The Bees of Rushton Farm: A Pollinator Perspective on Sustainable Agriculture

"What escapes the eye is the most insidious kind of extinction – the extinction of interactions"
D. Janzen

Benjamin Reynard

Independent Study

Yvette Bordeaux, PhD

University of Pennsylvania

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Abstract

Pollination services provided by bees are essential in the reproduction of plants, ecosystem vitality and food security, and should be viewed as elemental to conservation. While farming practices have been evolving gradually in the U.S. for roughly 200 years since the British-inspired agricultural revolution of the mid-1800's, a drastic shift has occurred since 1940--when a WWII fueled economy upgraded its farming methods with conversion from animals to machinery, along with a large increase in application of fertilizers, and the advent of synthetic organic pesticides (such as DDT) in a process of "agricultural intensification,"--accounting for the "25 year period between 1950 and 1975 when agricultural productivity changed more rapidly than at any other time in American history" (Trautmann, 1985). Because much of the U.S. agriculture output has been consolidated onto large-scale, conventional family farms (U.S. Department of Agriculture, 8/1/12), commercial farms have become heavily reliant on synthetic fertilizers and pesticides (Horrigan, 2002). As a result, researchers have come to realize that certain commonly used pesticides may be contributing to the decline of bees, negatively impacting their ability to provide important pollination services. With greater understanding of the role of bees within the ecosystem as well as the functions they facilitate, large-scale agricultural operations may be motivated to adapt their production practices to be more sustainable in ways that will protect native pollinators and safeguard the essential pollination services they provide. Programs to introduce and nurture native bees should receive more consideration from land managers, farmers, policy makers, and other land stewards when deciding the best use of agricultural lands. ***Sustainable farming has the capability to restore, protect, and enhance pollination networks between plants and animals, and extends beyond individual species conservation to a more interconnected, landscape level, conservation paradigm.***

Keywords: **Native Bees, Pollinators, Ecosystem Services, Sustainable Agriculture, Colony Collapse Disorder, Neonicotinoid Pesticides, Biodiversity Conservation**

Introduction

Currently, little is known about the diversity, abundance, and richness of native pollinators (which are primarily bees) at the landscape level due to a lack of data. Thus, this independent project aimed to conduct a bee survey at a sustainable farm in order to develop a baseline of the number and type(s) of native bees found there. This data will be useful to track changes over time as to the number of native bees found in the landscape, with the goal ultimately being to protect and conserve native pollinator diversity and abundance. The bee survey results may also be used to support a proposal for enacting a pesticide-free zone in the area around the sustainable farm, since the landscape is connected in a broader sense by the bees' pollination services, the floral resources available (and pesticides used for that matter), and nesting habitats found within a bee's foraging range.

Bee Study

A pilot bee survey was conducted at the sustainable farm with the help of USGS Bee expert Sam Droege in order to assess and monitor richness, abundance and diversity of the native bees at the site. The data obtained is beneficial in establishing a pollinator baseline for the area. Such studies of pollinator abundance provide a "biologically meaningful measure of change in the native bee communities of the U.S." (Droege, 2011) and also form the basis to begin quantifying the value of pollinator services.

The bee study at Rushton Farm sampled flying insects caught in glycol pan traps placed at three separate sites around the sustainable farm. Sam Droege, from the

USDA Bee Laboratory in Beltsville, MD, offered a great deal of assistance with the design of the study, in terms of how to construct and deploy the traps, answering general questions, and also was kind enough to offer to teach the author how to identify and classify bees in the lab. Pollinator specimens were collected ten times from the pan traps between 5/17/12 and 8/28/12 and stored in refrigerated Whirl Packs in an Alcohol solution. Netting was also conducted on 7/13/12. GPS mapping and GIS digitization of the test site were carried out on 6/8/12 using a Trimble GeoExplorer (see Figure 1). The collected bees were sent off to the USGS Bee Inventory and Monitoring Lab in Beltsville, MD where Sam Droege oversaw the identification and pinning (see Table 1).

