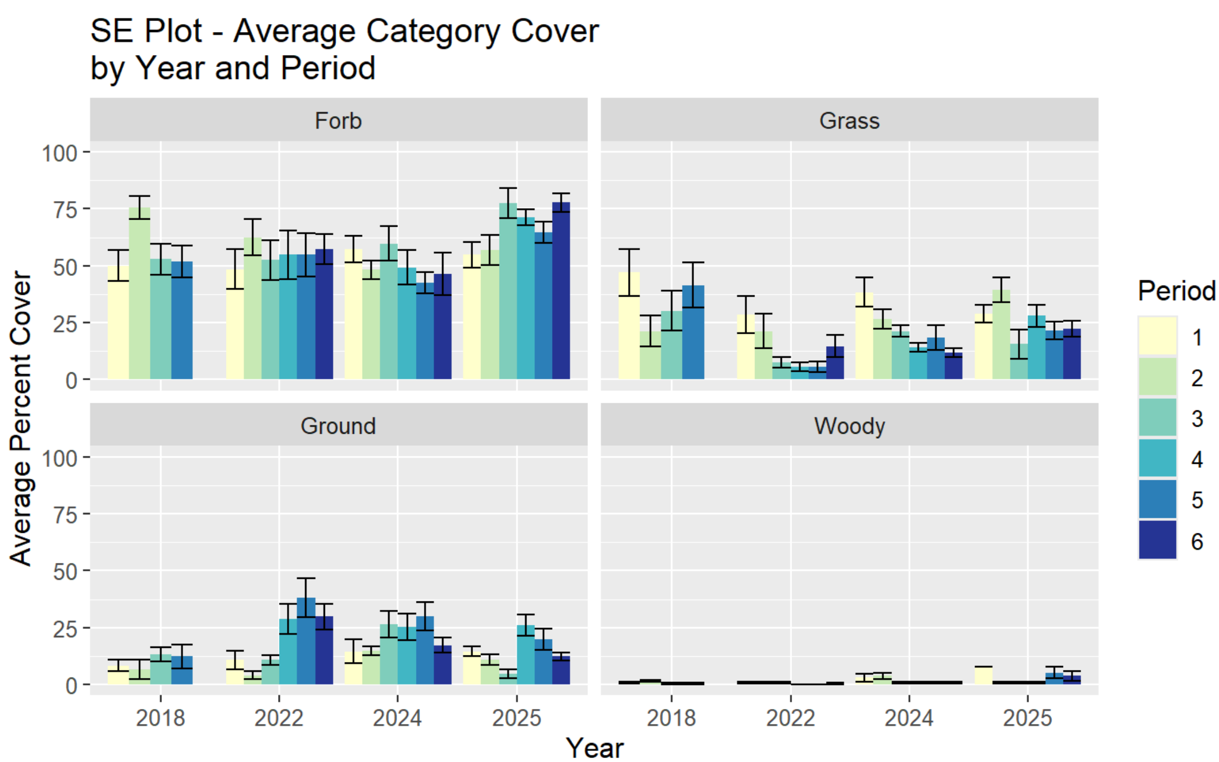

Figure 9. Cover averages (in percents) of each vegetation type by surveying periods over the sampling years for the Southeast plot. In 2018, the SE plot was not sampled during periods 4 and 6, thus they are not represented in the data.

Forb cover also dominates the NE plot, although grass has persisted since establishment (Figure 10). Like the SE plot, bare ground in the NE plot has been stable since plot establishment. Over the years, bare ground and leaf litter cover fluctuated, but bare ground did not exceed 12% cover on average.

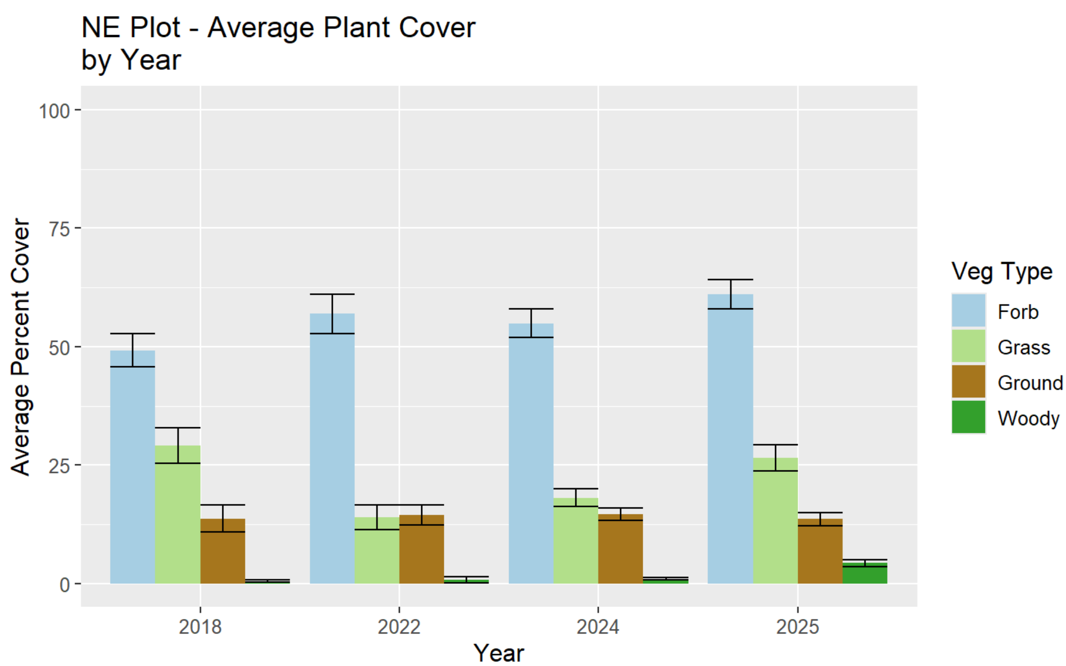

Figure 10. Plant cover averages (in percents) by vegetation type over the sampling years for Northeast plot.

Forb cover in the NE plot, like the SE plot, has remained relatively stable throughout the growing season (Figure 11). Native forbs were high in abundance consistently across the six periods.

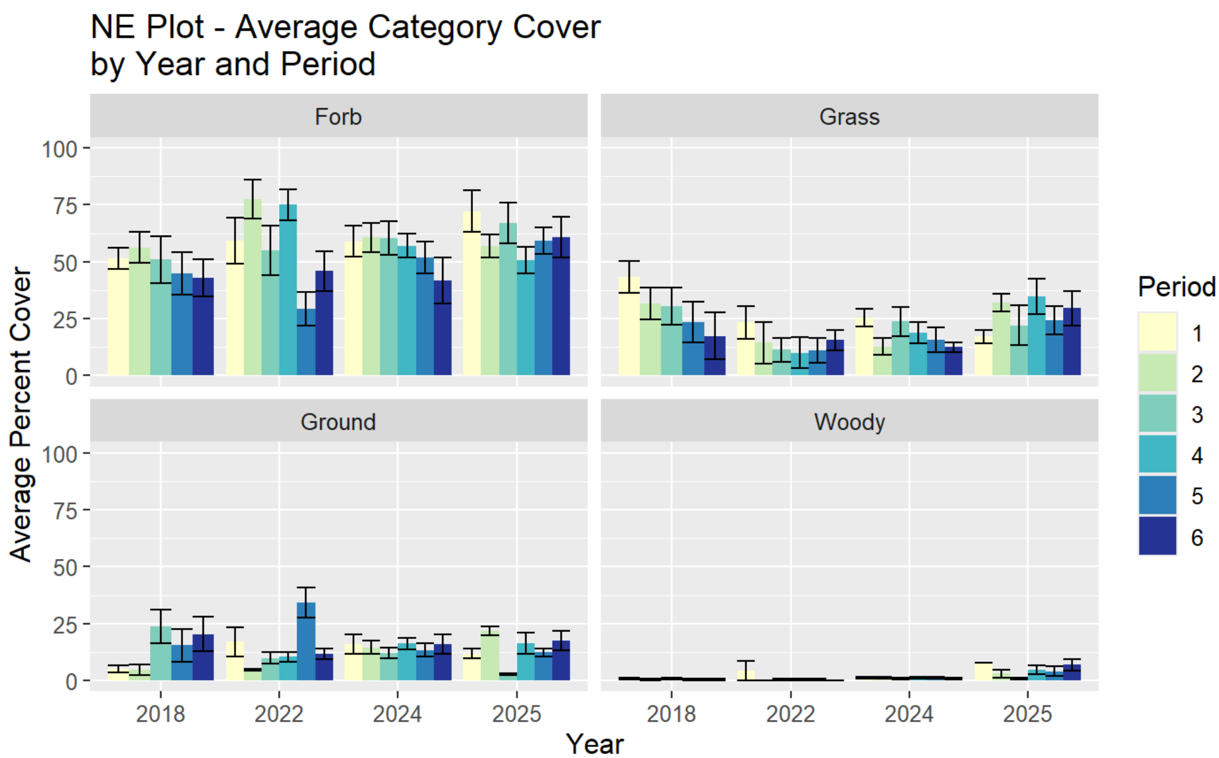

Figure 11. Cover averages (in percents) of each vegetation type by surveying periods over the sampling years for the Northeast plot.

