Monitoring Pollinators on Minnesota Solar Installations

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MONARCH JOINT VENTURE

Contents

Executive Summary

Severe declines have been documented in many insect pollinator populations around the world, including that of the monarch butterfly (Semmens et al., 2016; Schultz et al., 2017; Sanchez-Bayo and Wyckhuys, 2019). Many efforts are underway to restore and enhance pollinator habitat, mitigate threats, and recover populations, but data suggest that we have a long way to go to reaching many existing population and habitat targets (Thogmartin et al., 2017; Bloom et al., 2021). The renewable energy sector provides a unique opportunity for advancing pollinator habitat goals and there are numerous efforts across the U.S. to implement pollinator-friendly solar practices. We conducted an observational study to investigate impacts of pollinator-friendly solar practices on plant and pollinator communities in Minnesota. We observed a high number of flowering plant species flourishing within and adjacent to solar arrays, a variety of insect pollinators utilizing the habitat, and an abundance of bees, butterflies, moths, flies, and wasps. Our results indicate that pollinators utilized habitat regardless of solar panel presence, suggesting that solar installations in Minnesota can provide quality breeding and foraging habitat for monarchs and other pollinators. Continued long-term data collection is critical for monitoring population status and trends and to ensure that pollinator-friendly practices achieve and maintain desired outcomes.

Project Overview

The Monarch Joint Venture monitored pollinator habitat installations on four photovoltaic solar developments in Minnesota to investigate the impacts of solar array canopies on plant and pollinator communities. Sites were located in Anoka and Ramsey counties and ranged in size from 18-68 acres. All sites were seeded with a native pollinator mix; three were seeded in 2017 and one in 2018. At three of the sites, solar panels rotated throughout the day, following the sun. Panels remained stationary at the fourth site. Surveys were conducted at each site during the months of June, July, and August 2021 to document habitat condition and use by insect pollinators.

Methods

Field Data Collection

On each site visit, six 30-meter transects were surveyed for flowering plants, milkweed (*Asclepias* spp., monarch butterfly host plant), and insect pollinators. The transects were placed within two light conditions: 1) open, unshaded areas adjacent to solar arrays within the seeded habitat ('full-sun') and 2) seeded areas between solar arrays ('partial-shade'). We placed each partial-shade transect as close to the full-sun area as possible, and each set of transect pairs were placed a minimum 100 meters apart from each other. Transect locations were randomly-determined when possible but were largely derived based on the availability of full-sun seeded habitat within the site. Full-sun transects were oriented in the direction that allowed for the entire 30-meter transect to be placed. In partial-shade, we placed transects diagonally across the array row to capture the full swath of vegetation beneath and between panels (Figure 1). Transect locations differed on each subsequent visit in order to obtain a more representative depiction of the full site.

Milkweed & Flowering Plants

We utilized protocols from the Integrated Monarch Monitoring Program (IMMP, 2021) to measure the relative abundance and species richness of flowering plants and milkweed along each transect. We counted milkweed plants by species within 1 meter of each side of the transect line and documented flowering plants in bloom within 1-m^2 quadrats spaced five meters apart along each transect. Seven quadrats were sampled on each transect, for a total of 42 across the site (21 in full-sun, 21 in partial-shade). To capture a complete

species richness list for the site, we walked through additional areas after transect sampling and recorded additional flowering plant and milkweed species present.

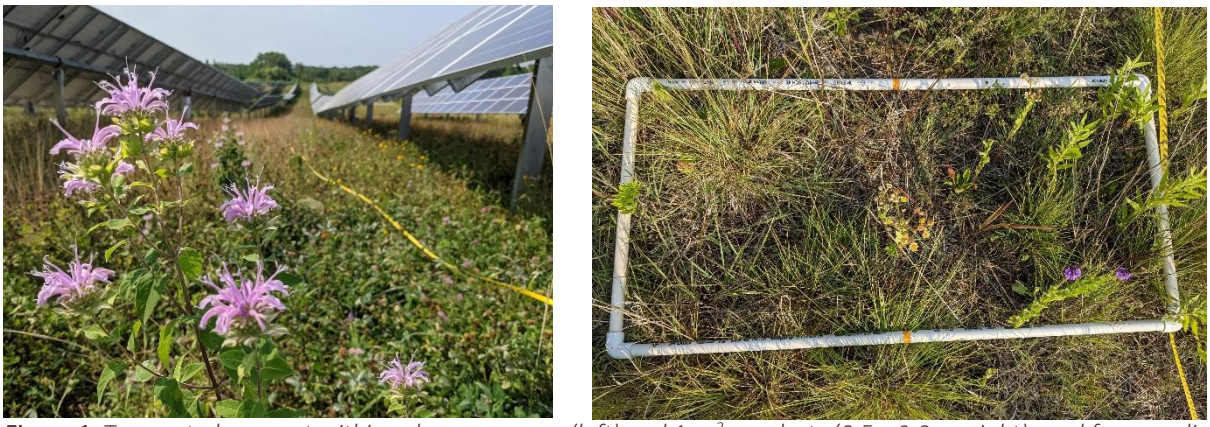

Figure 1. *Transect placement within solar array rows (left) and 1-m^2 quadrats (0.5 x 2.0 m, right) used for sampling milkweed and flowering plants.*

Insect Pollinators

Pollinator survey protocols were adapted from the study designs of Argonne National Laboratory (2019) and Graham et al. (2020). We conducted pollinator surveys during daylight hours of peak pollinator activity (10am-4pm), during dry weather conditions, and when temperatures were above 70°F (Ward et al. 2014). We recorded insect pollinators (Hymenoptera, Lepidoptera, and Diptera) within one meter on each side of the 30-meter transect (two-meter swath) during a slow-paced eight-minute walk. We counted and identified each pollinator to Order, differentiating native bees from the European honeybee, *Apis mellifera*.

Following systematically walking transects, we selected one sampling point for focused monitoring. Focal surveys were conducted over five minutes and occurred at the mid-point of each transect (~15 meters) unless there were fewer than three flowers blooming at that location. In that case, the sampling point was moved to the nearest transect location that contained three or more flowers. At each focal point, we counted the number of flower clusters present within a one-meter radius of the sample point as well as the number and type of pollinators visiting each cluster. We also recorded insect pollinators that were observed outside of transects as 'miscellaneous' observations.