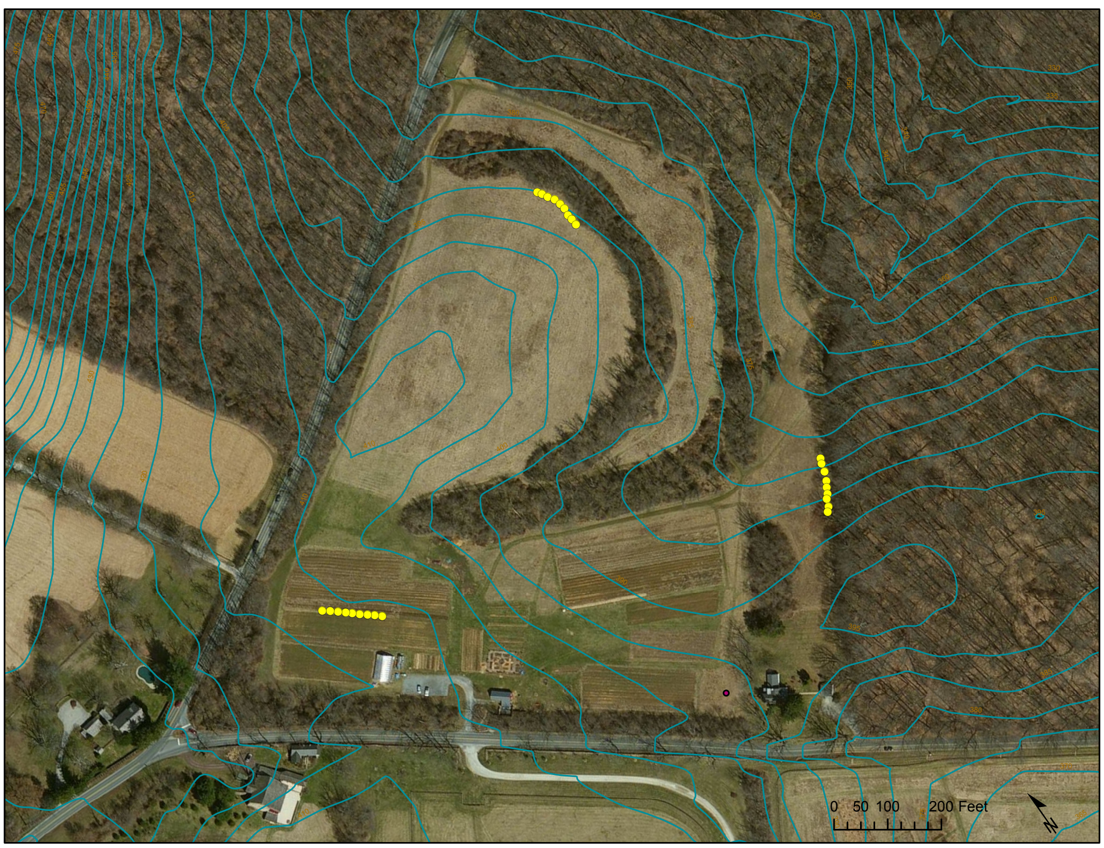

Figure 1. Bee Survey at Rushton Farm. Glycol Pan Traps deployed in 3 areas around the farm. Locations, surveyed with Trimble GPS device and mapped in ARCGIS, include: amongst crops, near Rushton Woods, along a hedgerow.