Early in the SW plot's establishment, grass cover was nearly equal to forb cover (Figure 12). Almost all of this (70%) grass cover was non-clumping or sod grass (Appendix D). By 2022, grass cover had dramatically leveled off. Meanwhile, forb cover stabilized and then increased in 2025. The vast majority (98%) of forb cover was native species. Peak forb cover varies from year-to-year, with the plot distinctly peaking in period 6 in 2022, period 2 in 2024, and period 3 in 2025 (Figure 13).

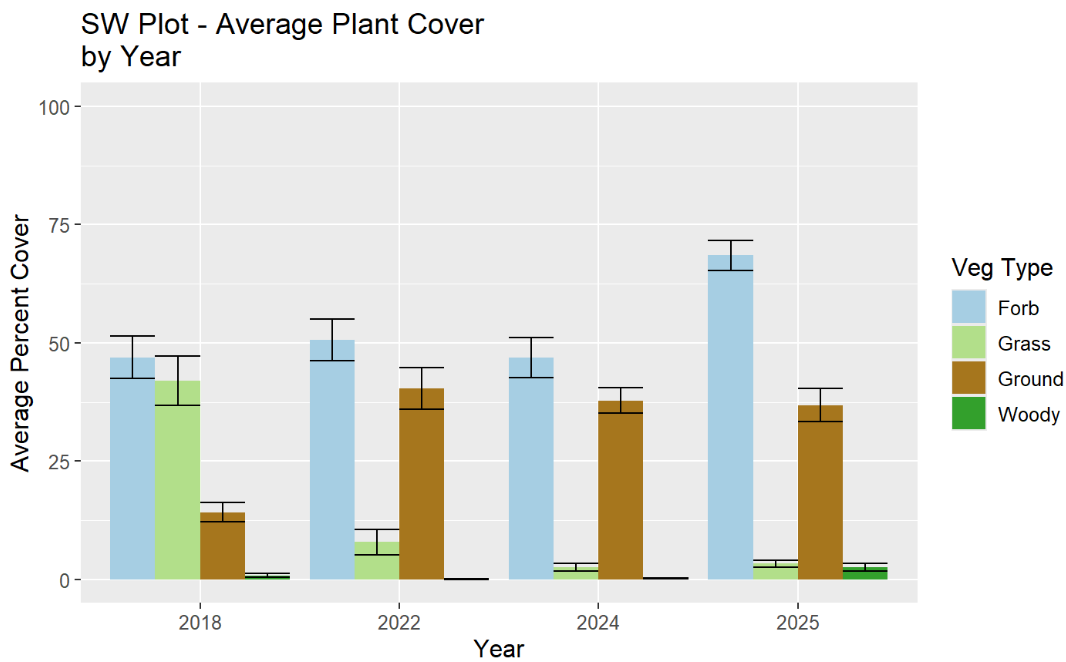

Figure 12. Plant cover averages (in percents) by vegetation type over the sampling years for Southwest plot. In 2018, the SW plot was not sampled during periods 4 and 6, thus they are not represented in the data.

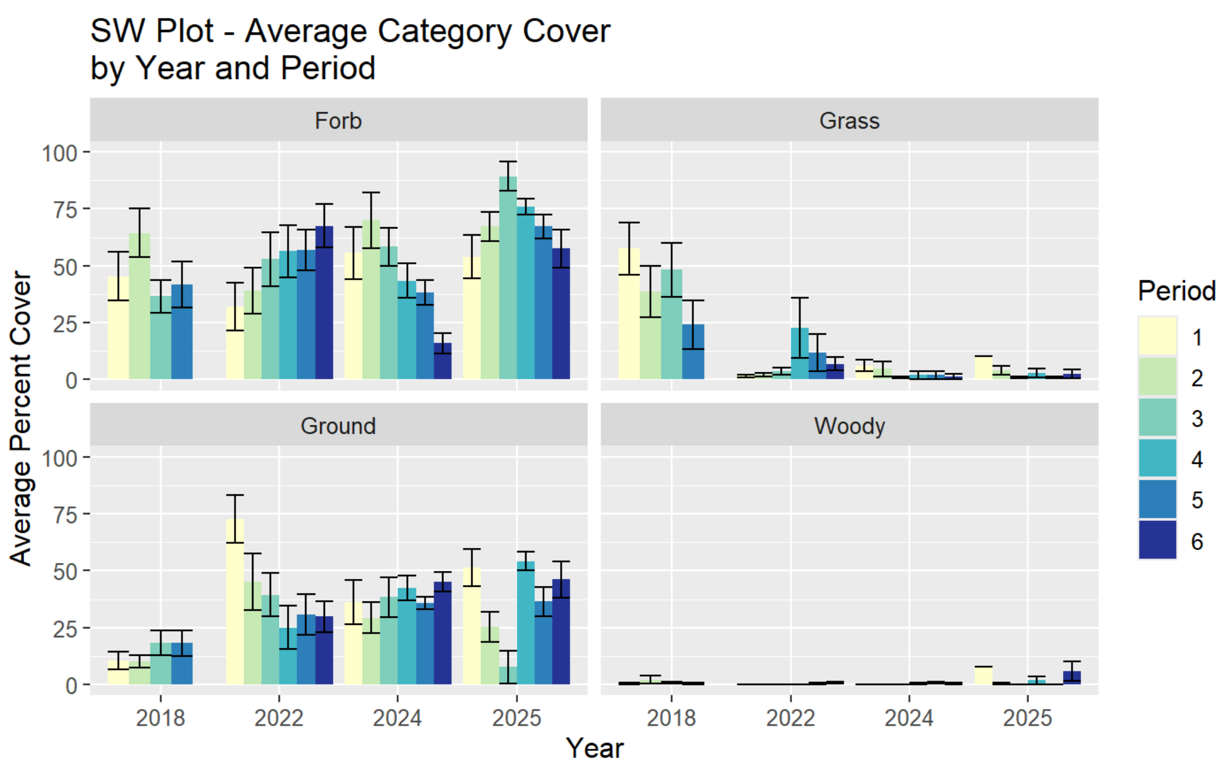

Figure 13. Cover averages (in percents) of each vegetation type by surveying periods over the sampling years for the Southwest plot. In 2018, the SW plot was not sampled during periods 4 and 6, thus they are not represented in the data.

Although forb cover increased over time, without stable grass cover in the plot, bare ground has been the second largest cover category since 2022. Since grass cover decreased, total ground cover increased in 2022 and stabilized in the following years. Initially, most of this cover was leaf litter, but by 2025, the majority of ground cover was bare (non-vegetated) ground, at 26.7% cover (SE = 3.3%) on average.

Since establishment, the NW plot has developed differently than the other three. In 2018, it was dominated by mulch, sedges, and bulrush (Figure 14). The anomalous target clumping grass cover in 2022 actually reflects an identification error, whereby sedges were misidentified as clumping grasses by surveyors. Almost all of that cover actually represents sod, sedge, and bulrush cover.

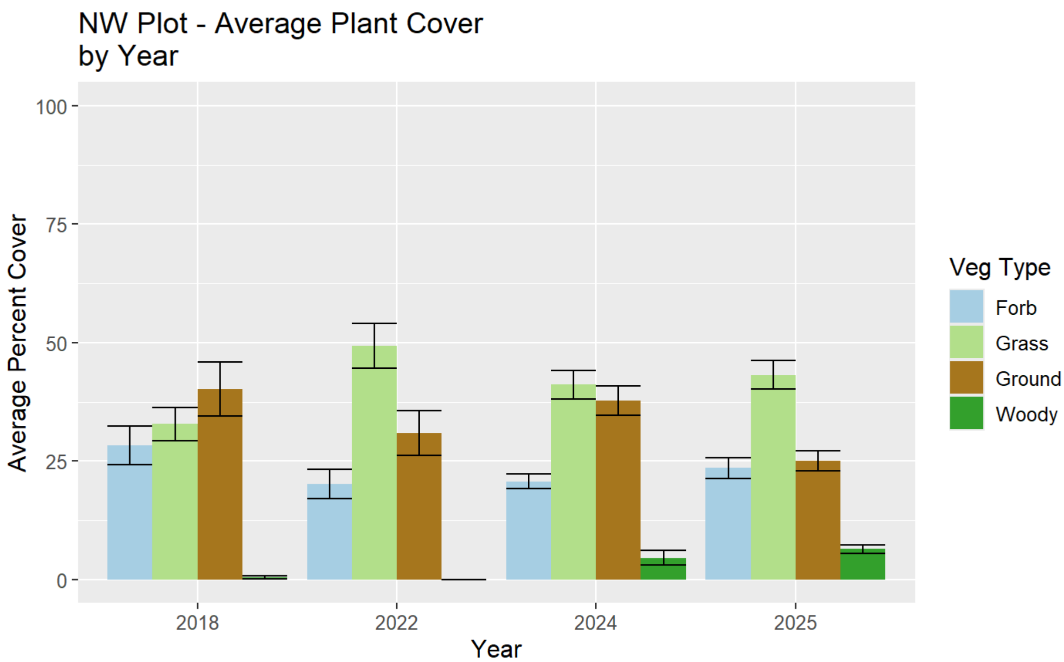

Figure 14. Plant cover averages (in percents) by vegetation type over the sampling years for Northwest plot. The 2025 data only include periods 1 and 2, as this plot was reset by period 3.

Initially, the NW plot struggled to maintain plant cover. The NW plot maintained its high abundance of non-target ground cover (which was entirely leaf litter and/or mulch after 2018) throughout the years. The little vegetation in the plot was mostly sedges and bulrush species. Over the years, the plot lost forb cover, only to regain some in the early 2025 growing season by way of undesirable invasive forbs, such as creeping thistle. Sod grass, sedge, and bulrush species most consistently populated the NW plot (Figure 15).