In addition to the pollinator surveys, we measured monarch reproduction during each site visit by examining all milkweed plants present on transects and recording the number and stage of immature monarchs present.

Statistical Analysis

Milkweed density represents the number of *Asclepias* plants observed per square meter. Flowering plant frequency refers to the mean proportion of 1-m^2 quadrats containing at least one blooming plant. Floral richness represents the total number of flowering species observed on transects throughout the season. Species nativity status was obtained from the USDA Plants Database (USDA, NRCS, 2021) and is based on nativity to the continental US. Transect pollinator abundance is measured as the mean number of pollinators observed per site, since distance and time were exactly the same on all transects. Focal pollinator abundance is presented in two ways: the number of pollinators observed, and the number of pollinators observed per flower present (since the number of flowers differed across focal surveys). Monarch per plant density refers to the number of eggs and caterpillars per milkweed plant examined.

We performed statistical tests in the R statistical programming language (version 4.1.1; R Core Team, 2021). We conducted univariate analyses to evaluate differences in plant and pollinator communities on full-sun and partial-shade transects. Because each site was monitored three times throughout the season, we used a one-factor ANOVA with repeated measures. To improve normality, we log-transformed milkweed density and immature monarch density prior to running statistical tests.

Results

Floral Richness & Abundance

Richness

Across all sites, 72 plant species were observed in bloom, 45 of which are native to the U.S. (Table SM1). The average number of flowering species observed per visit was 23.36 (median = 25.00, range = 10 – 35), with a mean of 39.25 per site when summed across the season (median = 37.00, range = 32 – 51). On average, 23.25 (median = 22.50, range = 16 – 32) of these species were native and 16.00 non-native (median = 16.00, range = 13 – 19; Table SM2).

Figure 2. Milkweed and flowering plants between solar array rows. Photo by Laura Lukens.

On a single visit to a site, we observed a mean of 12.00 flowering species on full-sun transects (median = 12.00, range = 6 – 18), and 10.83 on partial-shade transects (median = 9.50, range = 1 – 18). On average, there were 6.58 native species and 6.08 non-natives present on full-sun transects per visit, with 5.25 native and 4.82 non-native on partial-shade. There was no significant difference in overall floral richness on full-sun and partial-shade transects (p = 0.50; Figure 3).

Achillea millefolium (common yarrow, native), *Berteroa incana* (hoary alyssum, non-native), *Erigeron annuus* (daisy fleabane, native), *Lotus corniculatus* (bird's foot trefoil, non-native), *Medicago lupulina* (black medic, non-native), *Melilotus officinalis* (sweetclover, non-native), *Ratibida pinnata* (prairie coneflower, native), *Rudbeckia hirta* (blackeyed susan, native), *Silene latifolia* (bladder campion, non-native), *Verbena stricta* (hoary vervain), and *Zizia aurea* (golden alexander, native) were the most common species observed, present on all four sites. Five of these species are native to the continental U.S. and five are not.

Frequency

The mean frequency of flowering plants (i.e., the proportion of subplots with blooming plants) across sites was 0.63 (median = 0.65, range = 0.44 – 0.81). Mean frequency on full-sun transects was 0.69 (median = 0.76, range = 0.10 – 1.0) and 0.58 on partial-shade (median = 0.62, range = 0 – 0.95). When restricted to native flowering species, frequency was 0.52 on full-sun transects (median = 0.52, range = 0.30 – 0.75) and 0.37 (median = 0.42, range = 0.03 – 0.62) on partial-shade. The mean frequency of non-native flowering species was 0.30 on full-sun (median = 0.29, range = 0.11 – 0.52) and 0.37 on partial-shade (median = 0.31, range = 0.22 – 0.63). Though overall mean flowering frequency was higher on full-sun transects than partial-shade, the difference was not statistically significant (p = 0.28; Figure 3).

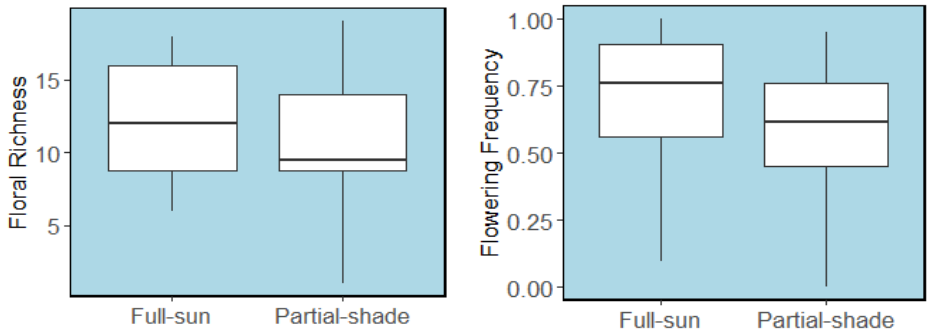

Figure 3. Mean floral richness (number of species observed in bloom) and frequency (proportion of quadrats occupied by blooming plants) per visit on full-sun and partial-shade transects.

Milkweed

Milkweed was present at every site, and we observed three different species (listed in order of highest occurrence): *Asclepias syriaca* (common milkweed; 4/4 sites), *A. tuberosa* (butterfly milkweed; 3/4 sites), and *A. incarnata* (swamp milkweed; 2/4 sites). Mean milkweed density across sites was 0.06 plants per square meter (243 plants/acre) (median = 0.04, range = 0.01 – 0.15). There was no significant difference in milkweed density on full-sun or partial-shade transects (p= 0.25). We observed a mean of 0.08 plants per square meter in full-sun (324 plants/acre) (median = 0.04, range = 0.01 – 0.25) and 0.04 (162 plants/acre) in partial-shade (median = 0.04, range = 0.02 – 0.06).