Species Name	Count of name
	1
Agapostemon virescens	6
Andrena cressonii	2
Andrena nasonii	5
Andrena perplexa	2
Anthidium oblongatum	1
Apis mellifera	41
Augochlora pura	17
Augochlorella aurata	5
Augochloropsis metallica	3
Bombus auricomus	1
Bombus bimaculatus	9
Bombus fervidus	2
Bombus griseocollis	6
Bombus impatiens	15
Calliopsis andreniformis	5
Ceratina calcarata	27
Ceratina dupla	1
Ceratina strenua	3
Colletes thoracicus	1
Eucera hamata	16
Halictus confusus	4
Halictus ligatus	12
Hoplitis producta	1
Hylaeus affinis/modestus	2
Lasioglossum bruneri	5
Lasioglossum callidum	1
Lasioglossum coriaceum	2
Lasioglossum cressonii	4
Lasioglossum hitchensi	7
Lasioglossum illinoense	1
Lasioglossum imitatum	2
Lasioglossum pilosum	1
Lasioglossum platyparium	1
Lasioglossum quebecense	4
Lasioglossum rubicundus	1
Lasioglossum subviridatum	4
Lasioglossum taylorae	2
Lasioglossum tegulare	2
Lasioglossum trigeminum	1
Lasioglossum versatum	12
Lasioglossum weemsi	1
Megachile frugalis	2
Melissodes bimaculata	3
Melissodes desponsa	3
Melissodes trinodis	5
Melissodes trinodis?	1
Nomada bidentate_species_group	1
Nonbee	34
Osmia pumila	1
Peponapis pruinosa	18
Triepeolus remigatus	1
Grand Total	308

Table 1. Bee Survey data from Rushton Farm. 49 different species of bees were identified amongst the crops, woods, and hedgerow/meadow of Rushton Sustainable Farm in Delaware County, PA (Lat. 39.9841, Long. -75.4881).

Agricultural Intensification

From an environmental stewardship perspective, the U.S. food system is producing inefficiently and unsustainably with numerous negative external costs arising from over-dependence on conventional commercial agriculture practices which degrade the landscape and deplete natural resources. Numerous naturally occurring ecological services are being eroded by conventional large-scale agriculture as the result of habitat degradation and fragmentation along with the introduction of pollution via pesticides and fertilizers. Native pollinators, and bees in particular, provide a great deal of unseen ecological value both directly, and indirectly, through the pollination services they provide. Despite gains in yield productivity (Keystone Alliance for Sustainable Agriculture, 7/12/12), large-scale commercial agriculture practices commonly produce negative environmental externalities due to the (over)use of: genetically modified crops, fertilizers and pesticides, and the resulting soil degradation, biodiversity loss, water shortages from over-irrigation or inappropriate crop selection, habitat fragmentation, and greenhouse gas emissions. Modern systemic pesticides, and the Neonicotinoids in particular, are beginning to gain more notoriety for their potential links to pollinator declines.

Pesticides

Recent scientific studies conducted in Europe and the U.S by Henry, Whitehorn, and Krupke published in 2012 have found links between a specific type of pesticide that impairs bees' ability to return to their hive, and also impacts bee reproduction. This type of pesticide has been banned in Europe, but is still being used in the U.S. where it is found in 94% of the U.S. corn, or on U.S. farmland totaling an estimated 142 million acres (PANNA report, 8/12/2012). Large-scale commercial agriculture has become dependent on genetically modified crops and the pesticides that have been engineered into the plants. Imidacloprid, the first of these new systemic insecticides, called Neonicotinoids, entered the market in 1991, and is now the number one selling insecticide in world. More evidence is emerging that the Neonicotinoids are harming bees and could very likely be a factor the Colony Collapse Disorder noticed by U.S. beekeepers since 2006.

Pollinator Declines

The global decline of pollinators has been extensively written on, and while it is difficult for scientists to precisely say what is causing the decline, it is agreed upon that numbers of pollinators have fallen around the globe and at an alarming rate. Evidence points to a combination of multiple environmental factors contributing to the bees' decline. Colony Collapse Disorder is a specific term used to describe what is now viewed as a global pollinator decline (Murray, 2009) (Paxton, 2009) (Pettis, 2012) (Krupke, 2012).

