ELECTRIC POWER RESEARCH INSTITUTE

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Pollinator Assemblages on Powerline Corridors Treated to Control Invasive Exotic Woody Plants in Northeastern Ohio

Pollinator Assemblages on Powerline Corridors Treated to Control Invasive Exotic Woody Plants in Northeastern Ohio

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ABSTRACT

Observations of plant communities and pollinator assemblages on select powerline corridors in northeastern Ohio were conducted in May, July, and September 2017. A total of nine large research plots (~1 acre [0.4 ha] in size) that had received various chemical vegetation management treatments were extensively sampled for plant coverage and insect pollinator abundance and diversity. Created plant communities were variable but normal for managed systems, with low tree cover and complex mosaics of shrubs, herbs, grasses, and ferns. Over 1,000 pollinator insects were collected using standard techniques (for example, pan traps and netting) across five insect orders: Hymenoptera, Diptera, Coleoptera, Lepidoptera, and Hemiptera. This is one of the first pollinators studies of any kind to include insects other than bees or butterflies. Removal of invasive exotic woody plants—the focus of the pre-existing vegetation experiment that is the basis of the insect pollinator study—did not result in a change in pollinator assemblages. It appears that significant coverage of forb/herb plants is related to the abundance and diversity of pollinators on powerline corridors: vegetation treatments had variable coverage of woody plants, but forb/herb cover generally was the same across treatments.

Keywords
Electric transmission line rights of way
Herbicide treatments
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PRIMARY AUDIENCE: Electric transmission line right-of-way vegetation managers, including industrial vegetation managers and environmental stewards

SECONDARY AUDIENCE: Policymakers and regulators for the electric transmission line industry

KEY RESEARCH QUESTIONS

1. What is the baseline diversity of pollinators on powerline corridors?
2. What can be done to manage for pollinator habitat on powerline corridors?

RESEARCH OVERVIEW

Observations of plant communities and pollinator assemblages on select powerline corridors in northeastern Ohio were conducted in May, July, and September 2017. A total of nine large research plots (~1 acre [0.4 ha] in size) that had received various chemical vegetation management treatments were extensively sampled for plant cover and insect pollinator abundance and diversity. Created plant communities were variable but normal for managed systems, with low tree cover and complex mosaics of shrubs, herbs, grasses, and ferns. Over 1,000 pollinator insects were collected using standard techniques (for example, pan traps and netting) across five insect orders: Hymenoptera, Diptera, Coleoptera, Lepidoptera, and Hemiptera. This is one of the first pollinators studies of any kind to include insects other than bees or butterflies.

KEY FINDINGS

- Electric transmission line rights of way are used by an abundant and diverse array of insect pollinators.
- Vegetation management treatments that reduced coverage of invasive, exotic woody plants did not result in a change in pollinator assemblages on Ohio rights of way.

WHY THIS MATTERS

Global declines in both native and managed pollinator populations—with highly visible decreases in honey bees, bumble bees, and monarch butterflies—have brought into focus the importance of pollinator conservation. Electric transmission line rights of way, also known as powerline corridors, have been proposed as important pollinator habitat. Current study results support this proposition.

HOW TO APPLY RESULTS

Results from the current study provide some basis for applying vegetation management techniques aimed at promoting pollinators on electric transmission line rights of way. The user is reminded that this study is only one of many pollinator studies supported by EPRI over the past decade.

LEARNING AND ENGAGEMENT OPPORTUNITIES

- Environmental Protection Agency, state regulatory agencies, and nongovernmental organizations

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BACKGROUND

Pollinators—insects (particularly bees, but also including flies, wasps, beetles, butterflies, and moths) and, to lesser extents in North America, birds and mammals—provide critical ecosystem service (pollination) and function (pollinate). A large portion of plants, including common forbs, shrubs, and trees, require pollinators in order to produce viable fruit and seed. (Some plants, such as grasses, depend primarily on wind pollination.) Many of the nearly 20,000 flowering plant species in the United States depend on pollinators to reproduce (Pollinator Health Task Force (PHTF) 2015). There are over 4,000 native bee species in the United States alone that contribute to pollination (Moisset and Buchmann 2011, cited in PHTF 2015). The attributed value of crops in the United States that are directly dependent on insect pollination was estimated at $15.12 billion in 2009, including an estimated $11.68 billion of crop value directly attributable to honey bees alone (Calderone 2012, cited in PHTF 2015).

Global declines in both native and managed pollinator populations, with highly visible decreases in honey bees, bumble bees, and monarch butterflies, have brought into focus the importance of pollinator conservation (PHTF 2015). Declines in pollinators have been speculatively related to changes in habitat extent and structure, pests and pathogens, pesticides and toxins present in the environment, and nutritional quality of forage, among other factors—with the impacts of these factors individually, and the interactions among them, not well understood (PHTF 2015).

