Using Butterfly Citizen Science to Increase Participation in Conservation

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Abstract

The use of citizen science in the field of conservation has expanded rapidly recently; with that expansion has come a heightened awareness of the role that citizen science can play in conservation beyond providing large-scale data. Here, I explore butterfly citizen science projects in the United States and the conservation outcomes produced by butterfly citizen science volunteers. Chapter 1 explores the current state of conservation education among butterfly citizen science projects. Chapter 2 surveys volunteers from multiple projects to determine the conservation actions in which they engage, how their participation in conservation has changed over time, and the volunteer and project characteristics that are correlated with those changes. Chapter 3 addresses the potential for citizen science volunteers to create and maintain habitat as a direct component of their participation in a project, and to engage in other forms of conservation outside of a project; this chapter also compares the conservation actions of citizen scientists to those of habitat conservation volunteers. Finally, Chapter 4 applies the findings of the first three chapters to an evaluation of the conservation education programming of the Monarch Larva Monitoring Project. Taken together, the results of this work clearly indicate that 1) butterfly citizen science projects are using a number of different methods to inform their volunteers about conservation and encourage their participation in conservation actions, 2) citizen science volunteers are actively participating in habitat conservation and conservation outreach, and 3) volunteers' participation in conservation increases after joining a citizen science project. Throughout the dissertation chapters, I provide recommendations to project managers for promoting conservation actions among volunteers.

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Introduction

When I joined the Conservation Biology Graduate Program in the fall of 2012, I came with a solid interest in citizen science and an extremely optimistic understanding of the field and how it intersects with conservation biology. My initial interest was fueled by the perspective that citizen science had benefits for everyone: professional scientists expanded the size and scope of their research through the power of volunteers, educators used citizen science as a tool to increase science and environmental knowledge, and the citizen scientists themselves gained knowledge, skills, and experience. Citizen science wasn't just a win-win; it was a win-win-win!

My original intention was to study citizen science as a tool for science and conservation education. The majority of the research that has been done to date on the impacts of citizen science on conservation has addressed the capacity of citizen science to contribute large or difficult-to-produce datasets, with a much smaller portion focused on the potential for citizen science to influence knowledge, attitudes, and behaviors. I view knowledge and attitudes related to conservation primarily as influences for conservation actions and behaviors, and as a result decided to focus my work primarily on behaviors and the conservation outcomes they generate.

Research into the conservation behavior outcomes of citizen science was minimal when I began my dissertation, and despite joining the field at a time of unprecedented growth, inroads into our knowledge of this area have remained limited. Most of the studies that have been done on how citizen science can influence participation in conservation look at the results of individual projects, all of which differ extensively, making it difficult to compare results and draw conclusions across studies. With this in mind, I designed the first and second chapters of my dissertation to compile data from multiple citizen science projects, allowing me to look for specific characteristics of volunteers and projects that could influence conservation outcomes. These chapters, as well as the work done by others in the field of citizen science, focused on citizen science volunteers becoming involved in conservation outside their participation in a citizen science project. However, I also wanted to address the potential for volunteers to be

directly contributing to conservation through their participation with a citizen science project. That is the focus of my third chapter, which also compares the conservation actions of citizen science volunteers to habitat volunteers, who are more traditionally acknowledged as playing a direct role in conservation. In my fourth chapter, I used the results of my work, as well as the findings of other studies, to inform an evaluation of the Monarch Larva Monitoring Project, a citizen science project based at the University of Minnesota. As a whole, my dissertation explores how citizen scientists take action to contribute to conservation and what project managers can do to promote conservation actions among their citizen science volunteers.

Chapter 1: Butterfly citizen science projects support conservation activities among their volunteers[1]

Introduction

Citizen science is an increasingly common conservation tool, with volunteers playing a key role in biological monitoring (e.g.,Devictor et al. 2010; Dickinson et al. 2012). However, nature-based citizen science has the potential to play an even larger role in conservation by educating and encouraging volunteers to engage in conservation activities outside of their citizen science projects. Many citizen science programs study or directly combat conservation concerns, making conservation education and the promotion of conservation actions a natural part of training and educating volunteers.

Volunteers can play a number of roles in citizen science, ranging from data collectors to project creators and administrators, depending on both the project and the individual (Bonney et al. 2009). Here, we primarily focus on the education and engagement of volunteers outside the project leadership structure, such as those who collect and report data. Figure 1 depicts the ways that nature-based citizen science projects can influence their volunteers' transition from participating in citizen science (left box) to engaging in conservation actions outside the project (right box). First, there are three key ways in which volunteers can interact with a project (left box). For many volunteers, the primary interaction with their citizen science project is through collecting and submitting data. Additionally, many projects offer initial or periodic training events, either in person or via print and online materials. Projects can also provide their volunteers with educational content that is not strictly related to data collection or training; project websites, newsletters, handouts, and lectures can all be used in this manner. When volunteers interact with a citizen science project in any of these ways, there are opportunities to promote additional engagement in conservation outside the project activities, either by increasing volunteer knowledge and skills (top box) or by influencing volunteers via social factors (bottom box).

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Previous research into environmentally responsible behavior suggests that knowledge of conservation threats, while important, will not alone guarantee conservation action (reviewed in Kollmuss & Agyeman 2002). Rather, as depicted in Figure 1 (top box), an understanding of conservation action strategies and the development of action skills through experience are also necessary (see meta-analysis in Hines et al. 1987; Jensen 2002). Social factors such as personal appeals (direct requests for people to make a change), positive feedback, and behavioral incentives (bottom box) can influence the transition from being knowledgeable about an environmental issue to engaging in conservation actions (reviewed in Kollmuss & Agyeman 2002). Social norms can also affect actions and behavior (see meta-analysis in Bamberg & Möser 2007) and small groups of people who regularly interact can form their own social norms (e.g.,McDonald et al. 2014). Figure 1 does not include factors outside of the project's control that might influence their volunteers' engagement in conservation, such as initial motivation or self-efficacy.

While citizen science seems primed to serve as a powerful tool in conservation education, there is only limited evidence that citizen science participants increase their engagement in conservation outside of their participation in citizen science activities. Over half of the 45 surveyed participants in Neighborhood Nestwatch, a citizen science project that observes bird nests, indicated they had changed their backyard behavior, for instance by making habitat improvements, after participating in the program (Evans et al. 2005). In Jordan et al.'s (2011) survey of 33 volunteers in an invasive species project, two thirds of the participants had changed their behavior related to invasive plants after their involvement with citizen science, with most behavior changes classified as passive, such as talking to others about invasive plants. Another study revealed that stream monitoring volunteers' participation in actions related to water quality increased with the length of time they had monitored; although again, the most commonly reported activities, reading and talking about water issues, could be considered passive (Overdevest et al. 2004).

While this small group of studies explicitly examined the conservation outcomes of participating in specific citizen science projects, there has been no systematic

assessment of the outcomes of conservation-focused education and outreach in citizen science, nor what specific strategies are being used. Here, we examine butterfly citizen science projects and the steps they are taking to educate their participants about conservation and invoke pro-conservation actions beyond engagement in citizen science. The general nature of the threats and action strategies involved in butterfly conservation, along with the popularity of butterfly citizen science, suggests that this case study is relevant to many nature-based citizen science projects, regardless of the taxa on which they focus.

Like many taxa, butterflies are facing serious conservation threats. Global climate change, habitat loss due to development and pesticide-induced loss of host and nectar plants, and disease have all been suggested as threats to butterfly populations (e.g.,McLaughlin et al. 2002; Bartel et al. 2011; Preston et al. 2012; Pleasants & Oberhauser 2013). These issues are not unique to butterflies. Climate change and habitat loss are common issues in conservation in general (Thomas et al. 2004; Lawler et al. 2006), and disease is often cited as a conservation concern (reviewed in Smith et al. 2009). To ameliorate these threats, members of the public are encouraged to engage in habitat conservation and creation by planting and maintaining native nectar and host plants, eliminating pesticides, and using other butterfly-friendly gardening strategies (Monarch Watch 2015; Vaughan n.d.). Others engage in conservation education and outreach activities (Oberhauser & Prysby 2008) and make financial donations. Habitat creation and protection, education, and financial donations are applicable conservation strategies for a variety of situations.

Many members of the public contribute citizen science data on the abundance, distribution, and infection by disease and parasites of butterflies (Breed et al. 2013; Ries & Oberhauser 2015). The conservation concerns facing butterflies and the active public involvement in butterfly citizen science present a problem and a possible solution. Citizen science projects can educate their participants about relevant conservation threats and strategies to mitigate those threats, and actively encourage conservation behaviors among their volunteers. By providing information about conservation threats and individual conservation strategies, offering an opportunity to develop hands-on

conservation skills, and using social factors to encourage conservation, these projects have the potential to invoke conservation actions among their volunteers.

We used an online questionnaire of citizen science project leaders and an inspection of project websites to census and assess the current state of butterfly citizen science projects' conservation education. We determined the degree to which butterfly citizen science projects are educating their volunteers about butterfly-related conservation issues and using social factors to encourage engagement in conservation activities outside the project.

Methods

Online Census of Project Leaders

We compiled a list of 28 butterfly-related citizen science projects in the United States. Projects were found through the website SciStarter (scistarter.com), which provides a database of hundreds of citizen science projects, and a Google search using the keywords "butterfly citizen science" and "butterfly monitoring" on July 19, 2013. The Google search was restricted to the first 100 results. No additional projects were found after the first 50 search results, suggesting that our list included all the butterfly citizen science projects in the United States. We emailed the leaders of the 28 projects and asked them to complete an online questionnaire that had been created in Qualtrics. The initial email request was sent on October 29, 2013, and we sent a second request on November 12, 2013. The questionnaire was closed on December 16, 2013.

The questionnaire contained questions about project characteristics, as well as about strategies and activities that could promote conservation activities among volunteers (Appendix 1). We provided lists of key threats to butterfly conservation and actions that could be used to ameliorate those threats and asked respondents if, and through what media, they provided their volunteers with information on those topics. We also included a series of questions about social factors that could potentially influence participation in conservation. We asked if volunteers were encouraged to engage in conservation activities outside their project. To determine the extent to which personal appeals, positive feedback, and incentives were used to encourage conservation, we

provided a list of strategies and asked respondents to select the ones they used. Finally, we asked questions designed to gauge if and how respondents attempted to create a sense of community among their citizen science volunteers and if they believed that their volunteers felt a sense of community as a result of their participation in the project. In an open-ended question, respondents were asked to describe how they fostered a sense of community among volunteers. We asked respondents if they provided volunteers with resources to help them contact one another, if their volunteers worked in groups, and how large those groups were. The University of Minnesota IRB Human Subjects Committee declared this research exempt from ethical review.