Insect Pollinators

Pollinator Abundance

Over the course of the season, we recorded 644 insect pollinators on transect and focal surveys. Of these individuals, 35% were native bees (Hymenoptera spp.), 22% honeybees (*Apis mellifera*), 20% butterflies and moths (Lepidoptera spp.), 18% wasps (Hymenoptera spp.), and 5% flies (Diptera spp.; Figure 4).

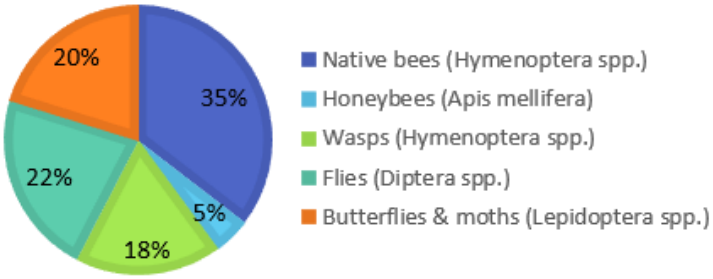

Figure 4. Percentage of pollinating insects contributed by taxonomic group.

Transect Surveys

We observed a mean of 44.67 pollinating insects during transect sampling on a single site visit (median = 42.00, range = 10 – 115). Though the mean number of pollinators observed was higher on full-sun transects (mean = 25.83, median = 23.50, range = 5 – 71) than in partial-shade (mean = 18.83, median = 15.50, range = 5 – 44; Figure 5), the difference was not statistically significant (p=0.22).

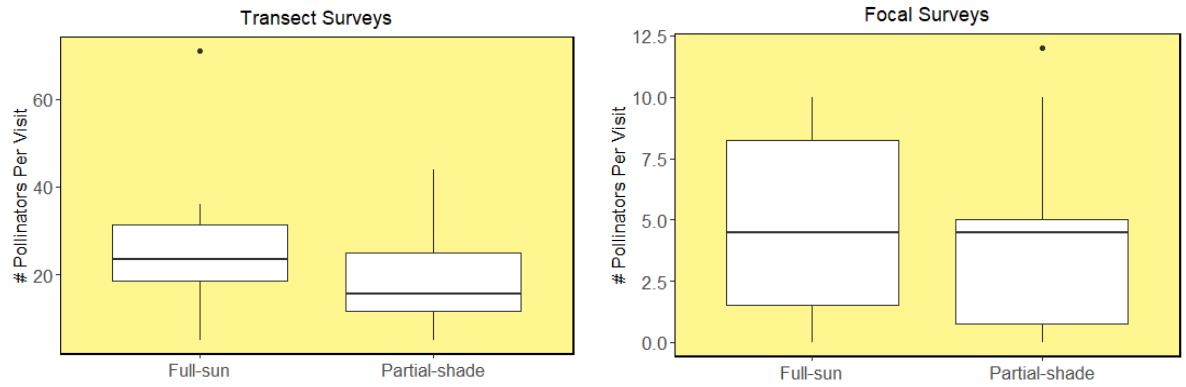

Figure 5. *Number of pollinators observed per site visit on transects (left) and focal surveys (right) in full-sun versus partial-shade.*

Focal Surveys

The vegetation was impacted by grazing sheep at one site and some of the transects were lacking flowering resources entirely. Because of this, we were unable to conduct focal surveys on six transects within the study.

A mean of 1.59 insect pollinators were observed during 5-minute focal surveys (median = 1.00, range = 0 – 10). When summed across all focal surveys on a single site visit, 8.92 insect pollinators were present on average (median = 7.00, range = 0 – 21). There was no significant difference in focal pollinator abundance (pollinators per minute) on full-sun and partial-shade transects (p=0.95; Figure 5). When controlling for the number of flowers observed (pollinators/flower), we still did not detect a significant difference in the number of pollinators observed in the two light conditions (p = 0.28).

Monarch Reproduction

Monarch butterfly reproduction was detected on all four sites. In total, we observed 38 immature monarchs (eggs and larvae) on transects throughout the season with a mean of three on each visit to a site (median = 2, range = 0 – 16). A higher number of monarch eggs and larvae were observed on partial-shade transects than full-sun. Immature monarchs were observed on full-sun transects at only 2/12 site visits but were found on partial-shade transects at 10/12. Both the number of monarchs observed and monarch per plant density were significantly higher on partial-shade transects (p=<0.01; p<0.01, respectively). The mean number of immature monarchs on partial-shade transects per visit was 2.92 (median = 2.00, range = 0 – 16) with a mean of 0.25 in full-sun (median = 0.00, range = 0 – 2). Mean monarch per plant density on full-sun transects was 0.46 on partial-shade transects (median = 0.19, range = 0 – 2.00) and 0.01 in full-sun (median=0.00, range = 0 – 0.08; Figure 7).

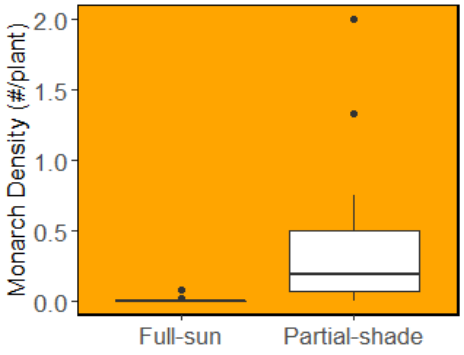

Figure 7*. Number of monarch eggs and caterpillars observed per milkweed plant per visit on full-sun vs partial-shade transects.*

Discussion

The sample size of this study was small (n=4) which limits our ability to draw conclusions about the quantitative differences in the communities within and around solar installations. We did not detect significant statistical differences in the plant communities adjacent to solar panels and within (full-sun versus partial-shade), which may be because there are truly no differences or because the sample size is so small. Furthermore, there were differences in the composition of seed mixes planted underneath solar panels and the adjacent habitat at sites. Because we did not learn of this until after sampling had begun, we could not account for these differences in our survey design. Future studies should ensure that any variation in seeding or management is considered in the development of the study design.