In 2014, President Obama issued the Presidential Memorandum "Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators," establishing a Task Force to develop a Strategy to promote the health of honey bees and other pollinators (PHTF 2015). The Strategy had three overarching goals (PHTF 2015):

- To reduce honey bee losses
- To increase the eastern population of the monarch butterfly
- To restore or enhance 7 million acres (2,832,800 ha) of land for pollinator habitat

To achieve these goals through evidence-based decision making, The Pollinator Research Action Plan (Action Plan) (see PHTF 2015), a stand-alone component of the Strategy, was developed as a roadmap for federally supported pollinator health research. The priorities in the Action Plan were divided into five main action areas (modified after PHTF 2015):

1. **Setting a baseline.** Assessing the status of pollinator populations using inventories to establish baseline conditions, with subsequent monitoring and longitudinal studies to detect deviations from the baseline as well as their causes.
2. **Assessing environmental stressors.** Many individual environmental factors have the potential to impact pollinator populations. These impacts will vary by species and can be mitigated or exacerbated by co-occurring environmental factors. These factors should be examined individually in controlled laboratory experiments; the way these factors interact

with one another in real-world situations should also be explored through longitudinal studies of pollinator health.

3. **Restoring habitat.** Pollinator populations depend directly on plant populations for nutrition; in turn, plants depend on pollinators for reproduction. There is much more to learn about the relationships between plants and their pollinators. Research should focus on understanding the spatial and temporal relationships between plants and their pollinators and identifying habitat with the highest potential for pollinator benefits.
4. **Understanding and supporting stakeholders.** The choices that land managers and beekeepers make depend on a complex web of cultural and economic values. Research will explore the costs and benefits to land managers and the public of adopting pollinator-friendly practices.
5. **Curating and sharing knowledge.** Long-term monitoring and sound research require an extensive and well-curated knowledge base.

The current research project is one of many ongoing and recently completed EPRI projects on pollinators and electric transmission lines that will contribute to the main areas being pursued in support of the federal Action Plan by various governmental and private institutions.

Electric transmission line rights of way (ROWs), also known as *powerline corridors*, have been proposed as important pollinator habitat (Wojcik and Buchman 2012; Nowak and Van Splinter 2017). These linear corridors provide 160,000 miles (230–765 kV operations) and ~10,000,000 acres (~4,046,856 ha) of quasi-permanent early successional habitat that is likely more important for pollinators than people generally realize. Yet little research has been done on pollinators and powerline corridors (Nowak and Van Splinter 2017). Research to date has shown the possible importance of powerline corridors in pollinator habitat and dynamics. However, many researchable questions remain with powerline corridors that are alignable with the federal government's Pollinator Research Action Plan (see PHTF 2015), including the following two basic questions:

1. What is the baseline diversity of pollinators on powerline corridors?
2. What can be done with management for pollinator habitat on powerline corridors?

Given the importance of this topic—and the fact that little is known about pollinators and electric transmission line ROWs—a full suite of studies is needed to investigate the current state of ROWs and vegetation management along with future opportunities to improve and promote pollinator habitat and dynamics.

Overall EPRI/SUNY-ESF Project Objectives

Project objectives are progressive, as follows:

1. Describe how pollinator habitat varies across electric transmission line ROWs.
2. Describe how pollinator diversity varies across a variety of electric transmission line ROWs.
3. Develop and test a variety of vegetation management practices that can be used to enhance pollinator diversity through manipulations of habitat on ROWs.

4. Develop protocol for the establishment of field experiments on ROWs across the United States.

Objective 1 was met by retrospectively using a replicated manipulated field experiment that was originally conducted from 2000 to 2003 (Nowak et al. 2016b). The plant abundance data, originally considered for ecological aspects of plant diversity based on complete floristic inventories of operational managed ROW plots, was re-examined for pollinator habitat values (focusing on flowering patterns and dynamics). Objective 2 has been met with two studies, including the current one reported here. A set of contemporary vegetation management research plots with replicated experimental structure—one in New York and one in Ohio—were remeasured for both plant community state and associated pollinator assemblages. In both studies, data were combined in various ways to develop understanding of the factors controlling pollinator assemblage patterns (abundance and diversity) on electric transmission line ROWs. A first-year report was developed as a technical update for EPRI in 2016 (Nowak et al. 2016a), followed by a second-year technical update in 2017 (Nowak et al. 2017).

As Objectives 1 and 2 were being met, the team began to develop possible vegetation management treatments to enhance pollinator habitat on ROWs (Objective 3). A long-term, replicated field experiment was established in New York State in late 2017–early 2018 to test conventional and new, pollinator-centric approaches to managing ROW vegetation (Objective 3). Experiences from the overall research and development project were recently summarized and codified in a protocol report that will provide users with information on how to develop similar research in other places across the United States (Objective 4) (Ballard et al. 2018).