Organization Websites

Of our 28 butterfly-related projects, 25 had websites. We visited these websites on August 19-21, 2013 and recorded the basic information listed about the project's focus, scope, and activities, as well as what butterfly conservation threat and action strategy information was provided. When a reference to conservation threats or action strategies was found on a website, we labeled the occurrence as either having simply mentioned the topic or providing actual information on the topic. We also recorded if a website provided information on events or activities that would allow participants to engage in conservation and develop their conservation action skills, such as a day spent planting a butterfly garden. There was not complete overlap between the projects that responded to the survey and the projects that had websites; as a result, there are some differences between the two datasets.

Because our study was designed as a census, meaning we attempted to collect data on all citizen science projects focused on butterflies in the United States, rather than sampling a subset, it would be inappropriate to use inferential statistics to analyze our data. Instead, we rely on descriptive statistics to provide an in-depth examination of the conservation education programming of the projects.

Results

Online Census of Project Leaders

Basic Project Information

Twenty-three project leaders responded to the questionnaire (82%). One respondent completed less than five percent of the questions; this response is not included in data summaries or analyses. The remaining 22 respondents (79%) viewed the entire questionnaire, but not all questions were answered by each respondent. Questionnaire completion for these respondents ranged from 84 to 100% (mean=97%, SD=4.7).

Exactly half of respondents represented monarch citizen science projects, and half represented general butterfly projects. Most (64%) projects were local (within one state), 9% were regional (within several states), 9% were national (within most or all of the United States), and 18% were international. All but one project reported an affiliation with a larger organization or institution, and some were affiliated with multiple organizations. Most (73%) were affiliated with a nonprofit organization, 45% with a college or university, 23% with a park or nature center, and 9% with a government agency.

The projects had been in existence from 1.5 to 27 years (mean=12.9, SD=8.0). The number of volunteers in projects ranged from fewer than 10 to 10,000, with some respondents unable to accurately estimate their number of volunteers. The number of months during which volunteers participated with the project each year was variable, with some projects relying on volunteers for less than one month and others for all 12 months.

The projects used a variety of data collection activities: 73% involved repeated butterfly monitoring, 68% involved collecting habitat or environmental data, 64% involved individual or opportunistic butterfly observations (volunteers report butterflies that they observe without systematic sampling), and 27% involved conducting one-time butterfly counts. Many projects (41%) also reported other activities, such as rearing butterflies, testing for parasites, and tagging monarchs. The majority (91%) of projects included butterfly conservation as a part of their project's mission or long-term goals.

Conservation Information

The majority of respondents reported that they supply their volunteers with information about the threats to butterfly populations that we listed in the questionnaire; information was provided by more than two-thirds of projects about each of the listed conservation threats (Table 1). Respondents also reported that they provided their volunteers with information about many of the butterfly-related conservation action strategies that we listed; information on contacting the media was the least frequently provided and information on habitat conservation the most (Table 1). In-person communication was consistently the most common method used to disseminate information, followed by print materials and websites (Table 1).

Social Factors

When asked whether they actively encouraged volunteers to engage in conservation activities outside their project, 74% of our respondents reported doing so. In-person appeals and incentives or positive feedback in the form of public acknowledgements were the most commonly reported methods used to encourage conservation among volunteers (Table 2).

The majority of respondents (74%) said that they attempted to create a sense of community among their volunteers, and 86% believed that their volunteers felt a sense of community as a result of their participation in the project. Project leaders fostered community through group work, newsletters or online communications with volunteer stories, in-person training sessions, and group t-shirts. Most project leaders reported providing volunteers with at least one way to contact one another: 36% provided some form of online discussion forum or list-serve, 32% provided a list of volunteers' email addresses, 9% provided a list of volunteers' phone numbers, and 46% provided other ways for their volunteers to contact each other, including meeting at training sessions and introducing volunteers on a case by case basis (options were not mutually exclusive). Only 14% provided no means of contact between volunteers. All projects reported that their volunteers either sometimes (86%) or always (14%) worked in groups. Most (53%) stated that volunteer groups remained mostly or completely unchanged over time, while

the remainder of respondents reported that their volunteer groups changed over time. Volunteer groups of fewer than five people were the most commonly reported (82%), with 27% reporting some volunteer groups of six to ten people, and 27% reporting some volunteer groups of more than ten people.

Organization Websites

Basic Website Information

Of the 25 butterfly citizen science project websites assessed, 68% were focused on multiple species of butterflies or on butterflies in general, and 32% were focused on monarchs. Most (60%) of the projects were local, 4% were regional, 4% were national, and 32% were international. A majority (60%) of the projects listed conservation among their goals or in the mission statement on their website, compared to the 91% of online questionnaire respondents who listed conservation among their project's goals or mission.

Conservation Information

Less than a third of the websites provided information on each of the butterfly conservation threats we included (Fig. 2), but 40% provided information on at least one threat. The percentage of websites offering information on specific butterfly-related conservation actions ranged by topic from 0% to 40% (Fig. 3), with 40% providing information on at least one action. In addition to providing concrete information about butterfly threats and conservation action strategies, many websites also briefly mentioned one or more of these topics without expanding upon them (Fig. 2 & 3). The percentage of websites offering information on or mentioning specific topics was similar to the percentage of project leaders who reported their websites offered information on these topics, with the exception of information on how to give public talks or presentations. No websites that we examined provided this information, but 32% of project leaders stated that they offered it online. Only 28% of websites contained information on conservation opportunities outside the project's data collection.

Discussion

Over 90% of our respondents listed conservation as one of the goals of their project or organization, making it clear that butterfly citizen science projects are appropriate vehicles for educating about conservation and encouraging conservation action. Butterfly citizen science also has access to tens of thousands of existing volunteers. While this study did not include the volunteers themselves, other research indicates that citizen science participants volunteer because they are interested in nature, want to become involved in their community, and want to meet like-minded people (Bell et al. 2008; Rotman et al. 2012). Conservation volunteers are similarly motivated, and they have a desire to help the environment and engage in conservation (Van Den Berg et al. 2009). Taken together, these findings suggests that butterfly citizen science participants, who can also be considered conservation volunteers, are likely to be people with a prior interest in nature, conservation, and interacting with those who share similar interests. Many citizen science volunteers are already familiar with some aspects of the conservation threat, organism, or ecosystem their project studies; however, volunteers also gain biological, ecological, and environmental knowledge while participating in citizen science (Brossard et al. 2005; Evans et al. 2005; Jordan et al. 2011). Therefore, the strong conservation focus of butterfly citizen science, coupled with the interests of their volunteers, indicates that conservation education and outreach that targets volunteers is a logical step for most projects.

Conservation Information

While all of the project leaders we censused reported engaging in at least some activities that could promote butterfly conservation, many projects did not provide their volunteers with information on more indirect, but still important, forms of conservation actions. For example, there remains great potential for projects to offer donation opportunities, directed either to themselves or to related conservation organizations. Similarly, there is much untapped potential for projects to share information on how volunteers can engage in conservation outreach and education by giving public talks or by contacting the media to initiate a news story. We recommend that citizen science

projects provide their volunteers with information on donations and outreach opportunities, in addition to direct habitat conservation.

Providing people with an opportunity to practice and develop action skills is also a key component of fostering conservation behaviors (Hines et al. 1987). Less than a third of project websites promoted opportunities to engage in and practice conservation, although it is possible that projects provide additional such opportunities that are not advertised on their websites.

Almost all butterfly citizen science projects had an informational website, but their use for disseminating conservation information was relatively low. Furthermore, most of them contained far less information on conservation issues and strategies than our project leader census suggested. There are two possible explanations for this discrepancy. First, not all project leaders responded to our questionnaire, so there was not perfect overlap between respondents and the websites we assessed. Because the questionnaire was anonymous, we were unable to look for congruence between individual project leader and website results. Second, there could be differences of opinion regarding what constitutes information about a topic. Given the higher percentage of projects that reported providing conservation information on their website compared to our own examination of websites, it is likely that some projects may have reported providing information when their website provided only a brief mention of a topic. We encourage project leaders to ensure that they are in fact providing volunteers with information to help them truly understand conservation issues and the ways in which they can address these issues. Because volunteers are likely to interact with websites many times (to enter data or access project updates) and because other people are likely to visit the websites, project websites appear to be key, but under-utilized, venues for disseminating conservation information.

Social Factors

In addition to providing volunteers with more information on conservation activities, there is also room for growth in directly encouraging volunteers to engage in conservation. There is consistent evidence that incentives and direct personal appeals for

behavior change are correlated with pro-environmental behaviors (e.g.,Hines et al. 1987; Bator et al. 2014). Many of the projects we studied used appeals and acknowledgement opportunities to promote conservation. However, almost a quarter of the projects did not use these techniques, despite the fact that they are relatively inexpensive and simple, which suggests that this is a potential area of improvement.

The promotion of a sense of community among projects suggests a favorable environment for the development of social groups, but as with the other aspects of promoting conservation, there is still room for improvement. Many of the community-building activities that project leaders described, such as encouraging group work and providing ways for volunteers to contact one another, are easily achievable for most projects. Other options, such as providing project t-shirts or in-person training sessions, might be more resource-intensive than some projects can accommodate. Projects should choose the community-building strategies that are most appropriate for their circumstances. Given that social norms can exert a powerful influence on behavior (Bamberg & Möser 2007; Bator et al. 2014), and that some citizen science volunteers stay in contact with each other and potentially share environmental information (Johnson et al. 2014), citizen science projects could invoke conservation actions among their volunteers by encouraging the creation of a social group among those volunteers.