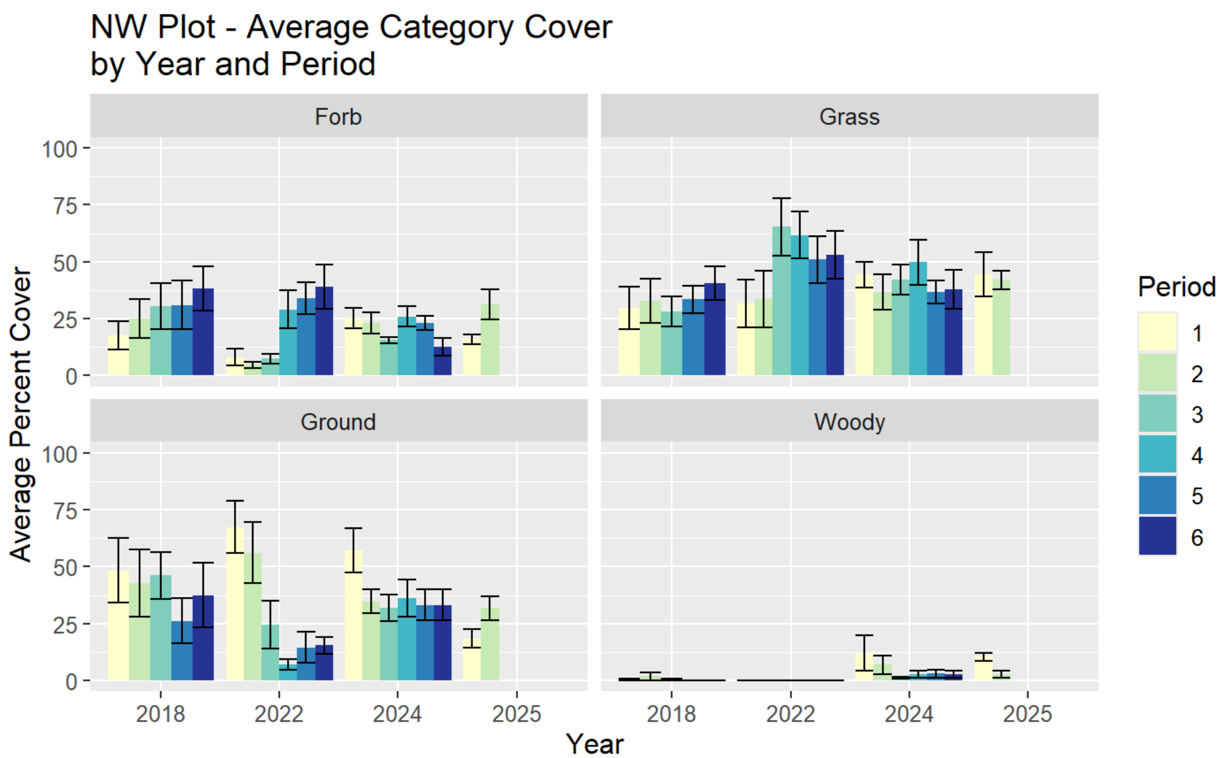

Figure 15. Cover averages (in percents) of each vegetation type by surveying periods over the sampling years for the Northwest plot. The 2025 data only include periods 1 and 2, as this plot was reset by period 3.

In terms of plant cover, the best performing plots were the NE and the SE. Both plots sustained high native forb cover throughout the sampling years. Though they both lacked clump-forming grass cover, they maintained overall grass cover, mostly with sod-forming grasses encroaching from the adjacent lawn rather than the clumping grasses included in the seed mixes. Thus, vegetation in the NE and SE plots maintains enough cover to minimize erosion, remaining compliant with utility management regulations, without being dominated by plants with low utility for pollinators, like grasses, or regulation violating woodies. Simultaneously, both plots maintained enough bare ground with utility for ground-nesting pollinators.

Though the SW plot started off with high grass cover, the plot transitioned to a composition with a greater forb abundance between 2018 and 2022. As native forb cover dominance increased, the bare ground cover increased to over twice the earlier recorded levels by 2025. This is the result of hemp dogbane, an aggressive native forb. Dogbane has an aggressive growth form whereby it develops into dense thickets of vegetation. Its height and growth form blocks light from reaching the ground, limiting grass and woody growth while increasing bare ground. Despite the abundance in forb cover, this plot risks erosion, though it remains compliant with utility clearance regulations.

The SW plot was the only plot to exhibit variation in forb cover density across periods within years. This suggests shifting plot forb compositions, as pollinator resources dwindle or increase throughout the growing season. These variations highlight the importance of considering plant phenology when establishing pollinator plots, as pollinators need consistent resources throughout the growing season.

Lastly, since establishment, plant cover in the NW least resembled that of the other three plots. In 2018, it was dominated by mulch, through which there was mostly sedge and bulrush growth, with some forb cover. By 2022, however, grass cover had dramatically overtaken the plot. Forb cover did not recover in the next three years, leading to the plot's eventual reset. This development is perhaps not surprising given the NW plot's seed mix was most unique and distinct, being the only mix to include sedge and bulrush seeds. In some ways, the NW plot reflected a common sight on ROWs: clearances dominated by sod-forming grasses or sedge species with little in the way of native forbs or clumping grasses.

To the north of the northern-most plots (NE, NW), there is a wooded lot. Similarly, south of the southern plots (SE, SW) and across a walking path, there is another wooded lot. Because of their proximity to these wooded areas, all four pollinator plots repeatedly faced encroachment from woody species, including red maple (*Acer rubrum*) and American elm (*Ulmus americana*) seedlings. There were also intrusions from invasive species, like multiflora rose, and other undesirable woody species, including brambles and poison ivy.

Although seedlings were able to infiltrate and establish in the plots, they remained sparsely distributed and were subject to reduced growth rates in the pollinator plots, allowing for greater opportunity for them to be maintained and treated over an extended window of time. Their lack of growth may indicate some sort of competitive exclusion or chemical allelopathy, especially in stands of denser goldenrod species, is occurring and portrays the significance of biological control – more clearly defined as establishing a desirable community that is so robust it discourages successful colonization and establishment by undesirable plant species. Perhaps that is exactly what we are observing.

Overall, the data revealed that most plots contained native forb levels that were maintained or experienced an increase in their percent composition across both the 5-year and 10-year intervals with no mechanical treatment and minimal management using selective herbicides. Generally, each plot had low erosion risk with sufficient bare ground for pollinator habitat, as well as few encroaching woody species.

Flowering Plant Richness

The SE plot seed mix contained 11 species, all of which were forbs. The plot was supplemented with plugs of two additional milkweed species in October of 2015, both of which were able to establish and persist over time in the plot. By establishment, the SE plot had a higher blooming species richness than its original seed mix (Figure 16). Although species richness fell in 2022, blooming species richness recovered by 2024 and 2025, where it seemed to peak in period 4 and 5. At establishment, blooming richness peaked by period 2. This difference reflects a change in plot forb composition, where early-to-establish and quick-to-bloom species give way in favor of forbs species that bloom mid-growing season. In both 2024 and 2025, peak species richness occurred with 12 unique species blooming at one time.

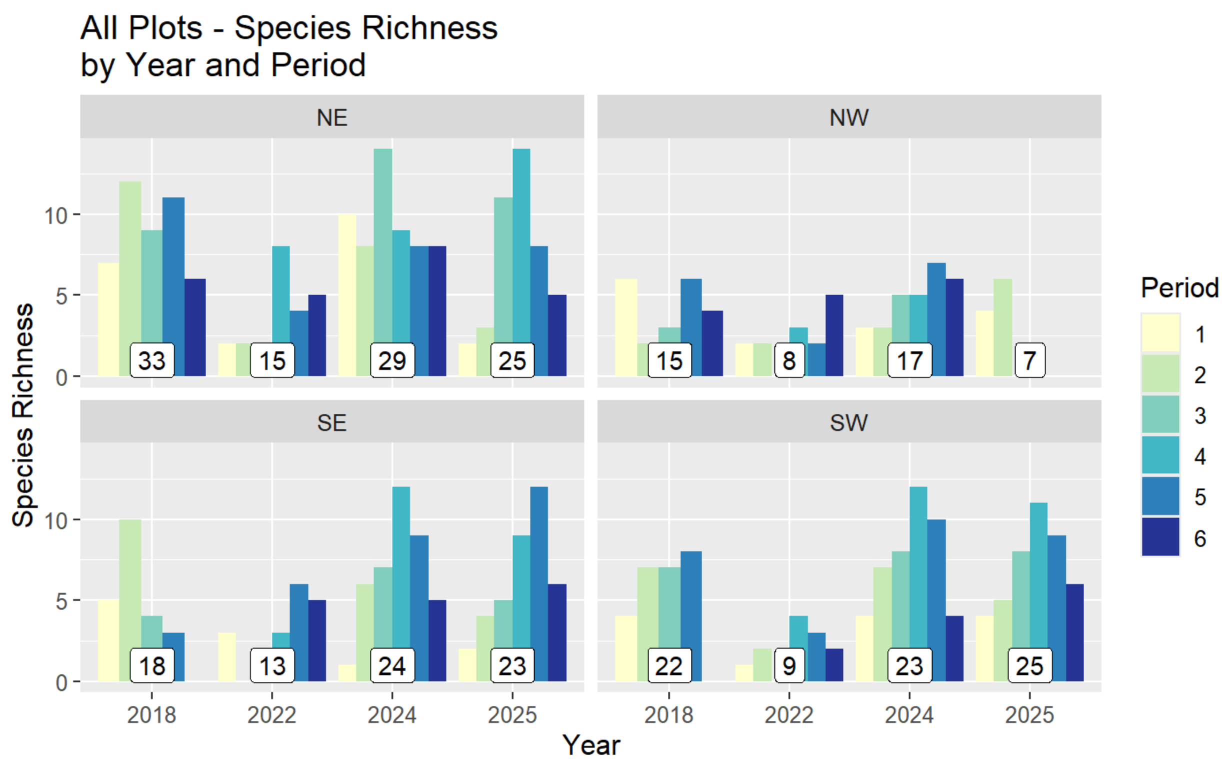

Figure 16. Species richness by period over the sampling years in the Northeast, Northwest, Southeast, and Southwest plots. Total species richness for each sampling year is at the base of each cluster of bars. In 2018, the SE and SW plots were not sampled during periods 4 and 6, thus they are not represented in the data. The 2025 data for the NW plot only includes periods 1 and 2, as the plot was reset by period 3.