We conducted all of our pollinator surveys during the morning and early afternoon hours, which may impact the number and types of pollinators detected as well as their location. Future studies should incorporate afternoon surveys in addition to morning surveys to capture potential differences in pollinator visitation throughout the day. Furthermore, there was considerable variability in plant and pollinator communities throughout the season (Supplementary Materials; Figures SM1-SM3), which may be in part due our sampling design. Transect locations differed among site visits in order to obtain a more representative sample of the full site. Further research is necessary to understand the seasonal variability in plant and pollinator richness and abundance in solar developments.

One of the study sites was heavily grazed by sheep which decreased the presence of flowering vegetation during our visits. The grazed areas differed on each site visit and often sheep were observed congregating beneath solar panels, perhaps grazing the partially-shaded areas more intensively. This situation makes it difficult to determine true differences in plant and pollinator communities within and outside of the solar array rows at this site.

A higher number of monarchs were present on partial-shade transects than full-sun. Further study is needed to investigate the relationship between solar array canopies and monarch reproduction. Weekly surveys would help identify whether adult monarchs prefer to oviposit on milkweeds within solar array rows or whether monarch survival is higher on those milkweeds than in full-sun.

The richness and frequency of non-native species presented includes clover species (*Trifolium* spp.) that were intentionally planted at sites to maintain perennial cover and mitigate erosion. That being said, there were 13-19 non-native species observed at each site and half of the ten most common species observed across sites were non-native and not planted. Additionally, some of these species are classified as invasive and/or noxious weeds (e.g., *Centaurea stoebe*/spotted knapweed, *Cirsium arvense*/Canada thistle). Though there were a high number of native flowering species present as well, the sites would benefit from targeted management to eradicate species that may become prolific and diminish habitat quality over time.

We observed a high number of flowering plant species within and outside of solar arrays, a variety of pollinator Orders utilizing the habitat, and an abundance of bees, butterflies, moths, flies, and wasps (as well as additional insect species beyond those identified). Though there were a higher number of pollinators observed on full-sun transects, our results indicate that pollinators utilized habitat regardless of solar panel presence. This study demonstrates that solar habitat installations in Minnesota have the potential to provide

Figure 8. *Verbena hastata (blue vervain) blooming at Minnesota solar installation. Photo by Laura Lukens.*

quality monarch breeding habitat, foraging resources for a variety of insect pollinators, and can foster diverse communities of native plants.

Though many pollinator conservation efforts are underway, a recent study determined that the US is failing to meet conservation goals outlined in the National Strategy to Promote the Health of Honeybees and Other Pollinators (Bloom et al., 2021). Continued investment in conservation action is necessary to recover pollinator populations. The energy sector could play an important role in contributing acres to national habitat goals. Long-term monitoring will be critical to ensure that pollinator-friendly practices are resulting in desired outcomes through time.

Acknowledgements

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Supplementary Materials

Table SM1. Flowering species observed in bloom at sites.

Scientific Name	Common Name	Nativity*	# Sites
Achillea millefolium	common yarrow	1	4
Berteroa incana	hoary alyssum	0	4
Erigeron annuus	eastern daisy fleabane	1	4
Lotus corniculatus	bird's-foot trefoil	0	4
Medicago lupulina	black medick	0	4
Melilotus officinalis	sweetclover	0	4
Ratibida pinnata	pinnate prairie coneflower	1	4
Rudbeckia hirta	blackeyed Susan	1	4
Silene latifolia	bladder campion	0	4
Solidago sp.	goldenrod species	1	4
Verbena stricta	hoary verbena	1	4
Zizia aurea	golden zizia	1	4
Asclepias tuberosa	butterfly milkweed	1	3
Cirsium arvense	Canada thistle	0	3
Cirsium vulgare	bull thistle	0	3
Dalea purpurea	purple prairie clover	1	3
Hieracium species	Hawkweed species	0	3
Medicago sativa	alfalfa	0	3
Monarda fistulosa	wild bergamot	1	3
Oenothera sp.	Evening primrose	1	3
Potentilla norvegica	Norwegian cinquefoil	1	3
Pycnanthemum virginianum	Virginia mountainmint	1	3
Ratibida columnifera	upright prairie coneflower	1	3
Rumex crispus	curly dock	0	3
Tragopogon dubius	yellow salsify	0	3
Trifolium hybridum	alsike clover	0	3
Trifolium pratense	red clover	0	3
Allium stellatum	autumn onion	1	2
Asclepias incarnata	swamp milkweed	1	2
Asclepias syriaca	common milkweed	1	2
Centaurea stoebe	spotted knapweed	0	2
Chamaecrista fasciculata	partridge pea	1	2
Dalea candida	white prairie clover	1	2
Desmodium canadense	showy ticktrefoil	1	2
Grindelia squarrosa	curlycup gumweed	1	2
Heliopsis helianthoides	smooth oxeye	1	2
Leucanthemum vulgare	oxeye daisy	0	2
Lobelia siphilitica	great blue lobelia	1	2
Potentilla arguta	tall cinquefoil	1	2
Solidago nemoralis	gray goldenrod	1	2

Sonchus arvensis	field sowthistle	0	2
Taraxacum officinale	common dandelion	0	2
Trifolium repens	white clover	0	2
Verbena hastata	swamp verbena	1	2
Vicia americana	American vetch	1	2
Amaranthus palmeri	carelessweed	1	1
Ambrosia artemisiifolia	annual ragweed	0	1
Apocynum cannabinum	Indianhemp	1	1
Aquilegia canadensis	red columbine	1	1
Astragalus canadensis	Canadian milkvetch	1	1
Carduus acanthoides	spiny plumeless thistle	0	1
Dalea villosa	silky prairie clover	1	1
Echinacea pallida	pale purple coneflower	1	1
Eupatorium perfoliatum	common boneset	1	1
Eutrochium maculatum	spotted joe pye weed	1	1
Geum canadense	white avens	1	1
Heterotheca villosa	hairy false goldenaster	1	1
Liatris pycnostachya	prairie blazing star	1	1
Monarda punctata	spotted beebalm	1	1
Oligoneuron album	prairie goldenrod	1	1
Oxalis stricta	common yellow oxalis	1	1
Penstemon grandiflorus	large beardtongue	1	1
Penstemon pallidus	pale beardtongue	1	1
Polygonum persicaria	spotted ladysthumb	0	1
Potentilla argentea	silver cinquefoil	0	1
Stellaria graminea	grass-like starwort	0	1
Symphyotrichum novae-angliae	New England aster	1	1
Tanacetum vulgare	common tansy	0	1
Trifolium arvense	rabbitfoot clover	0	1
Verbascum thapsus	common mullein	0	1
Verbena bracteata	bigbract verbena	1	1
Vicia villosa	winter vetch	0	1

*Nativity 1 = native to the United States; 0 = non-native.