Pollinators are very important for food security. One of every three bites of food we eat is the result of a pollinator: "According to the National Academy of Sciences, close to 75 percent of flowering plants on the earth rely to some degree on pollinators in order to set seed or fruit, and from these plants comes one-third of humankind's food and even greater proportions of the food for much of our wildlife" (Attracting Native Pollinators, 2011, p. 3). Estimates of the economic valuation of pollinator services globally ranges widely from 112 to 200 billion annually (Kremen, 2007). Threats, stressors, and limiting factors include habitat loss and fragmentation, invasive species, pesticides, parasites, and climate change (Brown, 2009).

Attracting and Protecting Native Pollinators

Native pollinators have been found to be capable of providing pollination services for crops that had previously been pollinated by commercial honey bee colonies and a study by Winfree (2008) of wild bee pollination found that wild bees provide the majority of crop visitation for the study areas in New Jersey and Pennsylvania and the study suggested that maintaining diverse bee communities can provide more complete pollination services, thus increasing plant productivity (Winfree, 2008) (see Figure 2).

Figure 2. Various Native Bees (Pollinator Partnership)

Over the course of growing season at Rushton Farm it became apparent that sustainable agriculture benefits native pollinators, and vice-versa. **These farming techniques benefit pollinators in many ways, but most importantly by bypassing fertilizers and pesticides.** Floral resources are provided by the diversity of plants found in organic and sustainable farms, which tend to be smaller and grow a wider variety of crops than in large-scale commercial monocultures. Just as sustainable farming supports pollinators, so too do pollinators support sustainable farming by providing pollination services which allow crops to thrive and eliminate “pollination deficits.” “Research suggests that where honey bees are absent, canola growers in Alberta, Canada, make more money from their land if 30 percent is left uncultivated, as natural habitat. This habitat supports populations of native bees close to fields, which increases bee visits and seed production in the adjacent crop” (Attracting Native Pollinators, 2011).

Sustainable Agriculture/Organic Agriculture

Sustainable farming and community supported agriculture offer a responsible alternative to large-scale, unsustainable, industrial agriculture by working to better manage the landscape and act as more of a steward instead of strictly a producer. Throughout the course of the 2012 growing season on the six-acre sustainable farm, through a comprehensive literature review, and through classroom study of pollination biology, the author was able to observe numerous land-stewardship and sustainable agriculture best practices which have been established, and the important, but often overlooked, pollinator services provided by bees at Rushton Farm (see Figure 3).

Figure 3. Rushton Farm. A model sustainable farming operation, and a prime example of an agro-ecosystem which has improved pollinator-plant linkage, is located approximately 20 miles west of Philadelphia in Willistown Township, Chester County, Pennsylvania. The Willistown Conservation Trust--a champion of open space preservation, protection, and resource management--established the six acre sustainable Rushton Farm in 2008 on the site of a former fox hunting preserve (Willistown Conservation Trust: http://www.wctrust.org/?page_id=91)

Organic and sustainable farming methods have been evolving alongside conventional agriculture by working to enhance the soil naturally. Whereas the latter aims to maximize yields per acre, sustainable agriculture seeks to work within and improve the local landscape:

> The underlying principles of organic agriculture revolve around land stewardship, and USDA's regulatory standards define organic production as a system that responds "to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity" (U.S. Department of Agriculture, 8/1/12).

Sustainable agriculture and organic farming are synonymous in many ways, and these farming systems differ in many regards from large-scale commercial agriculture in regard to (from Organic Farming Research Foundation: Organic Farming for Health and Prosperity Report, August 2012 edition):

- Crop rotation--Enhances soil quality, disrupts weed, insect, and disease life and cycles and sequesters carbon and nitrogen, diversifies production