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POLLINATOR ASSEMBLAGES ON POWERLINE CORRIDORS TREATED TO CONTROL INVASIVE EXOTIC WOODY PLANTS IN NORTHEASTERN OHIO

Introduction

Research has only rarely been conducted on pollinator assemblages in right-of-way (ROW) environs, especially on electric transmission line rights-of-way (see earlier background section), this despite the fact that ROWs may provide critical, cross-landscape habitat for pollinators. It may be that these ROWs can be managed to enhance pollinator habitat and result in increased populations of pollinators across North America. A first step in such an effort is to describe what the baseline state of pollinator assemblages is on ROWs, and how that base is affected by management.

Objective and Study Approach

The objective for this study was to describe how pollinator assemblages change with changes in plant community on an electric transmission line ROWs. The study was conducted in northeastern Ohio using a pre-existing manipulative field experiment where vegetation had been managed for using different techniques that resulted in difference plant communities. In summer, a detailed sample of vascular plant abundance was made using fixed area quadrats (Nowak et al. 2017). A companion, detailed sample of insect pollinator richness and abundance was made in the same plots using a set of measurement techniques, including pan trapping and sweep netting. The focus of the study is on the insect work. Plant work has been reported elsewhere in detail (Nowak et al. 2017).

General Description of Study Site

In 2014, EPRI and FirstEnergy initiated a manipulative field experiment on the Cleveland MetroParks electric transmission line rights-of-way (ROWs) in Northeast, Ohio, to test the effects of vegetation management on invasive, exotic (IE) plant species presence and dynamics Nowak et al. 2017). The experimental area had three replications (as blocks) of three treatments operationally applied to ~1-acre (0.4 ha) areas using herbicides to: 1) remove trees only; 2) remove trees and woody invasives plants; and 3) remove all woody plants. Final vegetation measurements were done concurrent to the sampling of insect pollinators – the focus of this current study and report.[1]

[1] While insects were measured for two years – 2016 and 2017 – only the 2017 data were used in this EPRI final report because the insect observations and changes with vegetation management treatment could be directly related to vegetation conditions.

Experimental Design

Experimental design was a complete randomized block with three blocks and three treatments.

Field Methods

Plant community

Plant community composition, density and structure were described using six 16.7-foot radius quadrats within each treatment plot. Vegetation measurements included the following variables, which were recorded by height class (<6 ft. (<2 m) and >6 ft. (>2 m)): percent cover of plant life form groups; and percent cover of invasive, exotic woody plants by species.

Vegetation conditions were measured on treatment plots in mid-July, 3-years post-treatment.

See Nowak et al. (2017) for more detail on vegetation treatments and measurements.

Insect pollinator assemblages

Insect sampling methods were modeled after previous pollinator research along ROWs (Hopwood 2008; Wagner et al. 2014). The nine plots treated in 2014 and located in the Substation East, Substation West, and Mills Run blocks (Figure 1-1) were sampled in May (5/16/17), July (7/3/17), and September (9/4/17). Sampling was carried out on favorable weather days using pan traps (blue and yellow plastic party bowls) secured to shelving brackets and supported by fiberglass rods. Rods were placed securely in the ground 10 m apart (Figures 1-2 and 1-3) and trap colors alternated. Bowls were filled 1/3 full with soapy water and collected 24–26 hr after deployment (Wagner et al. 2014). Samples were collected within 24-26 hours of deployment. Disposable paint strainers (large mesh size to avoid clogging) were an effective method of filtering insects from pan traps in the field. Date, time of day, temperature, and general weather conditions were recorded at the start and end of the insect surveys. Samples from pan traps were combined to the plot level, regardless of color.

Pan trap sampling was supplemented with a 20 min sweep netting effort, in general carried out by two people sweeping for 10 min, at times documented to be peak daily activity times (Bramble et al. 1997) following methods modified from Wagner et al. (2014) (Figures 1-3 and 1-4).

Insect specimens were frozen upon collection, and later identified to taxonomic ordinal level and then at least down to the family level. When possible, they are identified down to the species level. A representative sample of each insect group was pinned and archived. Captured specimens were considered pollinators if previous literature documented that species ability to transfer pollen. To verify identifications, representative specimens were compared to expertly identified material provided by Cornell University. Voucher specimens were deposited in the State University of New York College of Environmental Science and Forestry insect museum in Syracuse, NY.

Data Analyses

Plant community

Vegetation data 3 years post treatment (coincident with year of insect sampling) were examined with analysis of variance (ANOVA) using a randomized complete block design (n=3 blocks) to quantitatively compare plant community changes associated with the three different treatments. An alpha level of 0.05 was used to judge the level of statistical significance of treatment effects. Fisher's protected least significant difference (LSD) procedure was used for post-hoc comparison between treatments if the overall F-test for the treatment effect was significant for that variable (alpha=0.05).