The NE plot seed mix contained 26 species, with three grass species and 23 forb species. This plot was the only one to never be supplemented with plugs. By establishment in 2018, a total of 33 unique species bloomed throughout the growing season. After a steep decline in blooming species richness from 2018 to 2022, species richness recovered by 2024 and 2025. Establishment blooming species richness peaked earlier in the growing season; by 2024 and 2025, however, plot blooming species richness peaked in periods 4 and 5, with at most 14 species blooming at once in both years.

The SW plot seed mix contained 26 species, all of which were forbs. In spring of 2016, the plot was supplemented with plugs of 19 forb species. Species richness at establishment did not meet seed mix species richness, despite the supplemental plant plugs. After a decline in species richness between 2018 and 2022, blooming species richness increased in 2024 and 2025. This plot was the only one to have seen an increase in species richness in 2025. Blooming species richness peaked in periods 4 and 5 in 2024 and 2025, with at most 12 different species blooming at once in 2024.

The NW plot seed mix contained 21 species, two of which were grasses, five sedges, two bulrushes, and 12 forbs. The plot was supplemented with plugs of 13 forb species in the summer of 2024--the most recent of all the plug plantings. At establishment, blooming species richness exceeded the seed mix, although it was still the lowest of all four plots. Though blooming species richness decreased between 2018 and 2022, it recovered somewhat following the plug plantings. Ultimately, however, not even plugs were sufficient to recover forb abundance as the plot continued to be overtaken by sedge and bulrush species, which is why it was reset in 2025.

Over the course of these surveys, the NE plot consistently contained the greatest species richness, with the greatest number of unique species in bloom every year. Despite NE plot having less forb cover than the SE plot at establishment, the NE outperformed the SE in blooming species richness. This may be due partly to the NE plot seed mix containing twice as many different forb species as the SE plot seed mix. Conversely, the NE and SW seed mixes contained the same number of species, and the NE plot still outperformed the SW plot. As a result, the NE plot was the only one to not need supplemental plant plugs, independently maintaining its high blooming species richness with minimal management throughout the years.

Despite the dominance of hemp dogbane in the SW plot, the plot maintained a relatively high flowering plant richness. The SW plot blooming species richness is comparable to the NE and SE plots, suggesting that the aggressive growth of hemp dogbane has not yet limited species richness. Part of the SW's maintained species richness may be due to it having been supplemented with plugs of 19 forb species—the most out of any of all the other plots.

Like with plant cover, the NW Rain Garden Mix underperformed in blooming species richness and supplemental plug success when compared to the other three pollinator plots. The NW plot consistently had the lowest species richness of all plots, year after year. After supplemental plugs were planted in 2024, its blooming species richness increased, as evidenced by the high bloom richness early in the 2025 growing season. Unfortunately, by that point, the plot was dominated by sedge and bulrush; additionally, native forb abundance was low and invasive forb cover had increased. Ultimately, the plot was reset for lack of pollinator resources.

Blooming species richness increased from 2022 to 2024, with 2024 generally containing the most unique species blooming in one single period in every single plot. The period with the most unique blooming species varied from year to year for each plot, which makes sense as forb species composition shifted from year to year in each plot. Generally, periods 4 and 5 in all the plots saw the greatest blooming species richness. This makes sense as many native plant species' blooms overlap towards the middle and late growing season, especially those in the *Asteracae* family.

For species in bloom within the sampled D-frames, bloom abundance (or count) was collected. Although plot-level species richness dropped from 2018 to 2022, bloom count actually increased in 2022 during several months across plots. The early season June pulse was largely attributed to foxglove beardtongue (*Penstemon digitalis*); hemp dogbane and goldenrod (*Solidago* spp.) were dominant contributors during August and September. This lesson highlights an important principle – depending on which species dominate, a loss in biodiversity does not necessarily equate to a loss in pollinator resources for non-host plant-specific invertebrates.

Still, flowers are not created equal. For instance, an individual goldenrod flower is smaller than most pollinating insects, whereas a foxglove beardtongue flower is large enough that many pollinators crawl inside in order to access the nectar and pollen. Bloom count could be considered a proxy for pollinator resource abundance; however, flower size and potentially other factors would have to be incorporated for a robust estimation.

In the 5 years since the 2018 sampling, all plots lost flowering plant diversity in 2022. However, by 2024 and 2025, plant diversity had recovered dramatically. One explanation for this dip is that there may have been a mid-successional lull in the plots, where early to establish species are dying out but not all the later successional species have fully established yet. The longer a stand is established, the longer competition is able to crowd out certain species. Many of the quick-growing but low persistence annuals common to pollinator seed mixes likely disappeared after the earliest years of the planting post-establishment; however, many perennial species take multiple years to establish. Additional concerns of allelopathy might be coming to fruition in plots such as the SE where goldenrods are more heavily present. A consistent decline in the bloom species richness may also suggest supplemental inter-seeding or inter-plugging may be necessary to maintain higher biodiversity if biodiversity is a forward goal of the demonstration plots.

Additionally, we acknowledge some limitations to our study. There is a gap in the data for 2022, as in period 3, no blooming species data was collected for any of the pollinator plots. A similar gap occurred for the SE plot in 2022, where no bloom species data was collected for period 2. Ultimately, we recognize that the reported data is based on a sample, not a census – both spatially and temporally. As one example, the dense and highly synchronized bloom of foxglove beardtongue occurred between monthly data collection periods during 2018 but was virtually non-existent in our records. Nonetheless, we hope our data can illustrate the ways different seed mixes can meet a number of goals regarding utility regulatory compliance and pollinator or wildlife habitat.

Vegetation Height and Complexity

For three of the four plots, the average height of the tallest vegetation was generally stable over the growing season, at less than 160 cm (or 1.6 m) tall over all six periods (Figure 17). For the SW plot, however, the average height of the tallest vegetation increased as the growing season continued, surpassing 160 cm in 2025.

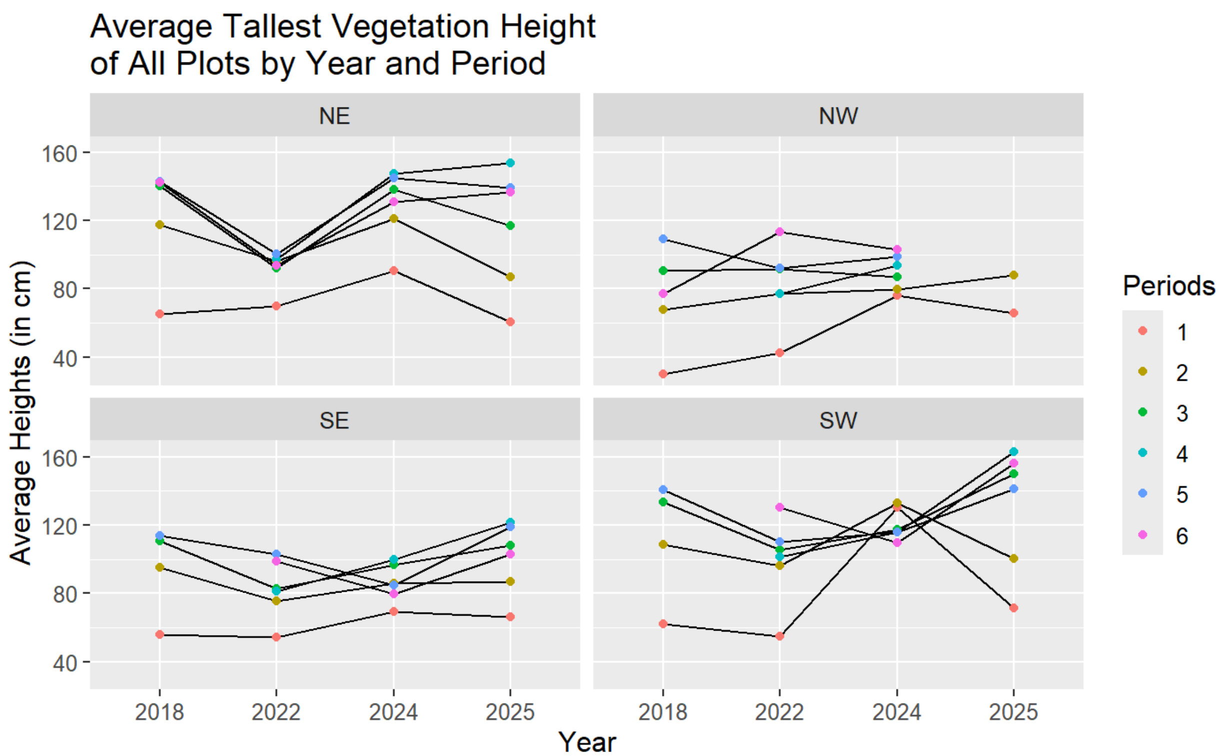

Figure 17. The average heights of the tallest vegetation in each plot during each sampling period over time.