This case study indicates that butterfly citizen science projects across the United States are educating their volunteers about conservation and encouraging them to engage in conservation outside of citizen science. Butterfly citizen science is widespread, focused on conservation, and has access to a large number of participants already interested in nature and conservation. By targeting these volunteers for conservation education, projects have the potential to invoke positive conservation actions among volunteers throughout the country. Many of the outreach strategies utilized by our respondents and the conservation actions they encourage are not unique to butterfly citizen science or butterfly conservation, and all nature-based citizen science projects have opportunities to provide their volunteers with high quality information about conservation threats and action strategies that are relevant to their project. Future research is needed to determine the effect that specific education and outreach strategies have on

volunteers and the extent to which citizen science projects can influence conservation actions. Given the room for growth among butterfly citizen science projects in providing educational websites, providing information on conservation outreach strategies, and encouraging financial donations, we suggest that it would useful for other conservation-oriented citizen science projects to assess their programming in those areas. Citizen science has the potential to inform and encourage conservation beyond citizen science participation, but we argue that this is more likely to occur when projects invest time and effort in promoting conservation behaviors.

Table 1. Percentage of project leaders who report supplying their volunteers with information on conservation topics, by format and overall total, n=22. Formats are not mutually exclusive.

Conservation Threats	Total	Print	Website	Email	In Person
Climate Change	91	32	32	32	59
Breeding Habitat Loss	86	54	50	36	68
Pesticide Use	77	50	32	32	59
Overwintering Habitat Loss	73	50	36	32	54
Disease and Parasites	73	32	27	32	54

Conservation Actions	Total	Print	Website	Email	In Person
Habitat Conservation	91	54	46	23	68
Plant Host Plants	86	64	46	32	73
Plant Nectar Plants	82	59	41	27	73
Gardening Strategies	82	46	36	27	64
Give Public Talks	68	32	32	32	36
Financial Contributions	54	36	41	23	41
Contact Media	27	13	9	14	14

Table 2. Percentage of project leaders using specific strategies to encourage conservation actions among their volunteers, n=22.

Encourage Conservation	**%**
In-person requests at trainings or other events	68
Acknowledgment of people who engage in conservation activities in newsletters, on the website, at project meetings or trainings	59
Written requests via email or mailings	36
Contests or prize drawings for individuals who engage in conservation	0
Other (responses included social media and partnering with conservation organizations)	18
None	23

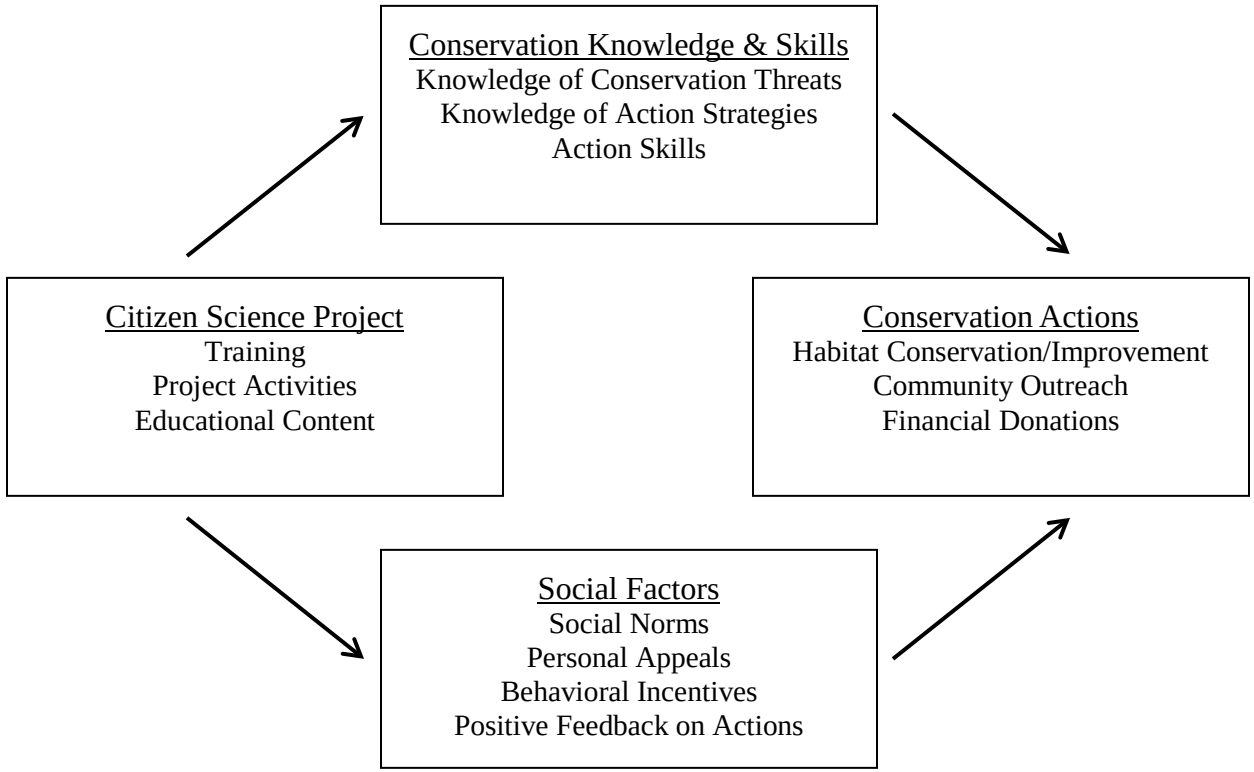

Figure 1. Model depicting a citizen science project's influence on its volunteers' transition from citizen science participation to conservation action.

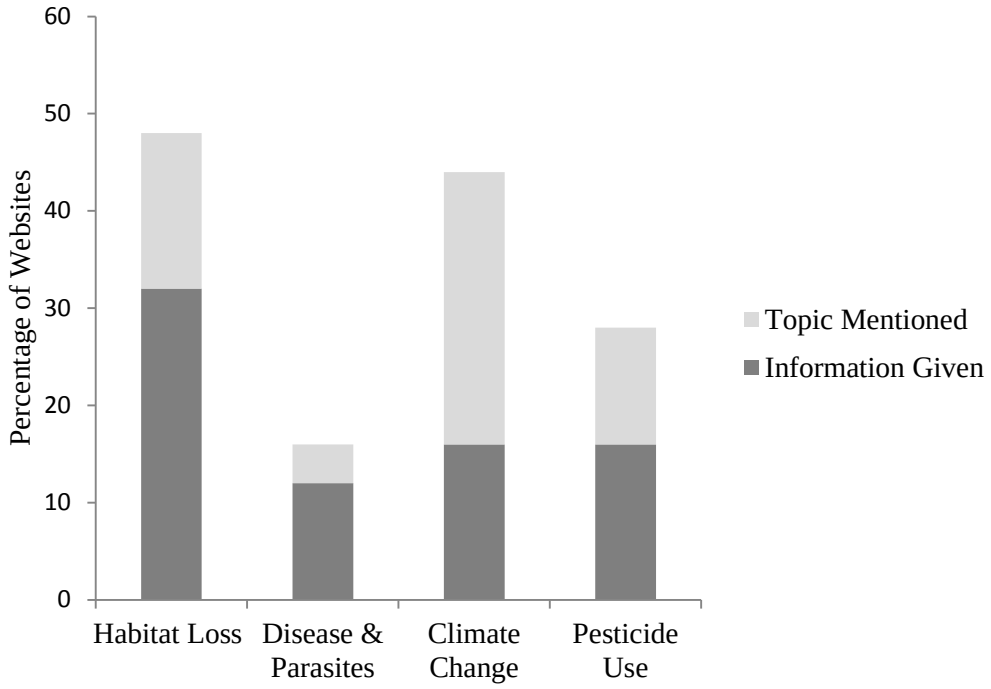

Figure 2. Percentage of project websites providing information on or mentioning butterfly conservation threats, n=25.

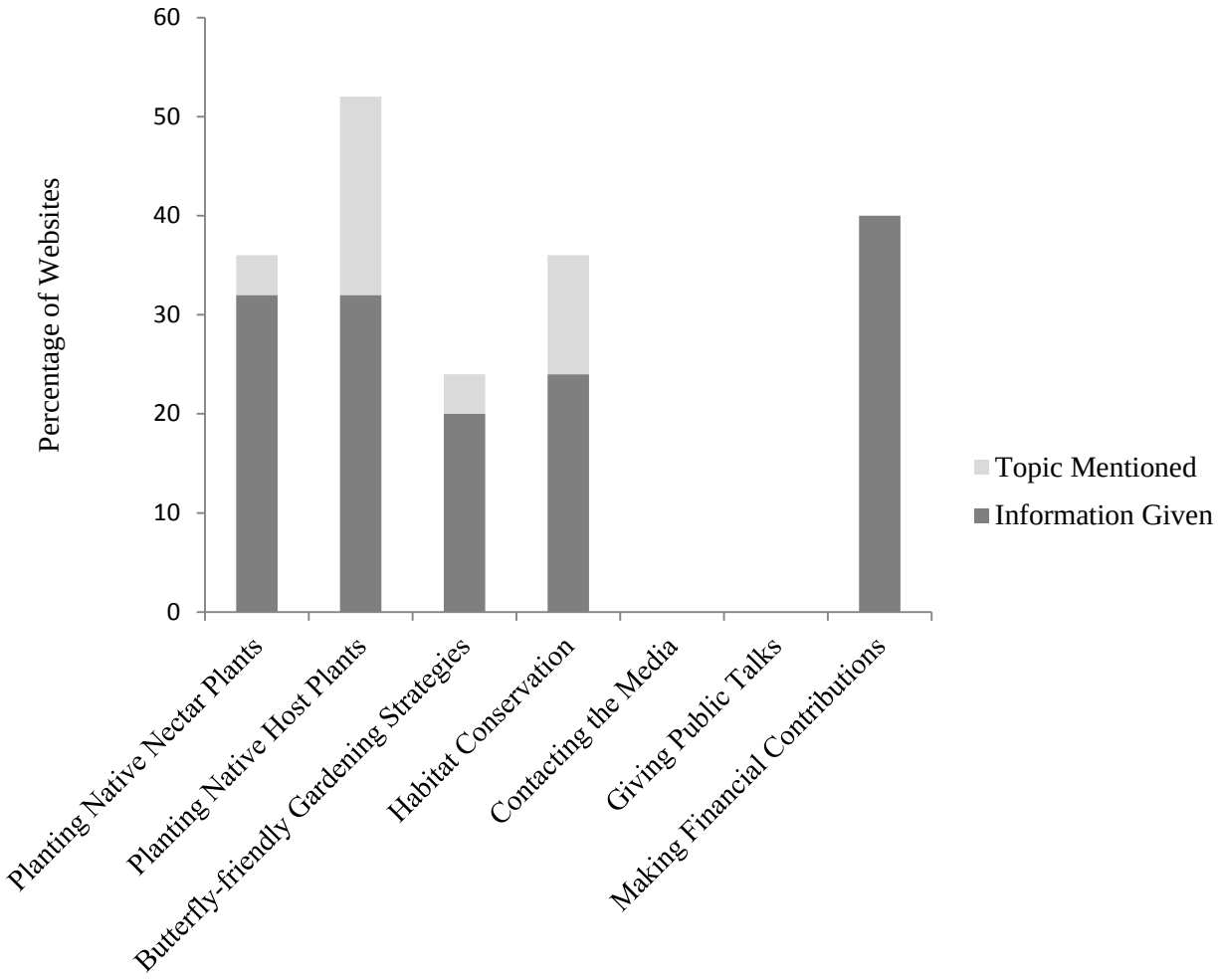

Figure 3. Percentage of project websites providing information on or mentioning butterfly conservation actions, n=25.