Insect pollinator assemblage

Pollinator data were analyzed at the family level due to some specimens being difficult to identify to to genus or species (*e.g.*, *Lasioglossum*, and for others this was due to a cold storage malfunction in 2016). A large outlier collection of *Olibrus* spp. beetles (>1500 individuals collected) was omitted from analyses as it was much more abundant than any other group and due to this beetle's size and morphology it is likely not a critical pollinator.

Pollinator abundance for pan traps was standardized to a per plot basis (mean individuals/plot) to account for bowls lost during the 24 hr sampling period (generally due to wildlife).

Analysis of variance (ANOVA) was used to test for differences in pollinator abundance, family richness, Shannon diversity, and Shannon evenness among treatments using the car package in the R statistical programming environment (Fox et al. 2016). When a statistically significant month-by-treatment interaction was observed (alpha=0.15), simple effects were tested in addition to main effects. Shannon diversity was calculated using the function diversity in the vegan package (Oksanen et al. 2013). Evenness was calculated using Evar in the fundiv program (Bartomeus 2013). This measure was used to demonstrate the distribution of abundance among pollinator families; it was chosen because it is independent of the number of families present and has been shown to have no severe problems as a measure of evenness, unlike many other common measures (Smith and Wilson 1996). Post- hoc multiple comparisons were conducted using Bonferonni t-procedure.

Results

Plant community

There were eight woody invasive, exotic (IE) species observed on the study sites, but the dominant woody IE across all plots and treatments was glossy buckthorn, with much lower abundances of multiflora rose and shrub honeysuckles. Total cover of woody IE less than 6-ft (2 m) height ranged from 10 to 35 percent across treatment; over 6-ft (2 m) height the range was 1 to 24%.

Treatments did produce differences in plant community coverage, including variable effects on IEs (as intended – this was the main objective of the treatments – to create variation in IE cover) (see Nowak et al. 2017). In general, the "remove trees only" treatment had relatively high cover of shrubs, short trees and IEs less than 6-ft (2 m) height, and high cover of short trees, trees and

IEs greater than 6-ft (2 m) height as compared to the other treatments (Table 1-2). The other two treatments – the "remove all woody plants" and the "remove tall-growing trees and woody IEs" – produced generally the same type of plant community with lower coverage in woody plant cover as compared to the "remove tall-growing trees only" treatment (one exception: shrub cover was the same between "remove tall-growing trees and woody IEs" and "remove tall-growing trees" treatments) (Table 1-2). Coverage of all other plant life forms – Rubus, woody vines, herb/forb, graminoids, and fern/moss – were not different among treatments (Table 1-2).

Insect pollinator assemblage

A total of 1,451 individual insects were identified as potential pollinators. These individuals were grouped together into four orders, with six families of beetles, six families of flies, seven families of bees and wasps, and one family of butterflies (Table 1-1). The most common families were Apidae (honey bee), Halictidae (sweat bee), Syrphidae (hover fly), and Cantharidae (soldier beetle), together comprising nearly 75 percent of the collected insects (Figure 1-5).

Pollinator assemblages – as measured by abundance, richness, diversity, and evenness – generally was not differ among treatments (Tables 1-3 and 1-4). Pollinator assemblages did differ across months, but that was not the focal interest of the study. A significant month-by-treatment interaction for insects sampling using pan traps was observed for insect abundance sampled through pan trapping. Using simple effects analysis it was observed that the only treatment effect of meaning was that the "remove all woody plants" treatment had higher pollinator abundance than the other treatments, but only in the month of May. This odd effect was due to the high abundance of only three insect families, which indicates that the result was somewhat spurious and not practically meaningful.

Discussion, Interpretation, and Insights

Abundance and diversity of insect pollinators was high, with four orders and 14 families of insects observed across the right-of-way. Honey bees, sweat bees, hover flies and soldier beetles were common representatives of the four most common families, which constituted nearly 75 percent of the insect assemblage. As one of the first studies to included insect pollinators other than bees, results of the current study show that a diverse assemblage of insect pollinators are commonly using electric transmission line rights-of-way.

Vegetation management treatments did create significantly different plant communities, especially in coverage of woody plants and changes in invasive exotics. Yet, insect pollinators assemblages did not change with these changes in vegetation. Apparently, the similarity of plant cover in plants other than shrubs, short trees and trees provided similarity of habitat for the insect pollinators. Key here might be the similarity (non-statistical difference) in cover of herb/forbs across treatments, which averaged 22% for all treatments, ranging from 12 to 28% across treatments.