The general stability of the tallest vegetation height in the plots suggests that the planted seed mixes are generally compliant with height and accessibility regulations for utility ROWs. Similarly, the average height of obstructing vegetation remained stable over the years for three of the four plots (Figure 18).

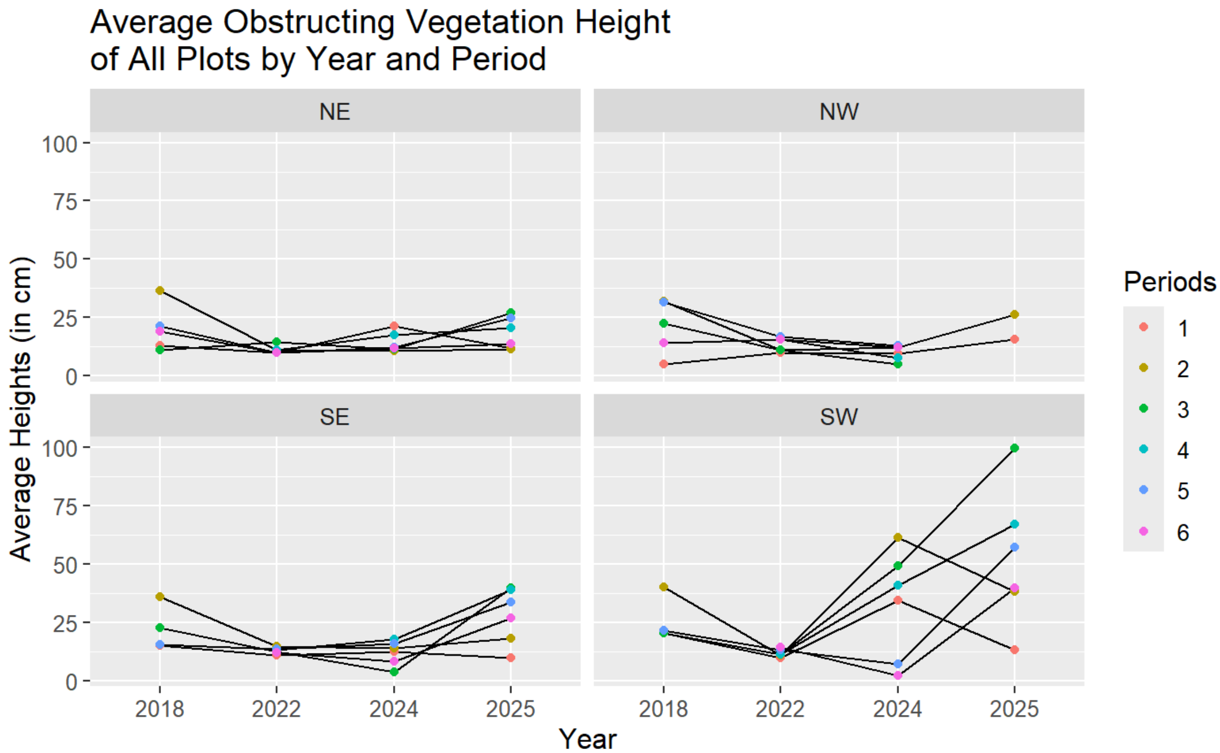

Figure 18. The average heights of the tallest vegetation in each plot during each sampling period over time.

The one exception was the SW plot, which had both the tallest individual vegetation and the tallest obstructing vegetation on average. Stable vegetation height indicates a stable plant structure over time. The SW plot did not exhibit the same level of stability in its vertical complexity as the other plots. This is likely due to the density of hemp dogbane in that plot. In dense monocultures, the height of the hemp dogbane is usually the maximum vegetation height, shading of all underneath layers and obscuring sunlight from penetrating down into the stand. For the SW plot, the establishment and subsequent aggressive growth of hemp dogbane has been a more recent occurrence, thus the plant structure of that plot changed dramatically since its original seeding.

Conclusion

The overall success of establishing and sustaining native forbs and grasses illustrates the capacity of ROWs as sites of conservation. Furthermore, with minimal management beyond establishment, the vegetation in each plot adheres to ROW safety and utility regulations. No planted nor encroaching species violated vegetation height requirements, ensuring safe and reliable function of the transmission lines. Even in an underground utility scenario, the plots would still meet all height restrictions, safety, and accessibility standards. We suggest this outcome is a demonstrable example of how biological control can be accomplished by certain native plants established in the demonstration plots. Indeed, with the growing space completely or near completely occupied by native vegetation, few non-native plant species were able to establish – and only then as isolated individuals. After a full decade and despite bordering forest cover where seed source is abundant, woody establishment of shrubs or trees was even less evident.

Continued monitoring of the pollinator plots will be a sustained priority into the future. With the NW plot slated for re-establishment in 2026, documenting its early phases will serve to contrast continued later stage developments in the other three plots. Data collection will shed additional light on how native pollinator plant communities evolve through time, and management decisions will continue to be informed by data gathered from the plots. Education and training events will continue to utilize the location to stimulate curiosity and positive conservation action for pollinators and pollinator habitat.

Acknowledgements

This work would not have been possible without the support of FirstEnergy Corp, the Ohio State University, the Ohio State Extension, the Pollinator Partnership, Ohio Prairie Nursery, Arnold's Landscaping, Arbormetrics, Davey Tree, and the Utility Arborists Association. In addition to the main project partners, additional collaborators – Pheasants Forever, Richland County Soil and Water Conservation District, and Ohio Division of Wildlife – make annual events such as Pancakes & Pollinators a huge success! This project reflects the dedication of several Ecolab fellows whose thorough fieldwork, data collection, and analysis made this effort possible - notably Maskin Sidhu, Miranda Wacker, Kira Metzinger, Caiden Moody, Rachel Coy, Garrett Caudill, Colleen Sharkey, Katelyn McDonald, and Kyle Dues. Everyone who has served on the Ohio State Mansfield Rights-of-Ways committee – thank you! Quarterly meetings have generated the momentum to keep collecting data on the plots, managing them intentionally, and offering excellent events each year to spotlight the showcase area. The Ecolab Land Manager at the time of publication is Dr. Gabriel Karns, and this report has been completed under his oversight (karns.36@osu.edu).

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Appendix A: Pollinator Demonstration Area Signs and Plot Information

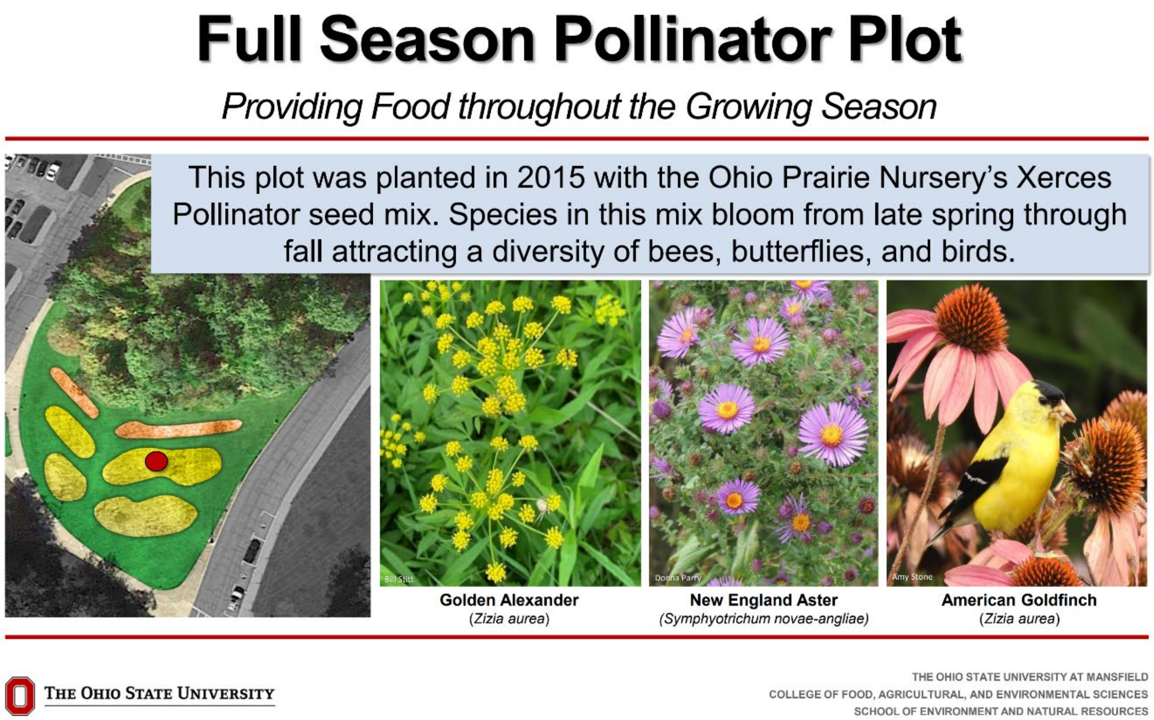

Figure A1. Sign identifying the Northeast plot in the Pollinator Demonstration Area.