Table SM2. Overall and monthly floral richness (number of species observed in bloom) at each site monitored. Data include species observed on transects and additional species observed flowering throughout the site.

	OVERALL		JUNE		JULY		AUGUST	
Site	**Native**	**Non-native**	**Native**	**Non-native**	**Native**	**Non-native**	**Native**	**Non-native**
Annandale	32	19	13	12	20	12	22	13
Lake Pulaski	21	13	9	8	18	9	10	6
Lawrence Creek	16	16	6	7	7	3	15	13
Anoka	24	16	11	5	14	11	18	11

Table SM3. Insect pollinator abundance in full-sun and partial-shade during each month surveyed.

	# Insect Pollinators (Transect + Focal Surveys)						**# Immature Monarchs**						**Average # Monarchs Per Milkweed**					
	FULL-SUN			**PARTIAL-SHADE**			**FULL-SUN**			**PARTIAL-SHADE**			**FULL-SUN**			**PARTIAL-SHADE**		
Site	**Jun**	**Jul**	**Aug**	**Jun**	**Jul**	**Aug**	**Jun**	**Jul**	**Aug**	**Jun**	**Jul**	**Aug**	**Jun**	**Jul**	**Aug**	**Jun**	**Jul**	**Aug**
Annandale	32	44	26	39	25	30	0	0	0	3	16	1	0.00	0.00	0.00	0.75	1.33	0.05
L. Pulaski	22	27	5	21	20	10	1	2	0	2	4	1	0.08	0.03	0.00	0.42	0.18	0.17
L. Creek	81	27	36	54	11	12	0	0	0	1	0	3	0.00	0.00	0.00	0.08	0.00	0.38
Anoka	36	26	5	26	17	11	0	0	0	2	0	2	0.00	0.00	0.00	2.00	0.00	0.20

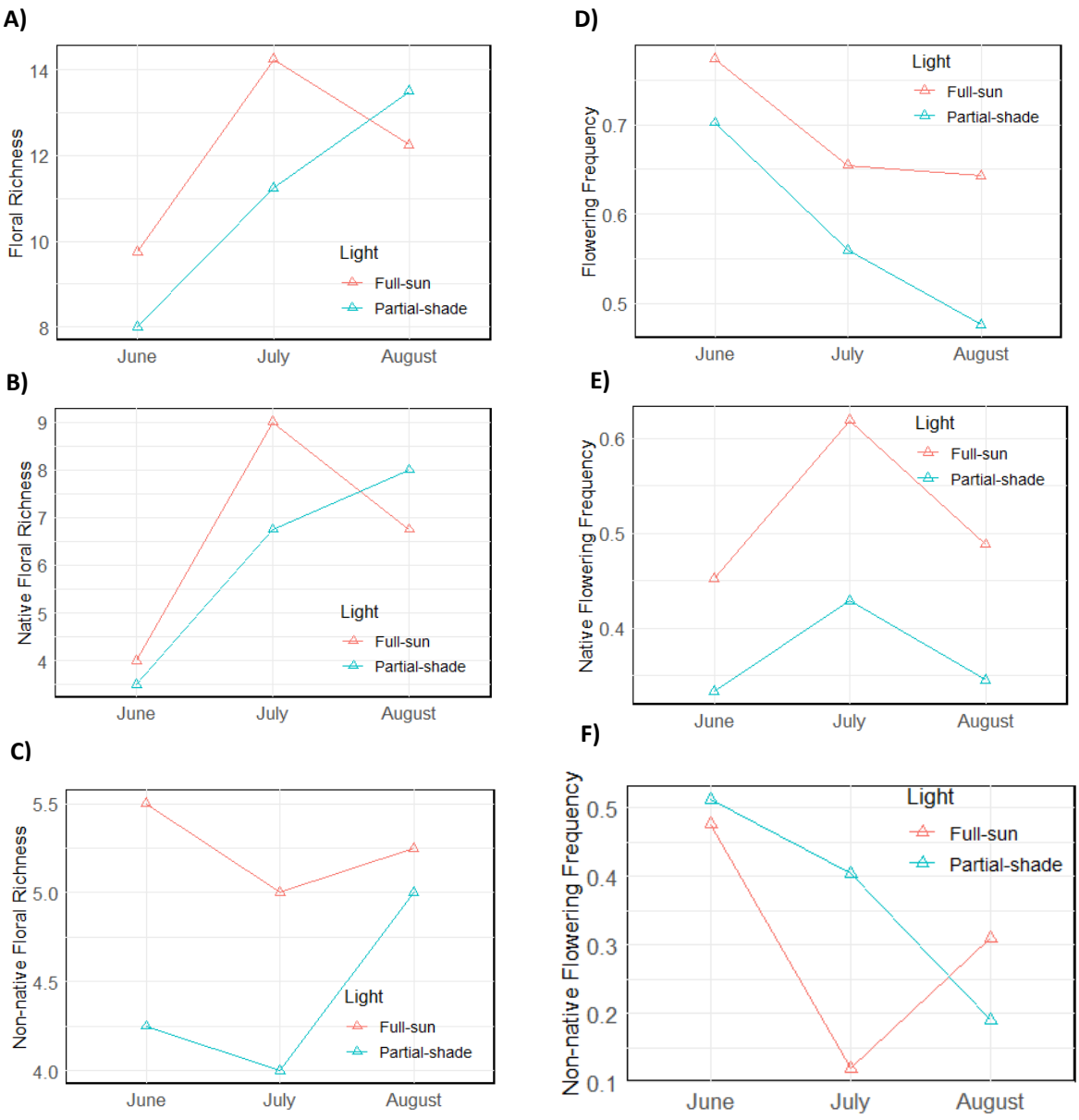


Figure SM1. *A-C) Mean floral richness across site visits: all species (A), native species (B), and non-native species (C). D-F) mean flowering frequency throughout the season: all species (D), native species (E), and non-native species (F). Note that transect locations differed on each site visit and may be responsible for some of the variation illustrated here.*