Future studies of insect pollinator assemblages on ROWs should expand treatment efforts to change pollinator habitat in different landscapes so as to learn how these pollinator assemblages can be affected, positively or negatively, by vegetation management. In the current study, significant changes in the woody plant community did not elicit a response in pollinators – all treatments produced similar pollinator assemblages. It is likely that other treatments would have produced a stronger effect on pollinators. For example, transforming the ROW to plant communities dominated by grasses would certainly change the pollinator assemblage. Increasing the coverage of forbs to might change pollinator habitat. It seems that to really learn how to manage for pollinator, a wide variety of treatments should be tried.

Implications for vegetation managers from the current study are simple: 1) managers should recognize that ROWs can harbor diverse assemblages of insect pollinators, including many species that are not just bees; 2) a variety of treatments can produce vegetation communities that support diverse assemblages of insect pollinators; and 3) invasive exotic woody plants do not seem to have a detrimental effects on insect pollinators (at least in the current study). It is recognized, of course, that these implications are associated with only this one study. ROW vegetation managers must examine the large of body of new information on insect pollinators and ROWs to make informed vegetation management decisions. *One study does not a pollinator vegetation management program make.*

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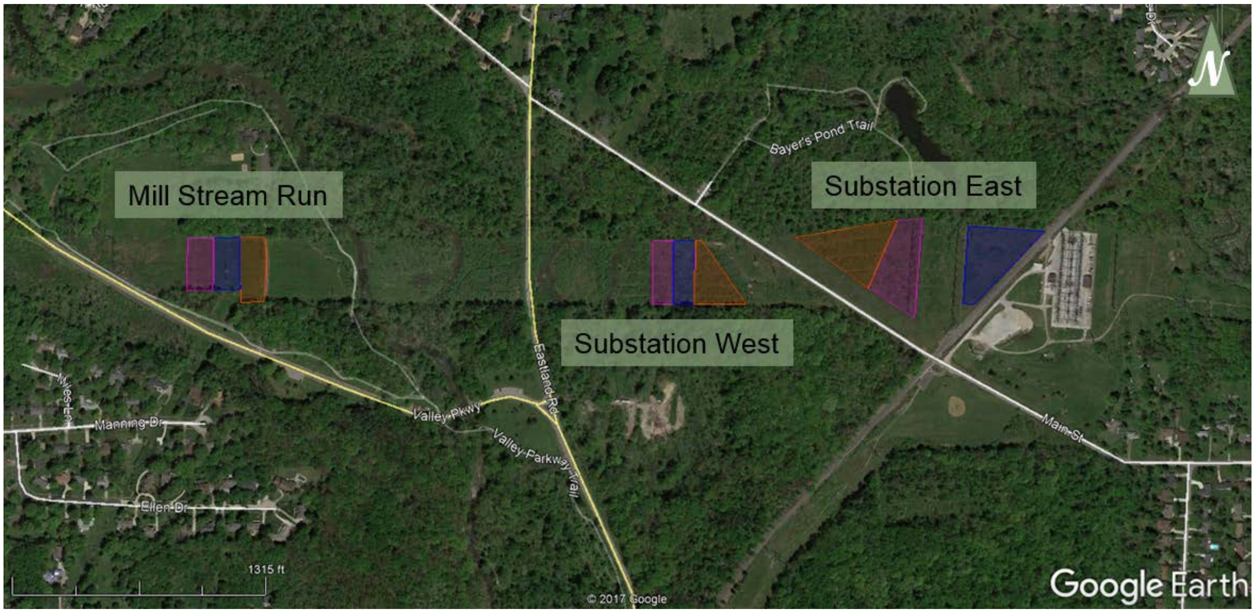

Figure 1-1
Map of the study sites established in 2014 along the FirstEnergy Lorain-Fowles 138 kV right-of-way through Cleveland Metroparks. Within each block are three replicated treatments (Blue – all woody plants removed; Orange – only tall-growing trees removed; Pink – all trees and woody invasive, exotics removed). Base map imagery from Google Earth (2017).