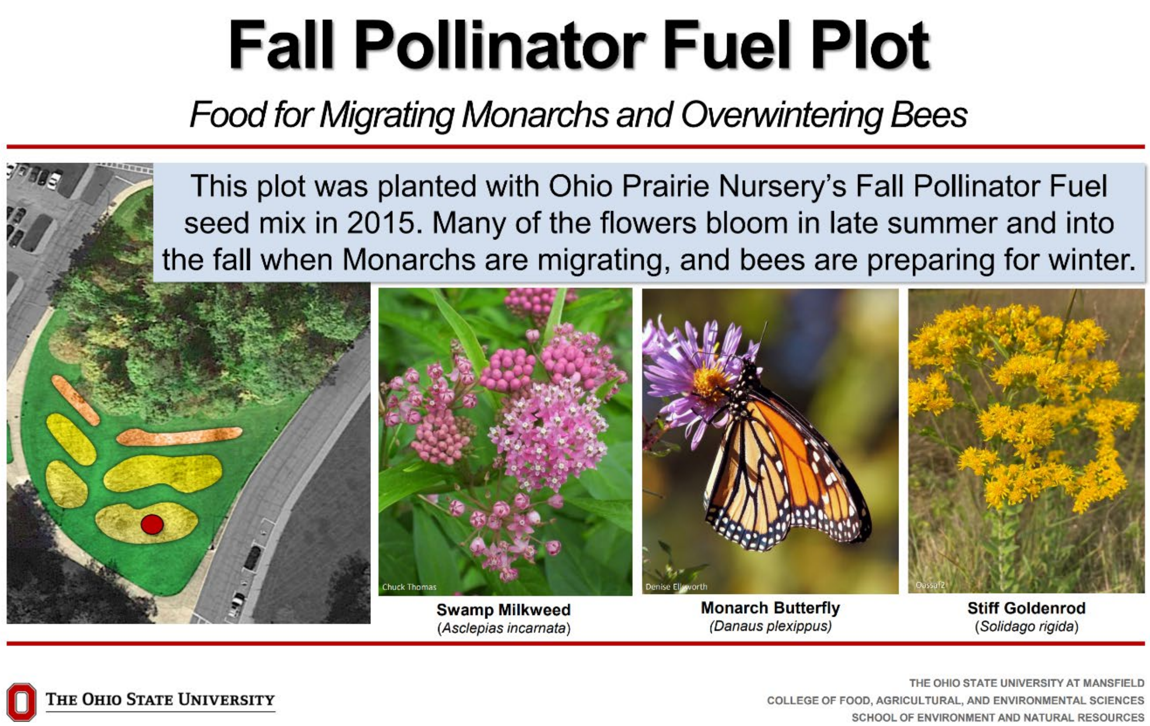

Figure A2. Sign identifying the Southeast plot in the Pollinator Demonstration Area.

Figure A3. Sign identifying the Northwest plot in the Pollinator Demonstration Area.

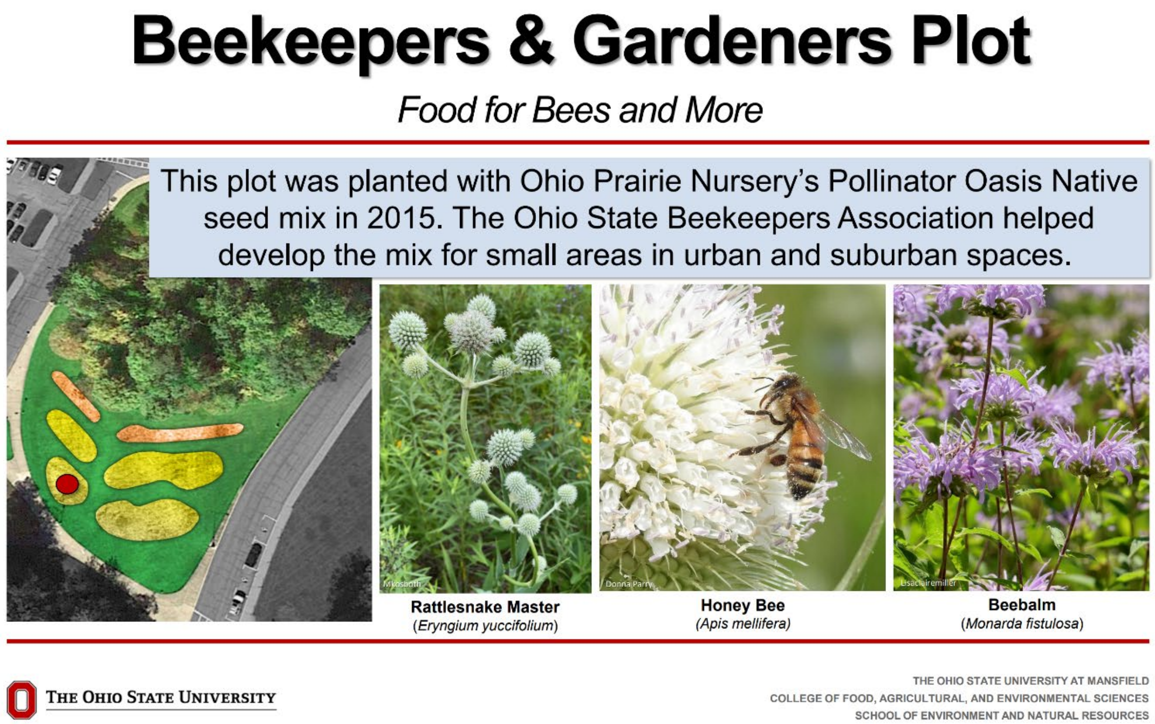

Figure A4. Sign identifying the Southwest plot in the Pollinator Demonstration Area.

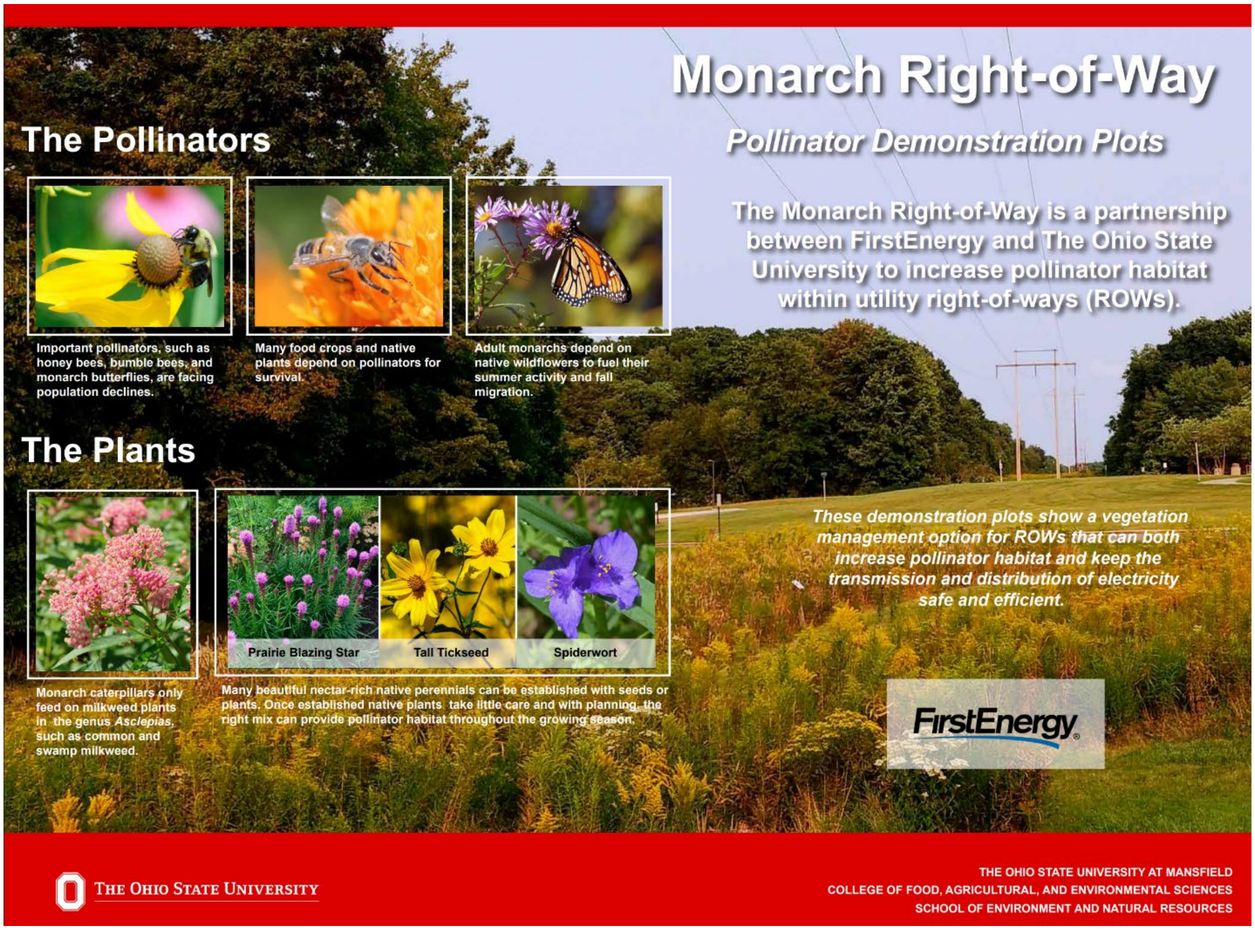

Figure A5. Sign describing Pollinator Demonstration Plot project and ROW partnership.