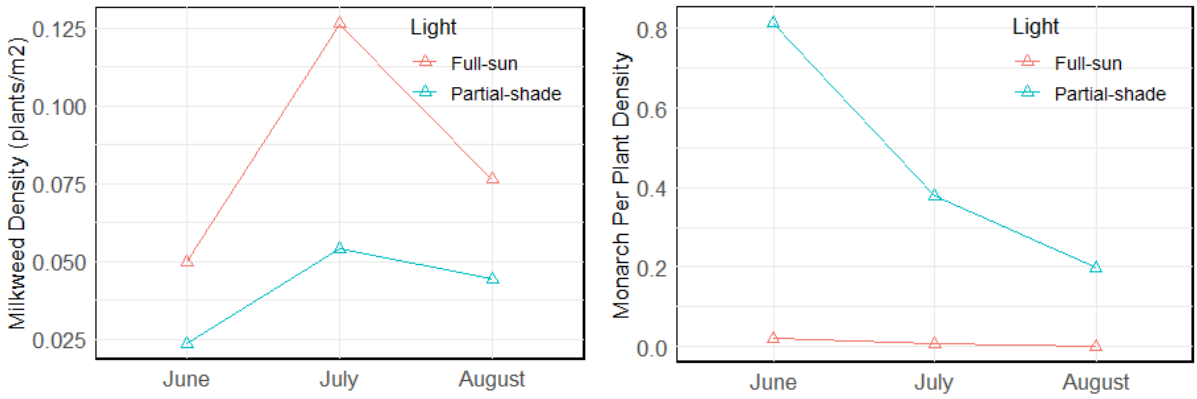


Figure SM2. *Mean milkweed density (plants per square meter; left) and monarch per plant density (right) during each month sites were sampled.*

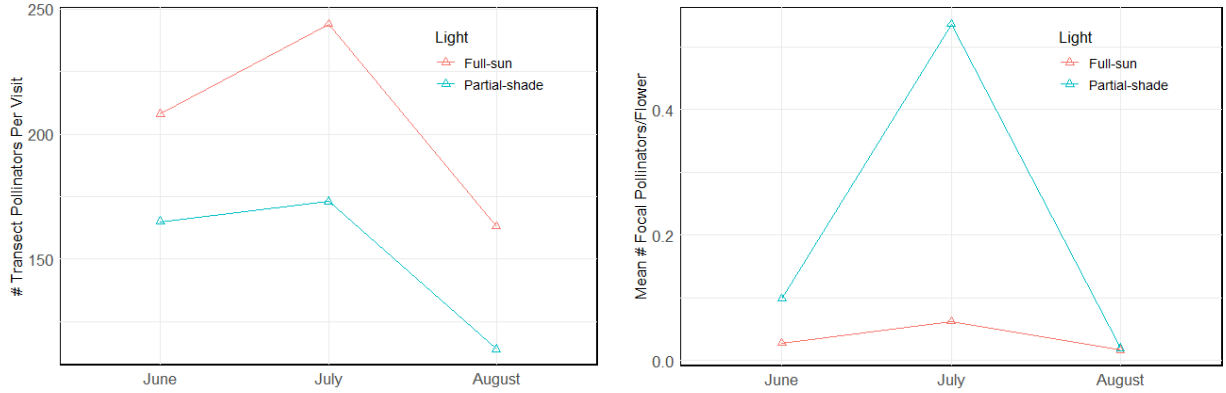


Figure SM3. *Transect pollinator abundance (mean number per visit; left) and focal pollinator abundance (mean number per flower; right) during each month sites were sampled.*

Pollinator Friendly Scorecards for Sites Monitored

BWSR

Habitat Friendly Solar Site Assessment Form for Project Planning

For solar companies and local governments to meet Habitat Friendly standards
5-26-2020

1) PLANNED % OF SITE DOMINATED BY NATIVE SPECIES COVER (wildflowers, grasses, sedges, shrubs, trees)

- ☐ 26-50% +5 points
- ☐ 51-75% +10 points
- ☒ 76% and above +15 points

Total points 15

2) PERCENT OF PROPOSED SITE VEGETATION COVER TO BE DOMINATED BY WILDFLOWERS (not grasses and sedges)

- ☐ 10-20 % +5 points
- ☐ 21-30 % +10 points
- ☒ 31% and above +15 points

Total points 15

Note: Projects may have "array" mixes and diverse border mixes; forb dominance should be averaged across the entire site. The dominance should be calculated from total numbers of forb seeds vs. grass seeds based on seeds per square foot(from all seed mixes to be planted).

3) PLANNED COVER DIVERSITY (# of species in seed mixes; numbers from upland and wetland mixes can be combined)

- ☐ 10-19 species +5 points
- ☒ 20-25 species +10 points
- ☐ 26 or more species +15 points

Total points 10

4) PLANNED SEASONS WITH AT LEAST 3 BLOOMING SPECIES PRESENT (check/add all that apply)

- ☒ Spring (April - May) +10 points
- ☒ Summer (June - August) +5 points
- ☒ Fall (September - October) +5 points

Total points 20

See BWSR Pollinator Toolbox about bloom season.