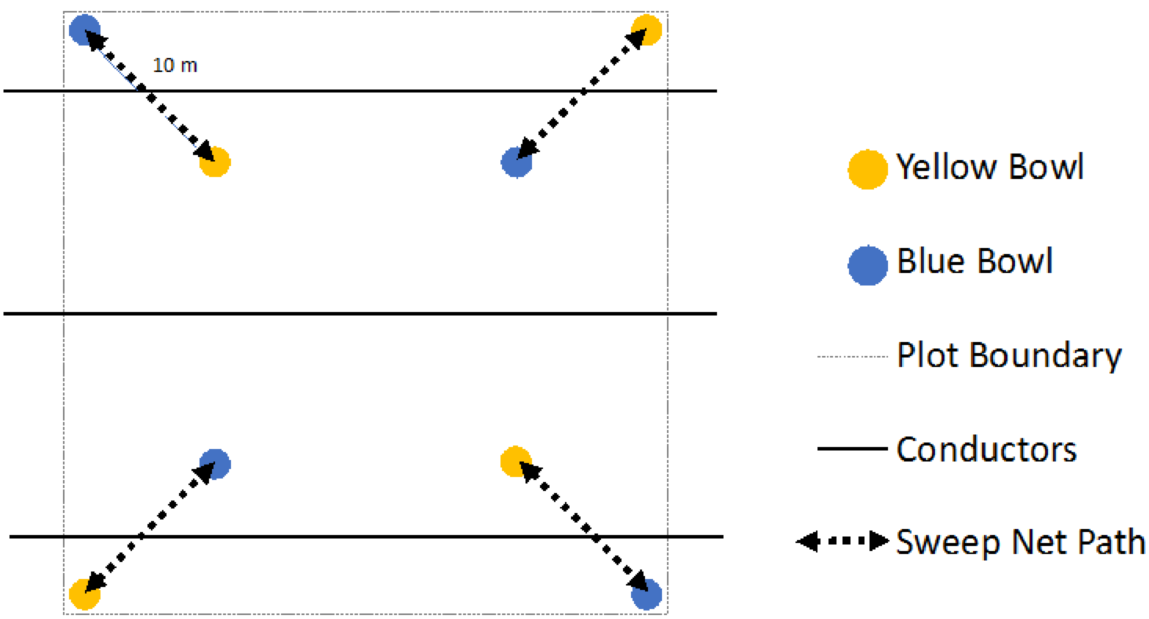

Figure 1-2
Pan traps were placed 10 m apart on the corners of concentric squares and left for 24 hr, while sweep netting was carried out 20 effort minutes between pan setups.

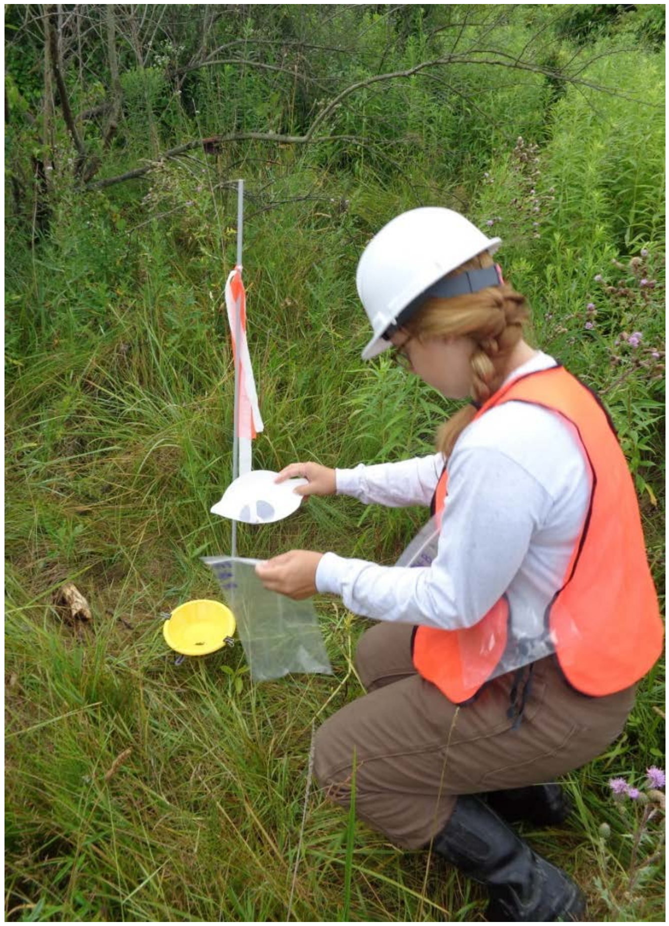

Figure 1-3
Pan trapping on an electric transmission line right-of-way in Ohio; Erica McPhail (M.S. student) filtering a bowl’s content through a paint strainer so that the collected insects can be bagged for storage and laboratory processing. (Photo courtesy of D. Hansen)

Figure 1-4
Sweep netting for insects in summer 2017 on an electric transmission line right-of-way by making passes along lines between pan sample point.