Appendix B: Table of Species Planted as Plugs

Table B1. List of forb species that were planted as plugs in at least one of the pollinator plots. Many of these species were also represented in their plot's original seed mix. The plugs in the SE plot were planted in October of 2015. The SW plot plugs were planted in spring of 2016. The plugs in the NW plot were planted most recently, in summer of 2024.

			SE Plot	SW Plot	NW Plot
Forbs					
	Asclepias syriaca	Common Milkweed	x		
	Asclepias incarnata	Swamp Milkweed	x		x
	Asclepias sullivacntii	Sullivant's Milkweed		x	
	Asclepias tuberosa, var. clay	Butterfly Weed for Clay		x	
	Aster novae-angliae	New England Aster		x	
	Casia hebecarpa	Wild Senna		x	
	Coreopsis palmata	Stiff Coreopsis		x	
	Dalea purpurea	Purple Prairie Clover		x	
	Echinacea purpurea	Purple Coneflower		x	
	Eupatorium purpureum	Sweet Joe Pye Weed		x	
	Liatris ligulistylis	Meadow Blazingstar		x	
	Liatris pyscnostachya	Prairie Blazingstar		x	
	Mondarda fistulosa	Bergamot		x	
	Penstemon digitalis	Smooth Penstemon		x	
	Schizachyrium scoparium	Little Bluestem		x	
	Solidago ohioensis	Ohio Goldenrod		x	
	Sporobolus heterolepis	Prairie Dropseed		x	
	Tradescantia ohiensis	Ohio Spiderwort		x	
	Vernonia fasciculata	Ironweed		x	
	Veronicastrum virginicum	Culver's Root		x	x
	Zizia aurea	Golden Alexander		x	x
	Allium cernuum	Nodding Wild Onion			x
	Lilium michiganense	Michigan Lily			x
	Lobelia siphilitica	Great Blue Lobelia			x
	Lobelia cardinalis	Cardinal Flower			x
	Phlox pilosa	Prairie Phlox			x
	Pycnanthemum tenuifolium	Narrow-Leaved Mountain Mint			x
	Physostegia virginiana	Obedient Plant			x
	Solidago uliginosa	Bog Goldenrod			x
	Verbena hastata	Blue Vervain			x
	Vernonia gigantea	Tall Ironweed			x

Appendix C: Table of Seeded Species and Bloom Phenology

Table C1. Table of forb species that were seeded and confirmed present and flowering in each pollinator plot. Rows indicate years a species flowered, and columns indicate the sampling period a species flowered. A grayed-out cell indicates that species did not establish in that plot despite being present in the seed mix. An "X" indicates that the species was present and flowered in that year and period.

We focused this phenology-based visual to four periods (from month date to month date; periods 2 through 5). It is worth noting that species such as Ohio spiderwort and golden alexander were recorded in bloom as early as period 1, and prairie dock, great lobelia, and New England aster were recorded in bloom as late as period 6. Additionally, because of identification difficulty, our lists of successfully seeded species are likely conservative and incomplete. For instance, we documented *Solidago* spp. but could not confirm whether it was indeed the planted species *Solidago rigida*, *speciosa*, or *nemoralis*, or another.

Species	NE Plot				NW Plot				SE Plot				SW Plot				
Periods	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	
Swamp Milkweed													X				2018
																	2022
																	2024
																	2025
Common Milkweed																	2018
															X		2022
	X	X											X	X	X		2024
														X	X		2025
Lemon Mint																	2018-2025
Virginia Mountain Mint																	2018
																X	2022
																	2024
															X		2025
Purple Coneflower				X		X											2018
																	2022
	X	X	X														2024
		X	X	X													2025
Sampson's Snakeroot																	2018-2025
Ohio Spiderwort	X																2018
	X																2022
																	2024
	X																2025
Indian Blanket																	2018-2025
Golden Alexander																	2018
																	2022
																	2024
																	2025
Butterfly Weed	X	X															2018
																	2022
																	2024
																	2025
Purple Prairie Clover																	2018-2025
White Prairie Clover																	2018-2025
Dense Blazingstar																	2018-2025
Southern Blue Flag																	2018-2025
Northern Blue Flag																	2018-2025
Tall Coreopsis		X		X													2018
				X													2022
		X	X	X													2024
			X	X													2025
Lanceleaf Coreopsis	X																2018
																	2022
																	2024
																	2025
Prairie Dock																	2018
																	2022
				X													2024
																	2025
Tall Ironweed																	2018
			X	X							X	X					2022
																	2024
				X							X	X					2025
White Wild Indigo																	2018-2025
Foxglove Beardtongue	X												X				2018
	X		X										X				2022
													X				2024
	X												X	X			2025
Yellow/Gray-Headed Coneflower		X		X													2018
																	2022
																	2024
																	2025
Wild Bergamot		X												X			2018
			X				X										2022
	X	X															2024
		X	X														2025

Stiff Goldenrod				X												X	2018
																	2022
																	2024
																	2025
Showy Goldenrod																	2018-2025
Grass-Leaved Goldenrod																X	2018
												X					2022
												X				X	2024
																	2025
Dwarf Goldenrod																	2018-2025
Black-Eyed Susan	X												X	X			2018
				X													2022
	X	X	X	X													2024
		X	X												X		2025
Green-Headed Coneflower																	2018
																	2022
								X									2024
																	2025
Purple Obedient Plant						X											2018
							X	X									2022
						X	X	X									2024
																	2025
Great Lobelia								X								X	2018
																	2022
								X								X	2024
																X	2025
Cardinal Flower								X									2018
																	2022
																	2024
																	2025
Partridge Pea																	2018-2025
Western Ironweed																	2018-2025
Culver's Root																	2018-2025
Monkey Flower																	2018
							X	X									2022
						X	X										2024
																	2025
Ox-Eye Susan													X	X			2018
																	2022
																	2024
																	2025
Rattlesnake Master														X			2018
																	2022
														X	X		2024
															X	X	2025
Canadian Milk Vetch																	2018-2025
Flat-Topped White Aster																	2018-2025
Sky Blue Aster																	2018-2025
Smooth Aster																	2018-2025
New England Aster				X				X									2018
																	2022
				X								X					2024
			X									X					2025
Frost Aster																	2018-2025

Appendix D: Figures of Average Cover by Target and Non-Target Vegetation

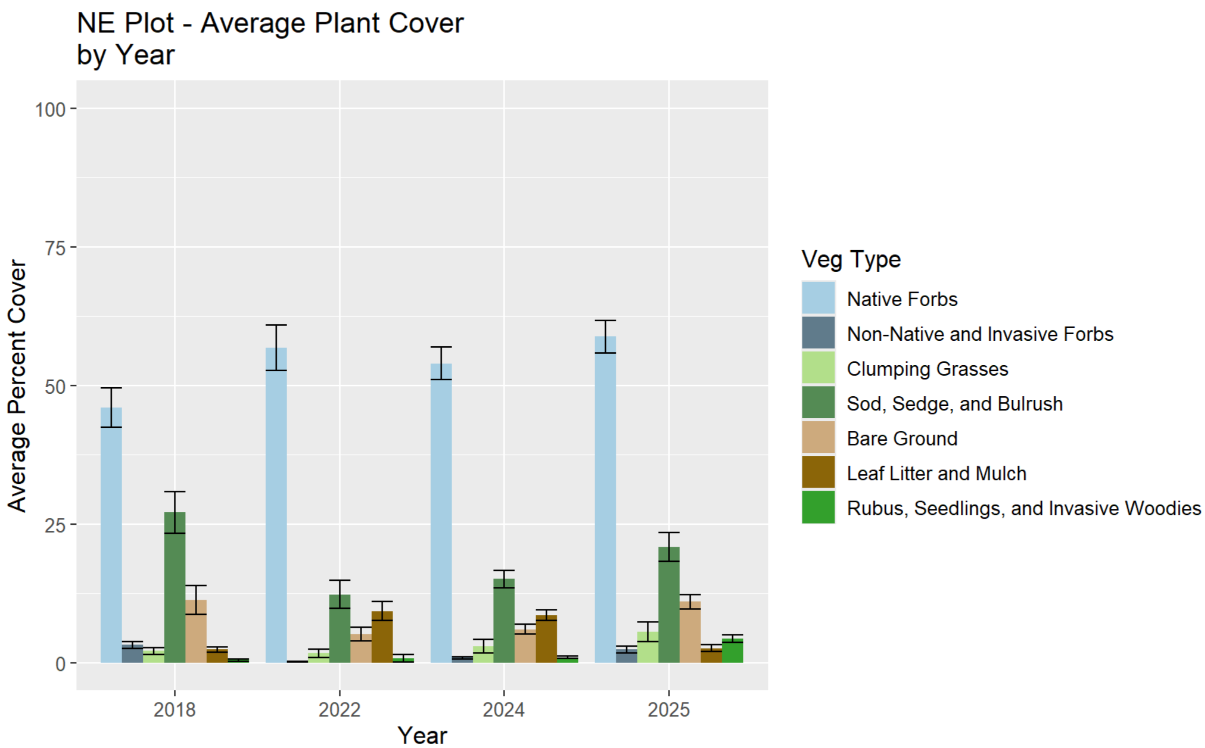

Figure D1. Northeast plot average cover by target and non-target categories.