Chapter 2: Butterfly citizen scientists in the United States increase their engagement in conservation[2]

Introduction

Citizen science involves members of the public in conducting scientific research, often through collecting data, and it has become quite common in ecology and conservation (e.g.,Devictor et al. 2010; Dickinson et al. 2012). In addition to providing large-scale datasets for research and management purposes, citizen science can provide a learning environment that fosters the understanding of conservation issues and encourages engagement in conservation.

Volunteers who participate in nature-based citizen science tend to be interested in learning about nature and protecting the environment in their local communities (Bell et al. 2008; Rotman et al. 2012). Because many citizen science volunteers might already be generally interested in or inclined towards conservation, they are an obvious audience for education components of citizen science projects that are designed to increase engagement in specific conservation actions.

In order to invoke conservation actions among their volunteers, citizen science projects must take a variety of factors into account. Research into environmental education indicates that knowledge of a conservation threat, understanding of action strategies to address that threat, and hands-on experience with the action strategy or conservation skill are all precursors to engaging in conservation actions (Hines et al. 1987; Jensen 2002). However, while factual and practical knowledge is necessary, it is not sufficient to lead to engagement in conservation. Social factors also have a strong role in influencing actions. For example, behavioral incentives, positive or negative feedback,

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and belonging to a group with pertinent social norms can all hamper or promote taking action (Hines et al. 1987; Bamberg & Möser 2007). In addition to education and social components, which projects can directly influence, behavior change can also be influenced by volunteer characteristics that are established prior to participation in citizen science. These include habits (Stern 2000), values, attitudes, and locus of control, which is the extent to which an individual feels like their actions matter and can affect the world around them (Kollmuss & Agyeman 2002).

Previous research, while limited, indicates that participating in citizen science can be linked to changes in conservation-related actions. A study of an invasive species citizen science project found that two-thirds of the participants had changed their behavior after their involvement with the project, by doing things like talking to others about invasive plants (Jordan et al. 2011). Another study revealed that stream monitoring volunteers' engagement in public water quality and protection issues increased the longer they had been monitoring, primarily through reading and talking with others about water issues (Overdevest et al. 2004).

These studies examined behavior change after participation in a single citizen science project. To our knowledge, there has been no examination of behavior changes across multiple projects and no attempt to determine what aspects of projects help or hinder engagement in conservation among citizen science volunteers. We surveyed participants from butterfly citizen science projects across the United States to determine if their engagement in conservation has changed since they began participating in citizen science, and if those changes can be linked to projects' characteristics and strategies.

We chose to focus our research on butterfly citizen science for two reasons. First, interest in butterfly conservation and butterfly citizen science is high in the United States. For example, almost 10,000 locations across the country have been designated as Monarch Waystations, sites that provide breeding and nectaring habitats to monarchs (Monarch Watch 2015), and in a survey of American households, Diffendorfer et al. (2014) found that individuals were willing to donate to monarch conservation to an extent that totaled more than 4 billion dollars nationwide. Butterfly citizen scientists have contributed data that have been used in numerous peer-reviewed studies (e.g., Breed et al.

2013; reviewed in Ries & Oberhauser 2015), and the Monarch Larva Monitoring Project has been used as a case study in several publications about citizen science (Bonney et al. 2009; Oberhauser 2012).

Second, many butterfly populations are facing known threats, most of which are common conservation concerns across taxa. Climate change has the potential to seriously impact butterfly populations, and it has been linked to mass mortality at overwintering sites, population range shifts, and extirpation from fluctuating precipitation levels (McLaughlin et al. 2002; Forister et al. 2010; Barve et al. 2012). Disease can also harm butterfly populations, and recent studies suggest that populations whose migration is at risk may be even more susceptible to outbreaks of disease (Bartel et al. 2011; Satterfield et al. 2015). Habitat loss and fragmentation can lead to population declines and local extinctions (Preston et al. 2012), and the use of herbicides on crops can reduce host and nectar plant availability in agricultural settings (Haughton et al. 2003; Pleasants & Oberhauser 2013). Just as with many conservation issues, members of the public can take action to combat or ameliorate these threats. Planting native nectar and host plants and gardening without pesticides are strategies often recommended to the public (Monarch Watch 2015; Vaughan n.d.). Individuals can also assist with conservation by engaging in outreach activities (Oberhauser & Prysby 2008) and making financial donations.

Here, we present the results of a survey of butterfly citizen science volunteers from across the country. Respondents provided information on the conservation information and resources they receive from their citizen science projects and how their own actions have changed since they became involved in citizen science. We use this information to describe volunteers' engagement in conservation. Then we explore the hypothesis that components of the education and social structure supplied by a project were linked to increased engagement in conservation. Specifically, we hypothesized that 1) receiving information about specific conservation threats and action strategies would make volunteers more likely to engage in the actions that address that threat, and 2) a supportive social structure, in the form of encouragement to engage in conservation, connection to other volunteers, and sense of community, would be linked to increased engagement in conservation.

Methods

We created an online questionnaire using Qualtrics (Appendix 2) and contacted 28 butterfly-related citizen science projects to request that they send the questionnaire to their volunteers. Between October 31 and November 8, 2013, project leaders from the Cascades Butterfly Project, the GTM NERR (Guana Tolomato Matanzas National Estuarine Research Reserve) Butterfly Monitoring Project, Monarch Health, the Monarch Larva Monitoring Project, and the Western Monarch Thanksgiving Count emailed their volunteers with the link to our questionnaire. Combined, the projects sent a total of 469 emails to their volunteers. However, we do not know the extent of the overlap between the projects' email lists, so we are not able to determine the exact number of individuals emailed; it is likely less than 469. The University of Minnesota IRB Human Subjects Committee declared this research exempt from review.

The questionnaire was open from October 31 to December 16, 2013. In that time, we received 151 responses. We removed 11 completely blank responses and one partially completed questionnaire at the request of the respondent, leaving 139 responses for our analysis. Some respondents did not answer every question, so sample size varied slightly from question to question. Because many citizen science volunteers participate in more than one project, we asked respondents to choose the butterfly project that they were most familiar with when completing the questionnaire.

Respondents answered questions about their history with their citizen science project, basic information about their project, and the types of actions they perform with their project. To examine the extent to which citizen science volunteers felt they belonged to a group and experienced a sense of connection or community with other volunteers, we asked a series of questions about how they interacted with and felt about other participants. Details on specific questions are summarized in the relevant results sections below.

The questionnaire also solicited information about the types of conservation-related information respondents received from their citizen science project, and their engagement in twelve conservation actions, ranging from direct action like planting native host plants to more indirect actions, such as participating in conservation outreach

or making financial donations (Table 1). Respondents were asked to label how their engagement in each conservation action had changed since they began participating in the citizen science project by selecting from the following response categories: "more involved now", "did before and haven't changed", "less involved now", "plan to in the future", and "don't now and don't plan to." Because the category "less involved now" was consistently the least selected and never constituted more than 3.5% (4 individuals) for any action category, we include it in our initial presentation of results (Table 1), but we exclude it from all statistical analyses. We ran all of our analyses with and without the "less involved now" category and found the results remained consistent, with no changes in model selection or significance of predictors.

We conducted the statistical analysis in R version 3.0.1. We used the multinom function in the nnet package to conduct multinomial logistic regression on volunteers' sense of connectedness to other volunteers, as well as their change in involvement for each of the 12 conservation actions (Hilbe 2009). The initial model for each conservation action contained the following predictor variables: years of experience with the citizen science project, yearly time commitment to the project (in hours per year), whether or not the project provided conservation information, whether or not the project encouraged involvement in conservation, the extent to which the respondent felt connected to other volunteers, and the extent to which volunteering made the respondent feel a broader sense of community.

For nine of our 12 actions, the predictor variable "conservation information" was based on a question or questions specific to the action of interest; for example, when modeling the action "contacting the media", we based our conservation information predictor variable on a question that asked if the respondent had received information on contacting the media. For "planting nectar or host plants" and "encouraging others to plant" we used two separate predictor variables: information on host plants and information on nectar plants. For three of the actions, "displaying signs to promote butterfly habitat", "involving others in monitoring or conservation", "talking informally with others about butterflies or conservation", we based our predictor variable on

responses to the more general question of whether or not respondents were supplied with information on butterfly conservation.

Burnham and Anderson (2002) recommend the selection of the most supported model when the goal of an analysis is not to determine model coefficients but to examine relationships between variables, especially when the possible models have different interpretations. Using the initial six-predictor models for each of the 12 conservation actions we examined, we performed backward stepwise selection based on second-order Akaike's information criteria values (AIC_c) to determine the model providing the most information. We then calculated p-values for the individual log odds coefficients to further elucidate the relationships between variables, using R code from the UCLA: Statistical Consulting Group (06/13/2014).

Results

Respondents

Volunteers reported participating in 18 separate butterfly citizen science projects; 68% reported volunteering with only one project, with the remaining volunteering with two to seven projects. The majority of respondents (77%) chose to describe their participation in a citizen science project that focused specifically on monarch butterflies. Respondents reported that they had participated in butterfly-related citizen science for one to 25 years (median=5.0, mean=6.67 ± 0.50 SE, n=134). Yearly time commitment to the project varied extensively, with some respondents devoting less than one hour per year to their project and others volunteering for several hundred hours each year (max: 420 hours, median= 36.0, mean=65.0 ± 7.27 SE, n=116).

Experiences with Citizen Science Projects

Respondents (n=131) engaged in a number of different activities with their projects, including: reporting individual butterfly sightings (54%); repeatedly monitoring an area for eggs, larvae, or adult butterflies (73%); collecting data on butterfly habitat (70%); and conducting one-time butterfly counts (13%).