5) AVAILABLE HABITAT COMPONENTS WITHIN SITE OR WITHIN .25 MILES (check/add all that apply)

- ☒ Native bunch grasses for nesting +3 points
- ☐ Native flowering shrubs +4 points
- ☐ Clean, perennial water sources +3 points
- ☐ Created nesting feature/s (bee blocks, etc.) +4points

Total points 3

6) SITE PLANNING AND MANAGEMENT

- ☒ Detailed establishment and management plan (see notes) developed with funding/ contract to implement. +15 points
- ☐ Signage legible at forty or more feet stating pollinator friendly solar habitat (see notes for number of signs). +5 points

Total points 15

7) SEED MIXES

- ☒ Mixes are composed of at least 40 seeds per square foot. +5 points
- ☐ All seed genetic origin within 175 of site (see notes). +8 points
- ☒ At least 1% milkweed cover to be established from seed/plants. +10 points

Total points 15

8) INSECTICIDE RISK

- ☐ Planned on-site insecticide use or pre-planting seed/plant treatment (excluding buildings/electrical boxes, etc.). -40 points
- ☒ Communication with local chemical applicators/neighbors about need to prevent drift from adjacent areas (see notes). +10 points

Total points 10 +8

Grand Total 103 - 111

Gold Standard - Provides Exceptional Habitat 85+

Meets Pollinator Standards 70

Project Name: Anoka Solar
Vegetation Consultant: Prairie Restorations Inc.
Project County: Anoka County
Project Size: 17.5 Acres
Projected Seeding Date: 10-18-2018

See notes related to the question on the back side of this form.

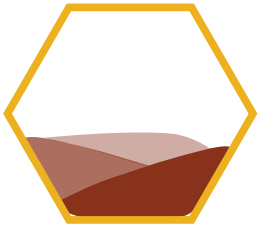
Pg. 1

DETERMINED TO BE PUBLIC INFORMATION
BY MINNESOTA BOARD OF WATER AND SOIL RESOURCES

BWSR

Solar Site Pollinator Habitat Assessment Form for Project Planning

For solar companies and local governments to meet pollinator/wildlife habitat certification



1. PERCENT OF PROPOSED SITE VEGETATION COVER TO BE DOMINATED BY WILDFLOWERS

- ☐ 31-45 % +5 points
- ☐ 46-60 % +10 points
- ☒ 61+ % +15 points

Total points 15

Note: Projects may have "array" mixes and diverse border mixes; forb dominance should be averaged across the entire site. The dominance should be calculated from total numbers of forb seeds vs. grass seeds (from all seed mixes) to be planted.

2. PLANNED % OF SITE DOMINATED BY NATIVE SPECIES COVER

- ☐ 26-50% +5 points
- ☐ 51-75%. +10 points
- ☒ 76-100% +15 points

Total points 15

3. PLANNED COVER DIVERSITY (# of species in seed mixes; numbers from upland and wetland mixes can be combined)

- ☐ 10-19 species +5 points
- ☐ 20-25 species +10 points
- ☒ 26 or more species +15 points

Total points 15

Exclude invasives from species totals.

4. PLANNED SEASONS WITH AT LEAST 3 BLOOMING SPECIES PRESENT (check/add all that apply)

- ☒ Spring (April-May) +5 points
- ☒ Summer (June-August) +5 points
- ☒ Fall (September-October) +5 points

Total points 15

See BWSR Pollinator Toolbox about bloom seasons

5. AVAILABLE HABITAT COMPONENTS WITHIN .25 MILES (check/add all that apply)

- ☒ Native bunch grasses for nesting +2 points
- ☒ Native trees/shrubs for nesting +2 points
- ☒ Clean, perennial water sources +2 points
- ☐ Created nesting feature/s (bee blocks, etc.) +2 points

Total points 6

6. SITE PLANNING AND MANAGEMENT

- ☒ Detailed establishment and management plan developed (see example plan) with funding/ contract to implement +15 points
- ☒ Signage legible at forty or more feet stating pollinator friendly solar habitat (at least 1 every 20ac.) +5 points

Total points 20

7. SEED MIXES

- ☒ Mixes are composed of at least 40 seeds per square foot +5 points
- ☐ All seed genetic origin within 175 miles of site (pg.7-8 of Guidance) +5 points
- ☐ At least 2% milkweed cover to be established from seed/plants +10 points

Total points 5

8. INSECTICIDE RISK

- ☐ Planned on-site insecticide use or pre-planting seed/plant treatment (excluding buildings/ electrical boxes, etc.) -40 points
- ☐ Communication/registration with local chemical applicators about need to prevent drift from adjacent areas. +10 points

Total points

Grand Total 91

Provides Exceptional Habitat	**>85**
Meets Pollinator Standards	**70-84**

Project Name: Aurora Annandale
Vegetation Consultant: Jake Janski
Project County: Wright
Project Size: 66 Acres
Projected Seeding Date: June-Nov 2017

Send completed forms, project plans, seed mixes and any communication with pesticide applicators to dan.shaw@state.mn.us

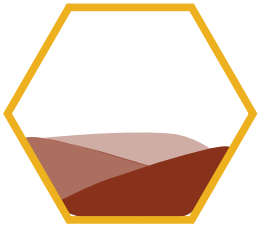
Note: Measurements of percent "cover" should be based on "absolute cover" defined as the percent of the ground surface that is covered by a vertical projection of foliage as viewed from above. To measure cover diversity it is recommended to use plots, and/or transects in addition to meander searches for accurate measurements. Wildflowers in question 1 refer to "forbs" which are flowering plants that are not woody, and are not graminoids (grasses, sedges, etc) and can include introduced clovers and other non-native species beneficial to pollinators.

DETERMINED TO BE PUBLIC INFORMATION
BY MINNESOTA BOARD OF WATER AND SOIL RESOURCES

BWSR

Solar Site Pollinator Habitat Assessment Form for Project Planning

For solar companies and local governments to meet pollinator/wildlife habitat certification



1. PERCENT OF PROPOSED SITE VEGETATION COVER TO BE DOMINATED BY WILDFLOWERS

- ☐ 31-45 % +5 points
- ☐ 46-60 % +10 points
- ☒ 61+ % +15 points

Total points 15

Note: Projects may have "array" mixes and diverse border mixes; forb dominance should be averaged across the entire site. The dominance should be calculated from total numbers of forb seeds vs. grass seeds (from all seed mixes) to be planted.

2. PLANNED % OF SITE DOMINATED BY NATIVE SPECIES COVER

- ☐ 26-50% +5 points
- ☐ 51-75%. +10 points
- ☒ 76-100% +15 points

Total points 15

3. PLANNED COVER DIVERSITY (# of species in seed mixes; numbers from upland and wetland mixes can be combined)

- ☐ 10-19 species +5 points
- ☐ 20-25 species +10 points
- ☒ 26 or more species +15 points

Total points 15

Exclude invasives from species totals.