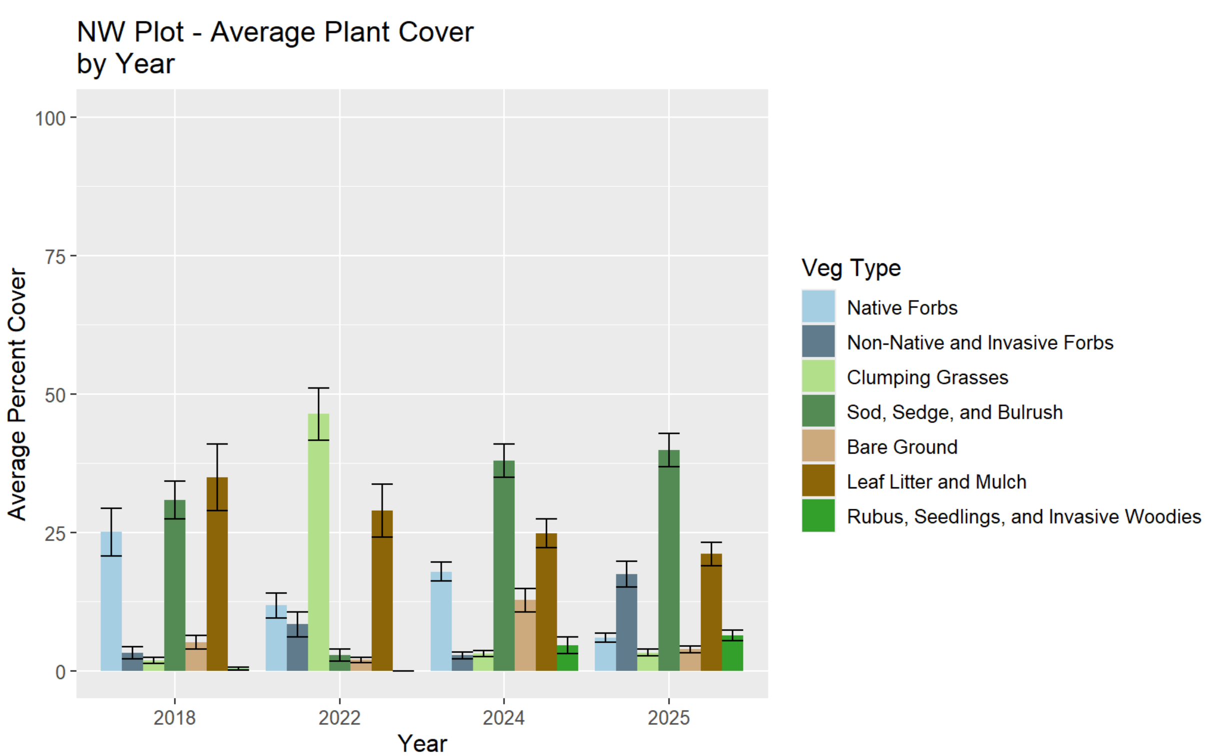

Figure D2. Northwest plot average cover by target and non-target categories.

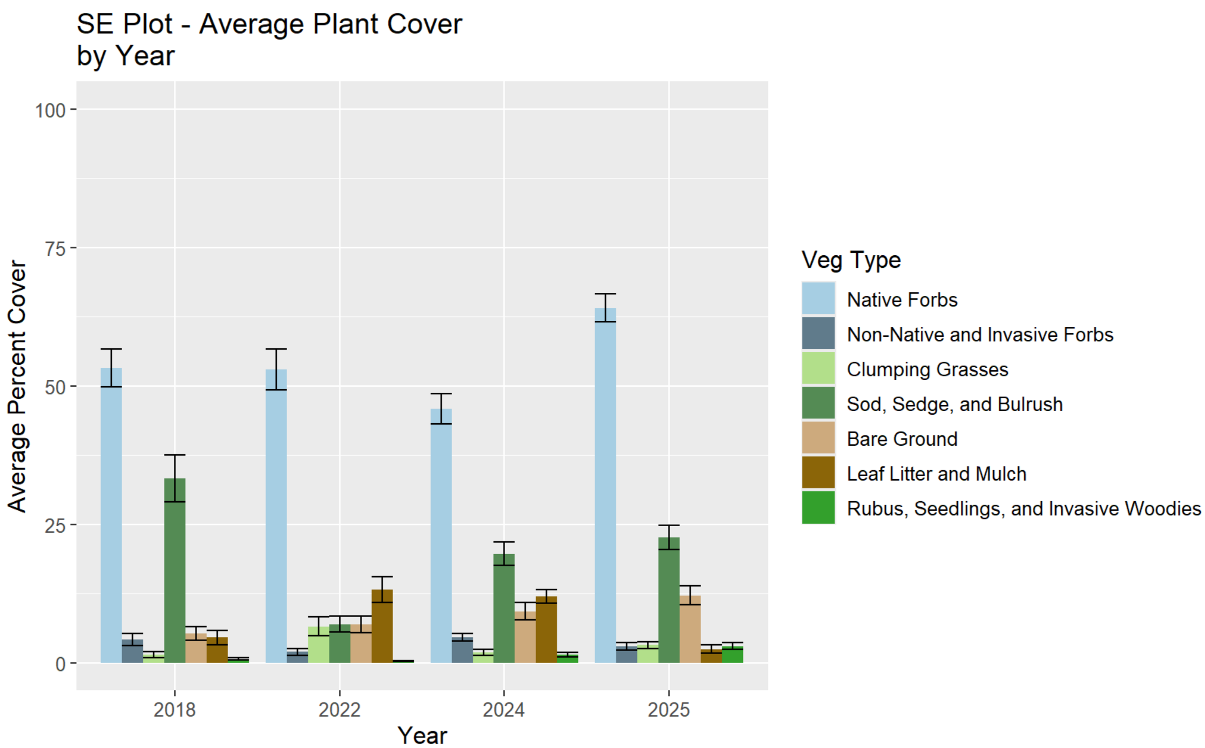

Figure D3. Southeast plot average cover by target and non-target categories.

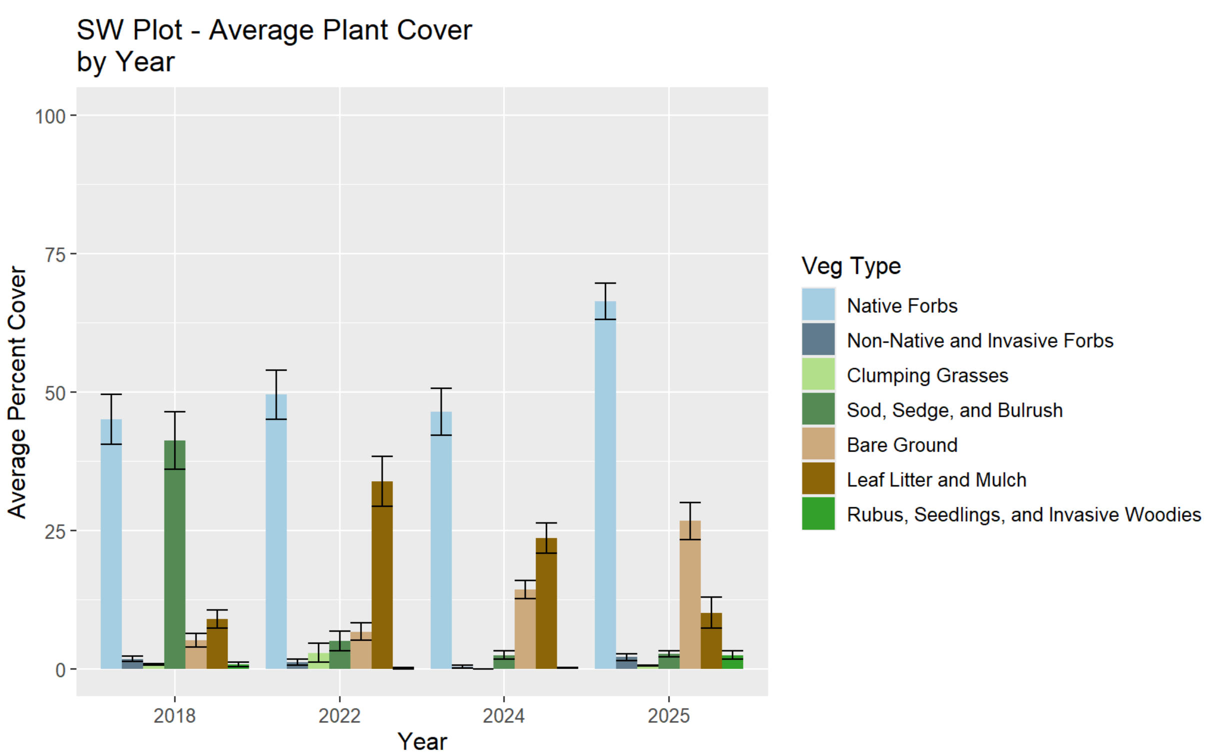

Figure D4. Southwest plot average cover by target and non-target categories.