We asked respondents if they never, sometimes, or always worked with others when collecting citizen science data; 40% chose never, 33% sometimes, and 27% always (n=123). Of those participants who sometimes or always engage in citizen science with others, more than half collect data with family members, with nature centers and informal groups also being common (Figure 1). The majority (65%) of participants who volunteer in groups reported that those groups remained mostly or completely unchanged over time, while the remaining 35% reported frequent changes in group composition (n=72).

The majority of respondents (55%) felt somewhat connected to other volunteers, and the frequency of respondents who felt not at all, somewhat, and very connected differed significantly between levels of how often they volunteered in a group. Volunteers who felt very connected to the project were more likely to monitor in groups (Figure 2A). Because connection to other volunteers was significantly impacted by working in groups, and because we were primarily interested in the role of connectedness, we used it, rather than working in groups, as a predictor in our models of conservation actions. For those respondents who worked in groups, we determined factors that were related to their degree of connectedness using model selection based on AIC values from multinomial logistic regression, with working with the same or different people and having a way to contact other volunteers as potential predictors. Working with the same or different people was not a significant predictor of connectedness (Appendix 2). Level of connectedness was instead predicted by whether or not participants were provided with a way to contact each other, with the participants more likely to feel very connected if they were provided with a way to contact other volunteers (Figure 2B). Overall, 45% of participants reported that their project had provided them with a way to contact other volunteers, most often through online forums, list-serves, or lists of email addresses (n=120). In addition to feeling connected to other volunteers, we also asked respondents if volunteering made them feel a broader sense of community; most reported that it did (Figure 2C).

More than half of the participants (55%) felt that their citizen science project actively encouraged them to engage in conservation outside the project (n=126). When asked if volunteering with their citizen science project required them to engage in any of

four conservation behaviors (for instance, if they would not be able to monitor or submit data on larval abundance without first eliminating pesticide use at a site), 40% stated that they were required to limit the use of insecticides or herbicides, 36% to plant host or nectar plants, 19% to give public presentations, and 18% to display signs about butterflies or their project (n=130). We asked respondents if their project provided them with information about butterfly conservation, and 79% reported that it did (n=125). When presented with a list of possible conservation topics, participants were most likely to report receiving information about breeding habitat loss (88%), with more than 77% receiving information about other key threats to butterfly populations as well (Table 2). The percentage of participants who received information from their projects about conservation actions they could take to help butterflies ranged from 23% receiving information on contacting the media to 77% receiving information about planting native host plants (Table 2). Respondents were most likely to receive conservation information through online communications such as email (57%) or from the project website (24%), with fewer people receiving information in person (12%), or from print materials (2%), and some receiving no information at all from their project (6%). These results closely matched what participants reported as their preferred method of receiving information from their project: (online communications 57%, website 24%, in person 12%, print materials 7%); only one individual stated that they did not wish to receive conservation information from their project (n=123).

Conservation Actions

When asked how their engagement in 12 butterfly-related conservation actions had changed since they joined their citizen science project, 95% of respondents reported that they had increased their participation in at least one conservation action. Talking to others about butterflies or conservation and involving others in monitoring or conservation were the two most increased actions. Table 1 details the changes reported for each of the twelve conservation actions addressed by our questionnaire.

Table 3 shows the best fit multinomial logistic regression models testing the degree to which each predictor variable affected volunteer engagement in each of the

conservation actions we examined, along with the log odds coefficients for the best fit models. Log odds coefficients are interpreted as the log odds of being in the action change category of interest (e.g. “did before and haven’t changed”) compared to the reference category of “more involved now”, as the predictor variable increases (continuous variables) or when switching from the reference predictor category to the predictor category of interest. For example, for decreasing herbicides, the log odds of being in the “future plans” category compared to the “more now” category decrease by 17.67 when conservation information is provided compared to when it is not. Details of the stepwise model selection can be found in Appendix 2.

Years of experience with butterfly citizen science was a predictor in the final model for eight activities: decreasing herbicides, decreasing insecticides, involving others in conservation, giving public talks, displaying signs, contacting the media, advocating for environmentally-friendly land management, and making financial donations. Volunteers with less experience tended to have higher odds of reporting that they planned to engage in a conservation activity in the future, as compared to more experienced volunteers who had already increased their engagement. Five conservation action models included yearly time commitment: planting, involving others, encouraging planting, displaying signs, and making financial donations. In these cases, participants who volunteered more of their time had higher odds of reporting that they were more involved in the activity now than when they joined their citizen science project.

Six conservation activities had being provided with conservation information as a predictor in the final model: decreasing herbicides, decreasing insecticides, planting, talking informally with others, encouraging planting, displaying signs, and contacting the media. For these actions, participants primarily had higher odds of an increase in their engagement in the action when their project provided information.

Encouraging volunteers to engage in conservation was included in the final model for six actions: decreasing herbicides, decreasing insecticides, talking informally with others, advocating for environmentally-friendly land management, speaking out against development, and making financial donations. For the most part, volunteers who received encouragement had higher odds of reporting that they had future plans to engage in the

action than that they had already changed their engagement. Additionally, volunteers who were encouraged had higher odds of reporting that they had increased their participation in the activity since joining their project compared to reporting they had no plans to engage in the action.

The final models for decreasing herbicides, decreasing insecticides, and giving public talks all included connection to other volunteers; in those models, the odds of having increased engagement in the conservation activity, compared to reporting future plans to do so, were higher for volunteers who felt the most connected. The final models for involving others in conservation, contacting the media, and making financial contributions included sense of community; for all three actions, the odds of planning future action compared to being more involved now decreased when comparing those who reported their sense of community as "a great deal" to those who reported "not at all" (Table 3).

Discussion

Our findings indicate that butterfly citizen science volunteers are actively engaged in conservation outside of their project. For nine of the 12 conservation actions our questionnaire covered, the majority of respondents reported maintaining or increasing their involvement in that action. Most of our respondents reported engagement in direct butterfly conservation, through planting host and nectar plants and decreased pesticide use. Additionally, participants reported substantial involvement in conservation outreach and education actions, ranging from informally talking to others to giving public talks about butterfly conservation.

Previous work on citizen science outcomes has addressed both direct conservation actions and outreach and advocacy activities (Overdevest et al. 2004; Jordan et al. 2011). Education and outreach are key parts of conservation, and there have been repeated calls for increased and improved conservation education (e.g., Bride 2006; Novacek 2008). Some citizen scientists in India give formal outreach lectures in their communities, while others engage in informal outreach in their workplace or neighborhood (Johnson et al. 2014). Citizen science has been called a "research army for conservation" (Oberhauser &

Prysby 2008), but it has the potential to create an outreach army for conservation as well. Our results suggest this is certainly the case for butterfly citizen science, given that the majority of our respondents engage in some form of conservation outreach or education.

Many of our respondents were already engaged in the conservation actions covered by our questionnaire prior to becoming involved in citizen science; they reported that they maintained, but did not increase, their involvement with a specific conservation action. These participants could already have reached their maximum interest or ability in that area, or increasing their engagement could require additional resources or support. Further research is needed to determine why these volunteers have not altered their actions, and what strategies, if any, projects can use to invoke further pro-conservation change.

Over half of the conservation actions we examined were more likely to increase when participants received conservation information from their citizen science project. The most straightforward explanation for this result is that participants who receive educational information from their project use that information to engage in conservation. Knowledge of an issue is a widely accepted precursor to taking action (Jensen 2002; Kollmuss & Agyeman 2002). Given the strong preference for receiving information online, we recommend that projects maintain and expand their dissemination of information through websites and email.

Only 55% of our respondents felt that their project actively encouraged them to engage in conservation, but our results indicate that such encouragement is linked to increased involvement or plans for increased involvement in a number of conservation actions, suggesting that this is a missed opportunity for some citizen science projects. Previous research also supports the claim that active encouragement through incentives and direct appeals can increase engagement in a desired behavior (Hines et al. 1987; Fisher & Ackerman 1998). Encouraging involvement in conservation can be a relatively simple and inexpensive activity for a project, done through requests at trainings, via email announcements, or by highlighting the conservation work of volunteers in newsletters or online posts.

In addition to active encouragement, social norms can play a pivotal role in influencing individuals' action (Kollmuss & Agyeman 2002; Bamberg & Möser 2007). In order to be influenced by social norms, an individual must first belong to a social group. The majority of our respondents felt only somewhat connected to other citizen science volunteers, suggesting they might not belong to a mutual social group with its own norms. Those who did feel strongly connected were more likely to have been provided with a way to contact other volunteers and to work in groups. The relationship between feeling connected to others and working in groups could be explained in several ways: those who work in groups receive an opportunity to develop a connection with others, those who already feel connected choose to work in groups, or a combination of the two. In contrast, the relationship between connectedness and having been provided with a way to contact others most logically suggests that a means to contact each other leads to opportunities for volunteers to develop connections with one another. A recent study on citizen science in India found that many volunteers choose to stay in contact with each other and potentially used that contact to spread environmental information (Johnson et al. 2014). Projects that wish to create a connection between their volunteers should consider encouraging group work and providing in-person events, email lists, or other contact methods to their participants, and additional research would illuminate the precise strategies that are most effective in a given setting.

Both years of experience with butterfly citizen science and the hourly time commitment to a project were correlated with increased engagement for many conservation actions. It is likely that increased time spent with a project, either over the course of a year or across multiple years, also increases access to conservation information and social factors that can encourage conservation. This emphasizes the importance of volunteer retention and could partially explain positive correlations between time and engagement; however, it is also possible that an individual's commitment to butterflies or conservation directly influences their engagement in both citizen science and conservation, resulting in the positive correlation between the two activities. Further research on the motivations of citizen science participants is needed to clarify this issue.

The majority of the citizen science participants who took our questionnaire reported that they had increased their involvement in butterfly conservation since they joined their citizen science project. It is possible that there was a response bias among the individuals who received the questionnaire, with those who are more heavily invested in butterfly conservation and citizen science perhaps more likely to respond. Response bias of this kind is common among voluntary surveys, but the large degree of variation in our respondents' self-reported actions indicates that we received responses from volunteers with a wide variety of commitments to conservation.