- Manure, compost, green manure use--Enhances soil quality, sequesters carbon, recycles nutrients, and contributes to productivity
- Cover cropping--Enhances soil quality, reduces erosion, sequesters carbon and provides nitrogen, prevents dust (protects air quality), improves soil nutrients, contributes to productivity
- Avoidance of synthetic fertilizers--Avoids contamination of surface and ground waters, enhances soil quality, sequesters carbon, mitigates salinization
- Avoidance of synthetic pesticides--Enhances biodiversity, improves water quality, enhances soil quality, prevents disruption of pollinators, reduces costs of chemical inputs
- Planting habitat corridors, borders, and/or insectaries--Enhances biodiversity, supports biological pest management, provides wildlife habitat
- Buffer areas--Improves water quality, enhances biodiversity, prevents wind erosion

"Farmers are the largest group of ecosystem managers on the earth" (Organic Farming Research Foundation, 2011). Sustainable agriculture and organic farming "are systems of management that prioritizes health with productivity" (Organic Farming Research Foundation, 2011). Agro-ecology is defined as:

> The application of ecology to the design and management of sustainable agroecosystems. A whole-systems approach to agriculture and food systems development based on traditional knowledge, alternative agriculture, and local food system experiences. Linking ecology, culture, economics, and society to sustain agricultural production, healthy environments, and viable food and farming communities (Agroecology, 8/12/2012).

Rushton Farm represents a model agro-ecosystem and offers many lessons on sustainability. This independent project offered an excellent case study to illustrate the links between sustainable agriculture, agro-ecology, pollination and ecosystem services, and the importance of protecting and restoring plant-pollinator networks. By focusing on pollination and examining Rushton Farm, one can see the potential for pollinator conservation as a tool to positively affect biodiversity conservation at the landscape level.

Conclusions and Recommendations

During this project: through literature review; work at the sustainable farm; consultation with bee scientists on pollinator sampling; accompanied with classroom study, “Introduction to Pollination Biology,” instructed by Dr. Tatyana Livshultz at the Wagner Institute of Free Science, it became apparent that pollination conservation presents a new model for protecting the landscape, and it so happens that sustainable farming practices offer optimal protection for native bees and their crucial pollination services. Sustainable farming has the capability to restore, protect, and enhance pollination networks between plants and animals, and extends beyond individual species conservation to a more interconnected, landscape level, conservation paradigm. Noted conservation biologist Dr. Claire Kremen, from Berkley University, views pollination provided by managed and native bees as an ecosystem service (Kremen, 2007). In Kremen’s conceptual framework, bees are viewed as “Mobile Agent Based Ecosystem Services (MABES)” (Kremen, 2007). Pollinator restoration and “conservation of interactions” are emerging fields in conservation biology which are conditional on the pollination services provided by bees. Through the work of Kremen and others, we are learning how restore, protect, and enhance pollinator ecosystem services with proper land management, foresight, proactive policies, and incentives. Since pollinator conservation and restoration are emerging as methods for quantifying and protecting ecosystem services, and since Rushton Farm could be viewed as an example of a restored pollinator network or system, a case study emerges to show how "management at the local scale can have profound effects on the diversity of pollination interactions at the landscape scale" (Dixon, 2011). By focusing on, and protecting the pollinators, which serve as a keystone and indicator species, this independent project demonstrates the potential for sustainable agriculture to provide a framework for pollinator conservation and habitat protection wrapped into one. The U.S. Farm Bill, expected to appropriate over 500 billion dollars in agricultural related spending (Audubon.com) is up for renewal in 2013. This piece of legislature needs to put greater emphasis on pollinator protection and restoration and incentivize U.S. farmers to do the same.

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Figure 1: Join the Conversation about Native Bees Poster, Pollinator Partnership, http://www.pollinator.org/PDFs/Identifying_Native_Bees_PosterFINAL.pdf, 7/14/12.