4. PLANNED SEASONS WITH AT LEAST 3 BLOOMING SPECIES PRESENT (check/add all that apply)

- ☒ Spring (April-May) +5 points
- ☒ Summer (June-August) +5 points
- ☒ Fall (September-October) +5 points

Total points 15

See BWSR Pollinator Toolbox about bloom seasons

5. AVAILABLE HABITAT COMPONENTS WITHIN .25 MILES (check/add all that apply)

- ☒ Native bunch grasses for nesting +2 points
- ☒ Native trees/shrubs for nesting +2 points
- ☒ Clean, perennial water sources +2 points
- ☐ Created nesting feature/s (bee blocks, etc.) +2 points

Total points 6

6. SITE PLANNING AND MANAGEMENT

- ☒ Detailed establishment and management plan developed (see example plan) with funding/ contract to implement +15 points
- ☒ Signage legible at forty or more feet stating pollinator friendly solar habitat (at least 1 every 20ac.) +5 points

Total points 20

7. SEED MIXES

- ☒ Mixes are composed of at least 40 seeds per square foot +5 points
- ☐ All seed genetic origin within 175 miles of site (pg.7-8 of Guidance) +5 points
- ☐ At least 2% milkweed cover to be established from seed/plants +10 points

Total points 5

8. INSECTICIDE RISK

- ☐ Planned on-site insecticide use or pre-planting seed/plant treatment (excluding buildings/ electrical boxes, etc.) -40 points
- ☐ Communication/registration with local chemical applicators about need to prevent drift from adjacent areas. +10 points

Total points

Grand Total 91

Provides Exceptional Habitat >85
Meets Pollinator Standards 70-84

Project Name: Aurora Lake Pulaski
Vegetation Consultant: Jake Janski
Project County: Wright
Project Size: 68 Acres
Projected Seeding Date: May-Oct 2017

Send completed forms, project plans, seed mixes and any communication with pesticide applicators to dan.shaw@state.mn.us

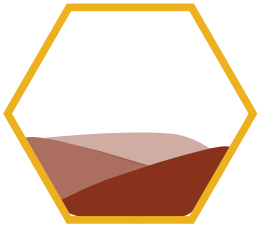
Note: Measurements of percent "cover" should be based on "absolute cover" defined as the percent of the ground surface that is covered by a vertical projection of foliage as viewed from above. To measure cover diversity it is recommended to use plots, and/or transects in addition to meander searches for accurate measurements. Wildflowers in question 1 refer to "forbs" which are flowering plants that are not woody, and are not graminoids (grasses, sedges, etc) and can include introduced clovers and other non-native species beneficial to pollinators.

DETERMINED TO BE PUBLIC INFORMATION
BY MINNESOTA BOARD OF WATER AND SOIL RESOURCES

BWSR

Solar Site Pollinator Habitat Assessment Form for Project Planning

For solar companies and local governments to meet pollinator/wildlife habitat certification



1. PERCENT OF PROPOSED SITE VEGETATION COVER TO BE DOMINATED BY WILDFLOWERS

- ☐ 31-45 % +5 points
- ☐ 46-60 % +10 points
- ☒ 61+ % +15 points

Total points 15

Note: Projects may have "array" mixes and diverse border mixes; forb dominance should be averaged across the entire site. The dominance should be calculated from total numbers of forb seeds vs. grass seeds (from all seed mixes) to be planted.

2. PLANNED % OF SITE DOMINATED BY NATIVE SPECIES COVER

- ☐ 26-50% +5 points
- ☐ 51-75%. +10 points
- ☒ 76-100% +15 points

Total points 15

3. PLANNED COVER DIVERSITY (# of species in seed mixes; numbers from upland and wetland mixes can be combined)

- ☐ 10-19 species +5 points
- ☐ 20-25 species +10 points
- ☒ 26 or more species +15 points

Total points 15

Exclude invasives from species totals.

4. PLANNED SEASONS WITH AT LEAST 3 BLOOMING SPECIES PRESENT (check/add all that apply)

- ☒ Spring (April-May) +5 points
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- ☒ Fall (September-October) +5 points

Total points 15

See BWSR Pollinator Toolbox about bloom seasons

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- ☒ Native trees/shrubs for nesting +2 points
- ☒ Clean, perennial water sources +2 points
- ☐ Created nesting feature/s (bee blocks, etc.) +2 points

Total points 6

6. SITE PLANNING AND MANAGEMENT

- ☒ Detailed establishment and management plan developed (see example plan) with funding/ contract to implement +15 points
- ☒ Signage legible at forty or more feet stating pollinator friendly solar habitat (at least 1 every 20ac.) +5 points

Total points 20

7. SEED MIXES

- ☒ Mixes are composed of at least 40 seeds per square foot +5 points
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- ☐ At least 2% milkweed cover to be established from seed/plants +10 points

Total points 5

8. INSECTICIDE RISK

- ☐ Planned on-site insecticide use or pre-planting seed/plant treatment (excluding buildings/ electrical boxes, etc.) -40 points
- ☐ Communication/registration with local chemical applicators about need to prevent drift from adjacent areas. +10 points

Total points

Grand Total 91

Provides Exceptional Habitat	**>85**
Meets Pollinator Standards	**70-84**

Project Name: Aurora Lawrence Creek
Vegetation Consultant: Jake Janski
Project County: Chisago
Project Size: 39 Acres
Projected Seeding Date: July 2017

Send completed forms, project plans, seed mixes and any communication with pesticide applicators to dan.shaw@state.mn.us

Note: Measurements of percent "cover" should be based on "absolute cover" defined as the percent of the ground surface that is covered by a vertical projection of foliage as viewed from above. To measure cover diversity it is recommended to use plots, and/or transects in addition to meander searches for accurate measurements. Wildflowers in question 1 refer to "forbs" which are flowering plants that are not woody, and are not graminoids (grasses, sedges, etc) and can include introduced clovers and other non-native species beneficial to pollinators.