Our results provide strong evidence only for a correlation between involvement in citizen science and a change in conservation engagement. Additional research is also required to precisely determine what percentage of people would have increased their involvement in conservation if they had not joined a citizen science project. However, the most reasonable interpretation of our results is that citizen science projects can increase conservation involvement among their volunteers by providing conservation information, encouraging engagement in conservation, and offering a sense of community or connectedness. The threats facing butterfly populations are not unique, nor are the strategies being used to encourage conservation action among butterfly citizen science volunteers. Our research suggests that the widespread engagement of citizen science volunteers in conservation is a valuable outcome of their participation in these projects.

Table 1. Percentage of respondents reporting change in action since beginning participation in citizen science project

Conservation Action	More Now	No Change	Less Now	Future Plans	No Plans	n
Decrease herbicides	40.5	43.7	1.6	4.8	9.5	126
Decrease insecticides	38.9	46.0	0.8	4.8	9.5	126
Plant nectar or host plants	51.6	41.3	0.0	3.2	4.0	126
Involve others in monitoring or conservation	69.0	19.8	2.4	3.2	5.6	126
Talk informally with others about butterflies or conservation	73.2	22.0	0.0	1.6	3.1	127
Encourage others to plant	55.9	32.3	0.0	3.1	8.7	127
Give public talks	41.6	15.2	3.2	12.8	27.2	125
Display signs	28.6	15.9	1.6	23.0	31.0	126
Contact the media	19.4	12.1	1.6	14.5	52.4	124
Advocate for environmentally friendly land management	38.1	31.0	0.8	11.1	19.0	126
Speak out against development	26.8	14.6	1.6	15.4	41.5	123
Financial contributions	45.2	18.3	3.2	15.1	18.3	126

Table 2. Percentage of participants who received information from their citizen science project about butterfly threats or conservation actions

Information about Threats	%	n
Breeding habitat loss	88	125
Overwintering habitat loss	80	125
Disease & parasites	78	125
Climate change	81	123
Pesticide use	77	122
Information about Conservation Actions		
Native nectar plants	72	124
Native host plants	78	125
Gardening strategies	72	123
Habitat conservation	76	123
Contacting the media	23	122
Giving public talks	25	124
Financial contributions	41	123

Table 3. Log odds coefficients from the best fit multinomial regression model for each conservation action change. F=future plans, NC=no change, NP=no plans, reference category is more now. Cons Info=provided with conservation information (reference level of no), Encourage=encouraged to engage in conservation (reference level of no), Conn=connected to other volunteers (reference level of "very much"), Comm=sense of community (reference level of "a great deal"). * indicates the coefficient is significant at $p<0.05$. See text for explanation of the proper interpretation of log odds coefficients.

		Years in Project	Time (hrs/yr)	Cons Info	Encourage	Conn. not at all	Conn. somewhat	Comm. Not at all	Comm. Not very much	Comm. Somewhat
Decrease	F	-15.87		-17.67	15.91	75.25	57.91*			
herbicides	NC	0.02		-0.75	0.15	0.63	-0.28			
n=109	NP	-0.01		-1.97*	-1.02	-0.06	0.77			
Decrease	F	-16.39		-18.33	16.23	80.24	62.56*			
insecticides	NC	0.04		-0.91	-0.21	0.51	-0.05			
n=109	NP	0.01		-2.14*	-1.21	-0.09	0.91			
Plant	F		-0.04	-2.16*						
n=113	NC		0.00	-0.77						
	NP		-0.14	-13.82*						

Table 3 continued

		Years in Project	Time (hrs/yr)	Cons Info	Encourage	Conn. not at all	Conn. somewhat	Comm. Not at all	Comm. Not very much	Comm. Somewhat
Involve	F	-0.40	-0.02					-7.83*	-0.10*	-1.09
others	NC	0.01	0.00					2.84*	-19.35*	-0.72
n=111	NP	0.12	-0.04					14.24*	12.48*	11.07*
Talk	F			-3.00	11.92					
informally	NC			-0.19	-0.17					
n=114	NP			11.88	-1.86					
Encourage	F		-0.02	-2.75*						
planting	NC		0.00	-0.78						
n=114	NP		-0.04	-2.72*						
Give public	F	-0.19*				11.54	10.74			
talks	NC	-0.04				-0.09	-0.86			
n=110	NP	-0.13*				1.86*	0.79			
Display	F	-0.20*	-0.01*	0.97						
signs	NC	-0.13*	0.00	-1.90*						
n=110	NP	-0.10*	-0.01*	-0.86						

Table 3 continued

		Years in Project	Time (hrs/yr)	Cons Info	Encourage	Conn. not at all	Conn. somewhat	Comm. Not at all	Comm. Not very much	Comm. Somewhat
Contact the	F	-0.12		-1.44				-7.42*	1.46	0.28
media	NC	-0.01		-0.74				17.47*	-13.05*	0.78
n=110	NP	-0.14*		-1.80*				18.42*	2.67	1.40*
Advocate	F	-0.21*			-0.75					
n=112	NC	0.04			-1.06*					
	NP	-0.06			-1.59*					
Speak out	F				-1.12					
n=109	NC				-1.23					
	NP				-1.66*					
Financial	F	-0.26*	-0.01		1.89*			-12.71*	1.37	-0.51
n=108	NC	-0.09	0.00		0.11			0.90	0.74	-1.34
	NP	-0.13	-0.01		-0.96			1.03	-20.56	-0.97

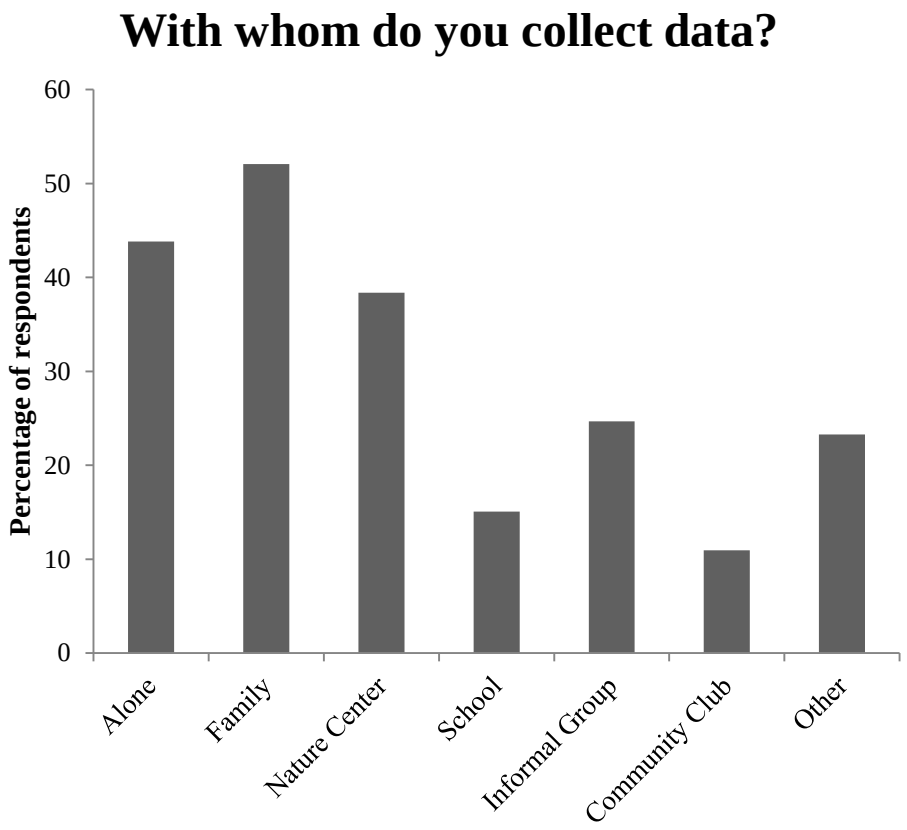
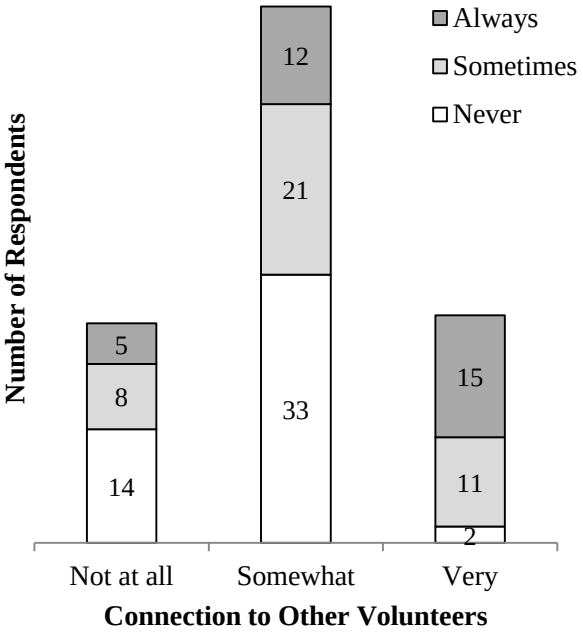
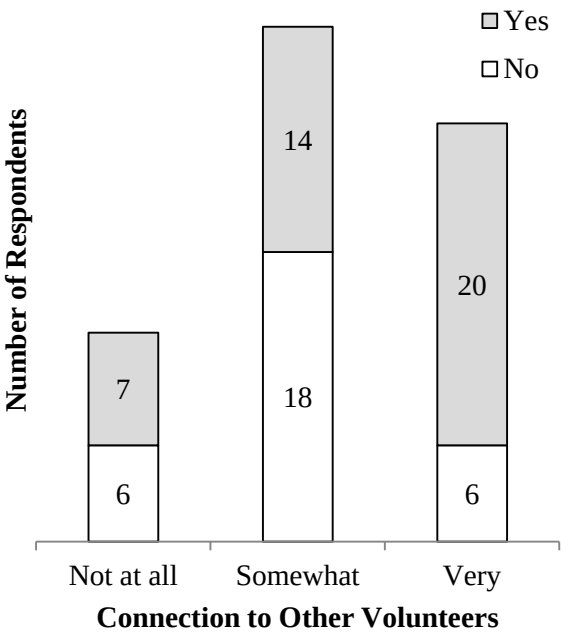


Figure 1. Percentage of respondents who collect data, by group. Options were not mutually exclusive. N=73

A


Always
Sometimes
Never
12
21
5
8
33
15
14
11
2
Number of Respondents
Not at all
Somewhat
Very
Connection to Other Volunteers

B


Yes
No
14
20
7
18
6
6
Number of Respondents
Not at all
Somewhat
Very
Connection to Other Volunteers