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Additional Figures from Bee Study

Figure 4. A Glycol Pan Trap, over 30 of which were constructed and deployed (photo by author)

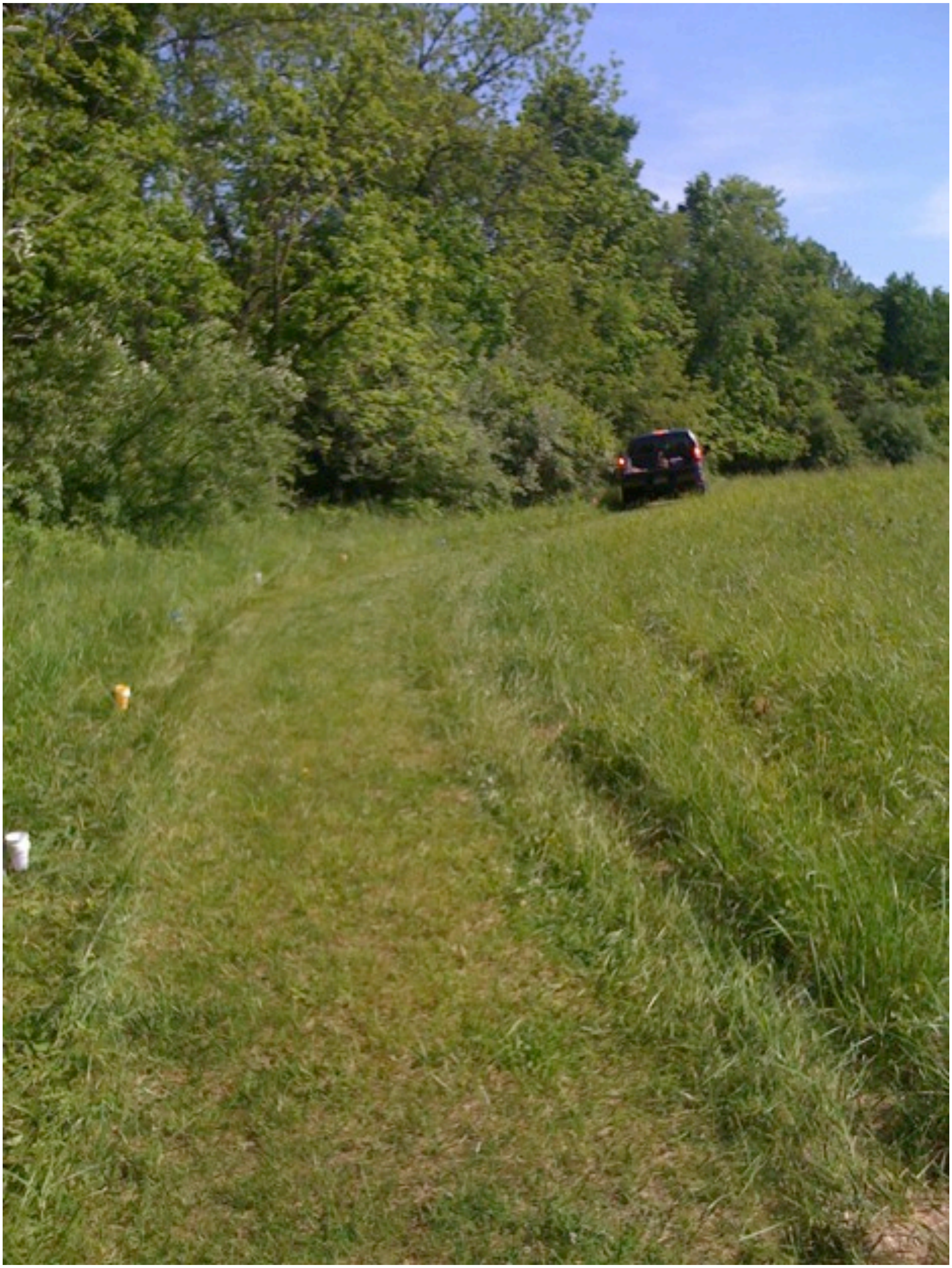

Figure 5. Hedgerow/Meadow Glycol Pan Trap Array at Rushton Farm (photo by author)

Figure 6. Growing Field Glycol Pan Trap Array at Rushton Farm (photo by author)

Figure 7. Rushton Woods Glycol Pan Trap Array at Rushton Farm (photo by author)