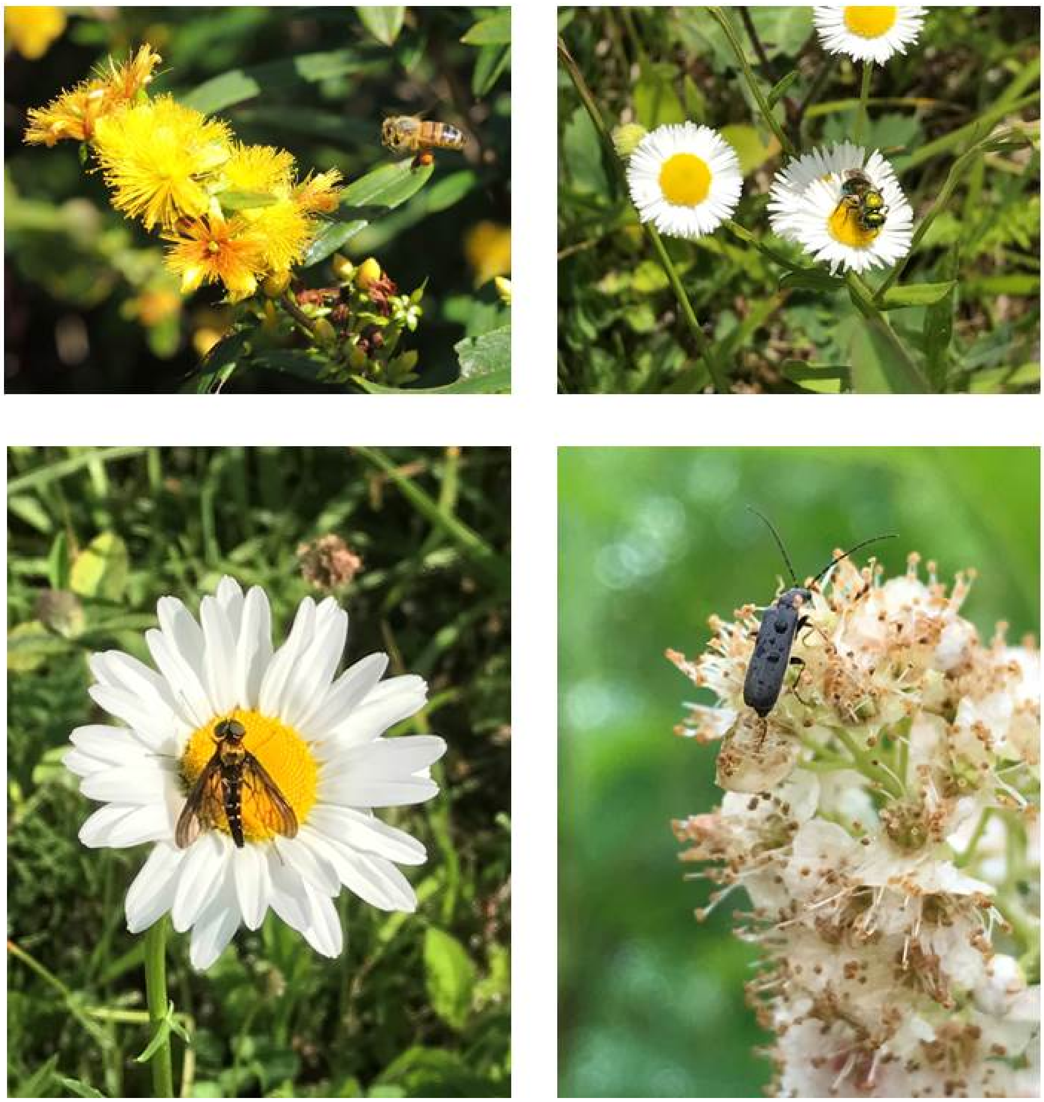

Figure 1-5
Common insects representatives of pollinator families found on electric transmission line right-of-way study sites in Ohio. Upper left: Apidae family (honey bee). Upper right: Halictidae family (sweat bee). Lower left: Syrphidae family (hover fly). Lower right: Cantharidae family (soldier beetle). Photo credits (2017): honey bee from Ben Ballard, and sweat bee, hover fly, and soldier beetle from Jessica Van Splinter.

Table 1-1
List of insect pollinators found in 2017 (May, July and August sampling dates) on electric transmission line rights-of-way in Ohio.

Order	Order Common Name	Family	Family Common Name	Count	Percentage
Coleoptera	Beetles	Cantharidae	solider beetles	137	9.4%
		Chrysomelidae	leaf beetles	3	0.2%
		Curculionidae	snout and bark beetles	5	0.3%
		Lygaeidae	seed beetles	4	0.3%
		Mordellidae	tumbling flower beetles	8	0.6%
		Scarabaeidae	scarab beetles	33	2.3%
Diptera	Flies	Calliphoridae	blow flies	30	2.1%
		Syrphidae	hover flies	403	27.8%
		Tabanidae	horse flies	127	8.8%
		Tachinidae	tachid flies	3	0.2%
		Tephritidae	fruit flies	18	1.2%
		Ulidiidae	picture-winged flies	11	0.8%
Hymenoptera	Bees, Ants, Wasps, and Sawflies	Andrenidae	mining bees	10	0.7%
		Apidae	honey bees, bumble bees, and allies	356	24.5%
		Colletidae	plasterer and masked bees	31	2.1%
		Crabronidae	crabronid wasps	2	0.1%
		Halictidae	sweat bees	252	17.4%
		Megachilidae	leafcutter and mason bees	10	0.7%
		Vespidae	vespid wasps	4	0.3%
Lepidoptera	Butterflies and Moths	Hesperidae	skippers	4	0.3%

Table 1-2
Analysis of variance and treatment means for plant cover by life form and height class.