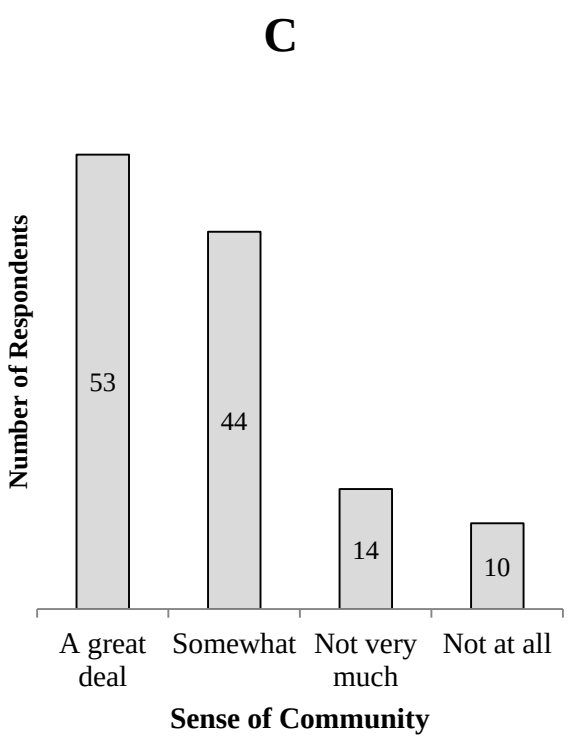


Figure 2A. Number of respondents who always, sometimes, or never volunteered in groups, separated by their sense of connection to other volunteers. The differences are significant (χ^2=20.62, df=4, n =121, p=0.0004). 2B. For respondents who volunteered in groups, the number who received or did not receive a way to contact other volunteers, separated by their sense of connection to other volunteers. See Appendix B for AIC values from model selection. 2C. Sense of community by number of respondents.

Chapter 3: Contributions of citizen scientists and habitat volunteers to monarch conservation

Introduction

Volunteers are an essential part of conservation efforts, with volunteers engaging in a wide variety of activities (e.g., Guiney et al. 2006; Measham & Barnett 2008). Here, we focus on two specific types of conservation volunteers. Habitat volunteers engage in conservation activities such as erosion control, the removal of invasive plants, and habitat restoration (Weston et al. 2003; Asah & Blahna 2012). Citizen science volunteers contribute to scientific research by participating in biological research, usually monitoring (Dickinson & Bonney 2012).

Much of the literature on habitat conservation volunteers provides only anecdotal or cursory descriptions of volunteer actions and their conservation implications, with recent work focusing primarily on volunteer motivations (e.g., Weston et al. 2003; Van Den Berg et al. 2009; Asah & Blahna 2012). The research that has been done to describe and quantify the importance of habitat volunteers in conservation indicates that they provide a substantial financial savings and a large contribution to on-the-ground conservation work (Guiney et al. 2006); although programs do not always fully meet their initial habitat conservation goals (Ewing et al. 2013). The extent to which citizen science volunteers become directly involved in habitat creation as a part of their citizen science project remains unknown, but recent work with nestbox monitoring volunteers indicate that many engage in some form of site management (Larson et al. 2016).

Both habitat and citizen science volunteering have been linked to changes in participants' pro-conservation or environmentally responsible behaviors. Studies of habitat volunteers (Ryan et al. 2001) and citizen scientists (e.g. Hvenegaard & Fraser 2014; Stepenuck & Green 2015; Lewandowski & Oberhauser In Press B, Chapter 2) have found that after joining a project, participants increased their engagement in environmental and conservation activities outside the project, such as creating wildlife habitat and talking to others about environmental issues.

A species of particular conservation concern is the monarch butterfly (*Danaus plexippus*), a popular and much-studied insect throughout North America (Oberhauser & Solensky 2004; Oberhauser et al. 2015). Brower et al. (2012) found a significant decline in the eastern population of North American monarchs based on their overwintering counts, and recent population estimates represent a decrease in monarch numbers of almost 90% in the past 20 years (Rendon-Salinas et al. 2015). The decline in the size of the eastern population of North American monarchs has been linked to herbicide use in agricultural fields, resulting in a more than 50% decrease in the availability of the monarch's host plant, milkweed, in the Midwestern region of the United States between 1999 and 2010 (Pleasants & Oberhauser 2013). Thus, it is likely that habitat loss in the monarch breeding range is a key factor driving their decline, although other factors, including habitat loss in the Mexican overwintering sites, insecticide use, and climate change, may also play a role (Shahani et al. 2015). It is therefore reasonable to conclude that protecting, restoring, and managing breeding habitat will promote monarch conservation.

Most of North America's western population of monarchs overwinters in California; while the decline in the western population has not been as dramatic as that of the eastern population, there is evidence to suggest that its numbers are also decreasing, possibly due to a combination of environmental conditions and habitat loss (reviewed in Jepsen & Black 2015).

Monarch conservation management and research involves extensive participation from the public. Ries and Oberhauser (2015) found that volunteers collectively contribute more than 35,000 hours collecting data for monarch citizen science projects over the course of a year and since 2000, close to two thirds of the published field studies of monarchs have used citizen science data. Many conservation efforts across North America center on creating breeding habitat for monarchs by planting nectar and host plants; members of the public are central to these efforts, both as private individuals and as volunteers with conservation organizations (Shahani et al. 2015).

We surveyed volunteers from two programs involved in monarch conservation and research, the Monarch Waystation Program and the Monarch Larva Monitoring

Project. The Monarch Waystation program, which is run by Monarch Watch at the University of Kansas, focuses on monarch research, conservation, and education. Monarch Waystations are sites that provide the habitat requirements, most notably milkweed and nectar plants, that monarchs need to breed and sustain their migration. Sites can be established by purchasing seeds directly from Monarch Watch or from other sources. Members of the public can register their sites with Monarch Watch for a small fee ($16). The Monarch Larva Monitoring Project (MLMP) is a citizen science project run by the University of Minnesota Monarch Lab that studies how and why the North American monarch population varies in time and space. Volunteers choose their own monitoring sites, which must contain milkweed plants. During the parts of the year when monarchs are present in their area, volunteers monitor the milkweed in their sites weekly and report the abundance of monarch eggs and larvae, as well as information on the milkweed and nectar plants present. Some volunteers also collect and rear monarch larvae and observe rates of survival and parasitism. While there are many monarch citizen science projects (reviewed in Ries & Oberhauser 2015), we focus on the MLMP because it has conservation goals and is site-based, with volunteers monitoring the same location week after week, making it similar to the Monarch Waystation program and likely to inspire habitat-based conservation. Additionally, the MLMP is representative of many other citizen science projects, such as the Cornell Lab or Ornithology's NestWatch Project and the University of Colorado's Bees' Needs, which ask volunteers to monitor the same site on a regular basis and for which some or all volunteers must create habitat in order to collect data (University of Colorado at Boulder 2015; Cornell Lab of Ornithology 2015).

Our survey was designed to 1) describe the current efforts being undertaken by MLMP and Monarch Waystation volunteers, as part of their programs, to protect or create monarch habitat and 2) describe the extent to which citizen science volunteers and habitat restoration volunteers changed their involvement in on-the-ground conservation and conservation outreach after joining their projects. We focus on efforts that are likely to contribute to monarch conservation, including the creation of high quality habitat,

monarch-friendly habitat management, and advocating for conservation through outreach and financial contributions.

Methods

To gather information about the habitat characteristics and personal behaviors of volunteers from the MLMP and registered Monarch Waystation participants, we created an online questionnaire using the survey platform Survey Monkey. At the time of the survey, there were approximately 6,300 registered Waystation users (that number has now grown to over 10,000 (Monarch Watch 2015)). 388 MLMP volunteers were considered active, having submitted data since 2005; 327 of those had active email addresses on file and received the questionnaire.

We collected survey responses from February 4 to April 15, 2013 and received a total of 1053 responses. We removed 32 respondents whose answers did not allow us to determine if they participated in the MLMP or the Waystation program, resulting in an overall sample size of 1021. Not all respondents answered every question in the questionnaire, so we report the sample size for each question. This research was approved by the University of Minnesota IRB Human Research Protection Program. The questions relevant to this study are included in Appendix 3; the full survey is available upon request.

Some respondents had more than one monitoring site or Waystation. If respondents had a site that was both a monitoring site and a Waystation, they were asked to complete the questionnaire based on that site. If they did not, they were asked to complete the questionnaire based on the site with which they were most familiar.

We asked respondents a series of questions about their site, including how it was established, what size it was, where it was located, what bordered it, and what was contained within it. Respondents were also asked who owned and managed the site and what types of land management, if any, occurred at the site. Additionally, they were asked how their engagement in a list of conservation actions had changed since they joined the MLMP or the Waystation Program. Respondents characterized their change in participation for each conservation action by choosing from the options “more involved

now", "did before, no change", "plan to in the future", "no plans to do this", or "less involved now." Respondents were also asked to rate their initial motivation to participate in their program in terms of interest in nature, interest in monarchs, desire to help monarchs, desire to be outside, desire to help scientists, desire to learn about science, and desire to provide learning opportunities for children. The questionnaire also provided space for respondents to share stories about their involvement in monarch conservation and citizen science.

Statistical analyses were run in R version 3.0.1. We log transformed the number of milkweed species per site, in order to better meet the assumptions of normality and homoscedasticity for a regression. Our regression of milkweed species per site used ordinal site, volunteer type, and a binomial site creation variable (grew naturally or planted/augmented by humans) as dependent variables; interaction terms were not significant, and were removed from the final model. We used Fisher's Exact Tests, Kruskal-Wallis ANOVA, and Chi Square Tests with Bonferroni corrections to examine differences in other site characteristics between volunteer groups. To analyze differences in changes in conservation action between types of volunteers, we used Fisher's Exact Tests. For all the actions we examined, the response category "less involved now" was chosen by 0-5% of respondents. We performed the initial Fisher's Exact Tests with and without the "less involved now" category and found no change in the results. We therefore eliminated this category from our analysis and report only the results for the remaining set of responses. For conservation actions that showed significant differences between types of volunteers, we used pairwise Fisher's Exact Tests with Bonferroni corrections to examine differences between "more involved now" and the other response options for specific volunteer categories. We also used Fisher's Exact Tests and pairwise comparisons with Bonferroni corrections to examine the difference between volunteer groups in the importance of various initial motivating factors.