Main Effects ANOVA of a RCBD Experiment (n=6 blocks)		**ANOVA (p-values)**		**Treatment Mean**		
Response Variable	Size Class	Block (df = 2)	Treatment (df = 2)	Blue	Pink	Orange
Life Form Groups (Percent Cover)		(Error df = 4)				
Tree	<6'	0.13	0.13	0.9	1.4	1.2
	≥6'	0.80	**0.10**	**0 b**	**0.1 b**	**0.7 a**
Short Tree	<6'	0.13	**0.09**	**10.2 b**	**11.8 b**	**32.4 a**
	≥6'	0.29	**0.02**	**1.2 b**	**1.7 b**	**22.0 a**
Shrubs	<6'	<0.01	**0.02**	**6.9 b**	**14 a**	**13.6 a**
	≥6'	0.19	0.18	1.2	15.4	24.2
Rubus	<6'	0.31	0.91	4.4	5.6	5.7
	≥6'	0.67	0.67	0	0.2	0.3
Woody Vines	<6'	0.30	0.66	0.3	0.4	0.8
	≥6'	0.44	0.44	0	0	1
Herbs+Forbs	<6'	0.15	0.39	27.8	26.3	12.4
	≥6'	0.44	0.44	0	0	0
Graminoids	<6'	0.02	0.20	46.2	36.4	28.1
	≥6'	0	0	0	0	0
Ferns+Moss	<6'	0.06	0.53	1.3	2.4	2.4
	≥6'	0	0	0	0	0
Woody Inasive Exotics	<6'	0.10	**0.07**	**10.5 b**	**14.1 b**	**35.2 b**
	≥6'	0.26	**0.01**	**1.4 b**	**1.9 b**	**23.8 a**

Table 1-3
Analysis of variance source of variation tables from testing treatment and month effects on insect pollinator abundance and diversity.

		Sweep Nets			Pan Traps		
		df	**F value**	**p-value**	**df**	**F value**	**p-value**
Abundance	Block	2	2.38	0.12	2	2.38	0.12
	Treatment	2	0.07	0.93	2	3.33	**0.06**
	Month	2	1.67	0.22	2	13.85	**< 0.001**
	Treatment:Month	4	0.24	0.91	4	2.08	**0.08**
	Error	16			16		
Richness	Block	2	0.68	0.52	2	3.15	0.07
	Treatment	2	1.35	0.29	2	1.32	0.30
	Month	2	7.29	**0.006**	2	27.72	**< 0.001**
	Treatment:Month	4	1.11	0.39	4	0.09	0.98
	Error	16			16		
Diversity	Block	2	3.7	0.05	2	1.13	0.35
	Treatment	2	0.61	0.56	2	1.34	0.29
	Month	2	8.63	**0.003**	2	13.46	**< 0.001**
	Treatment:Month	4	0.73	0.58	4	0.08	0.99
	Error	16			16		
Evenness	Block	2	0.09	0.91	2	0.39	0.68
	Treatment	2	0.14	0.87	2	2.12	0.15
	Month	2	1.25	0.31	2	15.38	**< 0.001**
	Treatment:Month	4	0.39	0.82	4	0.98	0.45
	Error	16			16		

Table 1-4
Treatment and month means for insect pollinator abundance and diversity.

	Treatment	Month	Abundance (insects / sample)	Family Richness	H' Diversity	E_{var} Evenness
Sweep Nets	Remove all woody plants	May	33.7	5.7	1.10	0.50
		July	41.3	9.3	1.80	0.54
		September	33.3	3.3	0.79	0.37
	Remove tall-growing trees and woody IEs	May	17.7	5.0	1.00	0.74
		July	44.0	5.3	1.20	0.47
		September	36.7	3.7	0.89	0.46
	Remove tall-growing trees	May	19.3	3.7	0.96	0.66
		July	53.7	7.0	1.50	0.54
		September	38.7	3.7	0.76	0.45
Pan Traps	Remove all woody plants	May	71.0	7.0	1.40	0.37
		July	14.3	3.3	0.88	0.61
		September	2.3	1.3	0.34	0.96
	Remove tall-growing trees and woody IEs	May	29.3	7.7	1.60	0.60
		July	11.3	4.0	1.10	0.78
		September	6.0	2.7	0.74	0.89
	Remove tall-growing trees	May	22.3	6.7	1.50	0.58
		July	6.7	2.7	0.83	0.86
		September	2.3	1.7	0.42	0.94

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