Results

Of the 1021 respondents, 857 had created Monarch Waystations, 64 were MLMP volunteers, and 100 had both Waystation and MLMP sites (hereafter referred to as

combination sites). Thus the response rates were 15% for Waystation volunteers (957/6300) and 50% (164/327) for MLMP volunteers.

Sites were established in a variety of ways. Many were existing sites that had been planted by humans and had milkweed or nectar plants added after the participant joined MLMP or the Waystation program. Others were planted prior to joining the programs, with no additional plants added, and some were completely new sites planted specifically for the program. Some sites grew naturally with no additions from humans, and others grew naturally with some milkweed or nectar plants added after the respondent joined MLMP or the Waystation program. MLMP sites were more likely than Waystations or combination sites to be natural sites with no additional plants, and Waystation and combination sites were more likely than MLMP sites to have been previously planted, with plants added after joining the project (Figure 1a).

MLMP sites were more likely than Waystations to be found in rural areas, with the majority of all sites located in rural or suburban areas (Figure 1b). Sites ranged in size from less than $10m^2$ to over $10{,}000m^2$, and we did not find a significant difference between the sizes of the three types of sites, although there was a trend (Kruskal-Wallis test statistic = 4.6, $p = 0.1$) for MLMP and Combination sites to be larger than Waystations (Figure 1c). Many sites (56.5% of Waystations, 51.9% of MLMP, 42.2% of combination) were 100 sq. m or less. The majority of Waystation and combination sites were classified as gardens, and most MLMP sites were described as gardens, old fields, or prairies (Table 1).

By definition, all sites must contain milkweed. Waystations had an average of 3.1 ±1.6 SD species of milkweed (n=795), MLMP sites had 1.8 ± 1.0 species (n=54), and combination sites had 3.1 ± 2.4 SD species (n=81). We performed a regression of the natural log of number of milkweed species per site, with site size, volunteer type, and site creation as independent variables. Waystation and combination sites had significantly more species than MLMP sites ($p < 0.0001$), and human-created or augmented sites had significantly more species than completely naturally-occurring sites ($p < 0.0001$). Site size had significant linear ($p = 0.0001$) and quadratic ($p < 0.001$) coefficients, indicating a general trend of increasing number of species with increasing site size, with a drop in

number of species among the largest sites. The full regression table, including coefficients, is available in Appendix 3. 33.8% of Waystation sites, 7.4% of MLMP sites, and 27.2% of combination sites contained the non-native *Asclepias curassavica* (n_{tot}=930, χ^2=17.16, df=2, p=0.0002). Pairwise chi square tests with Bonferroni corrections revealed significant differences in the presence of *A. curassavica* between MLMP and combination sites (χ^2=6.91, df=1, p=0.03) and MLMP and Waystation sites (χ^2=15.00, df=1, p=0.0003), but not between Waystations and combination sites (χ^2=1.19, df=1, p=0.83). Additional information on the physical characteristics of sites can be found in Appendix 3.

Most sites were owned by the volunteer respondents (Waystation: 80.7%, n=707; MLMP: 71.4%, n=49; combination: 57.1%, n=63). Sites on government property were also common (Waystation: 7.4%, MLMP: 20.4%, combination: 20.6%). The majority of volunteers managed their own sites (Waystation: 91.6%, MLMP: 77.6%, combination: 83.9%). Weeding was the most common management technique, followed by mowing, and MLMP volunteers were significantly less likely than Waystation volunteers to engage in weeding or fertilizing (Table 2).

When asked to describe how their participation in specific conservation actions had changed since joining their monarch project, for most actions the majority of respondents reported that they had increased their involvement or that they had already been involved in that action (Table 3). The exceptions to this pattern were making financial donations to conservation organizations and posting signs for MLMP volunteers; and giving presentations about monarch conservation, contacting the media about monarch conservation, and speaking out against development that threatens monarchs for both MLMP and Waystation volunteers. For all actions, the highest percentages of respondents reporting increased participation in conservation were volunteers from combination sites. Pairwise comparisons for changes in conservation actions revealed that volunteers from combination sites were less likely to state that they had no plans to engage in conservation compared to MLMP and Waystation volunteers (Table 3).

In the space provided for respondents to describe their experiences with monarchs, volunteers shared details about the conservation activities in which they participated. Both MLMP and Waystation volunteers described the work involved in creating and maintaining their monarch habitat. One MLMP volunteer wrote "I have worked HARD to establish milkweed in my yard (it has been difficult!), so I use insecticides sparingly if I expect any monarch activity around here." A Waystation volunteer stated:

> Registering my home garden as a Waystation raised my awareness and commitment to avoiding invasive plants, and thinking about my garden as a habitat rather than merely a source of pleasure. My connectedness with the natural world has increased; I want my garden to work, not just sit there and look pretty.

Many volunteers also described their efforts to get others involved in monarch conservation. One MLMP volunteer wrote "I'm not an activist, but I talk about my garden and butterflies to anyone who will listen, and offer free plants to anyone who wants." Both MLMP and Waystation volunteers collected and distributed seeds from milkweed and nectar plants, and some shared stories about helping to establish butterfly gardens at schools, churches, and others' homes. Respondents often wrote about their outreach efforts, from informal conversations with neighbors to giving workshops on gardening for monarchs at schools and garden clubs.

A common theme among Waystation volunteers was the importance of having a formally registered site. Volunteers with registered sites can purchase an educational aluminum sign describing the Monarch Waystation program; respondents reported that these signs garnered interest from neighbors and passersby, creating opportunities for dialogue about monarchs and monarch conservation. Registration was also used as a method to counter complaints from neighbors and government officials who viewed the Waystations as unruly or unappealing. For instance, one volunteer wrote:

> Waystation status allowed me to justify the yard to the city officials that were attempting to cite us for a weed violation for having a butterfly garden instead of

a lawn – allowed me to educate them about the importance of other plants, even those with the name "weed" in their title.

Waystation, MLMP, and combination volunteers were similarly motivated by an interest in nature and a desire to be outside. Waystation volunteers were more likely to report a strong motivation of interest in monarchs or desire to help monarchs, and MLMP volunteers were more likely than Waystation and combination volunteers to be very motivated by an interest in science or a desire to help scientists (Table 4).

Discussion

Both MLMP and Waystation volunteers are creating and maintaining habitat for monarchs. Our results align with previous work on the impacts of habitat conservation volunteers, indicating that this type of volunteer work can lead to habitat creation and enhancement (Guiney et al. 2006; Ewing et al. 2013). Our research also shows that citizen science volunteers who participate in site-based projects are likely to create and protect wildlife habitat, providing evidence for the importance of their role in conservation beyond the collection of monitoring data. This result has important implications for the field of citizen science, as many projects involve repeated monitoring of the same site, giving volunteers an opportunity to either create or maintain habitat in order to continue monitoring. In addition to projects like the MLMP, whose participants can create monitoring habitat by planting host plants, other projects can involve habitat creation by adding artificial nesting habitat for bees, birds, and other taxa. Given that the majority of MLMP participants and Waystation volunteers owned and managed their own sites, the individual volunteers had more control over the creation and protection of habitat than would volunteers for citizen science or habitat protection projects that primarily occur on public lands.

While MLMP and Waystation volunteers did not demonstrate a difference in the frequency with which they created new habitat for monarchs, our results found some differences in their conservation strategies. MLMP volunteers tended to protect and maintain rural, existing milkweed sites that weren’t intentionally planted by humans and

were less likely to be weeded or fertilized. Waystation volunteers, on the other hand, were more likely to create or enhance sites specifically for monarchs in more urban areas and to intentionally manage these sites. There was not a statistically significant difference in size between the two types of sites, although there was a trend for MLMP and combination sites to be larger. Larger sites can clearly support more monarchs, and Nail et al. (2015B) found that MLMP sites with more milkweed plants (a proxy for site size) had higher egg through larval survival. However, per plant monarch density tends to be higher in sites with fewer plants (Stenoien et al. 2015).

While there is currently a nationwide public appeal to plant and protect milkweed in all types of rural and urban habitats, it has been suggested that lands found in agricultural areas but which are not under production are especially crucial for monarch conservation (Pleasants 2015). It appears that the MLMP program is slightly better at reaching volunteers in these key rural areas, but that Waystation volunteers are more likely to be involved in the creation of new habitat, and that, by their sheer numbers, they are creating and protecting more habitat. Citizen science or habitat conservation projects that wish to target specific land types for conservation may need to use selective recruitment of volunteers to ensure they are meeting their goals.

The conservation relevance of milkweed diversity is not clear, although we have observed that monarch use of species often varies across the summer. Some species, like *Asclepias syriaca*, are most commonly used early in the season, but when they begin to senesce in early August, monarchs begin to use other species (in our University of Minnesota garden, *A. verticillata* is most commonly used in August).

The presence of the non-native *A. curassavica*, often referred to as tropical milkweed, in many Waystation sites and some MLMP sites is not surprising. It is a common garden plant and in many areas is readily available in garden centers and nurseries. *A. curassavica* has recently become a topic of conservation concern for biologists; in locations without a hard freeze *A. curassavica* does not die back during the winter (Batalden & Oberhauser 2015). The continual presence of *A. curassavica* provides an opportunity for monarchs to breed year-round and has been linked to increased disease prevalence (Satterfield et al. 2015). Additionally, it could potentially interrupt monarchs'

transcontinental migration by inducing them to break their migratory diapause and breed (Batalden & Oberhauser 2015). It is essential to note that our questionnaire was distributed prior to the release of research on the conservation implications of *A. curassavica* (Satterfield et al. 2015; Batalden & Oberhauser 2015). Since the story was well-publicized, including in the New York Times (Gross 2014), it is possible that some individuals who reported having *A. curassavica* have since removed it. Additional research is needed to determine the degree to which the widespread news coverage and outreach about *A. curassavica* has influenced its inclusion in gardens and other monarch habitat.

In addition to the direct habitat conservation associated with the creation and protection of MLMP and Waystation sites, the volunteers we surveyed participated in a number of other types of conservation actions, both on and off their sites. Many respondents maintained or increased their participation in monarch conservation outreach while volunteering. Similar to behaviors of citizen scientists in India (Johnson et al. 2014), most outreach was informal, such as talking to others about monarch conservation, with fewer volunteers engaging in more formal outreach activities like giving presentations or speaking to the media about monarch conservation. The posting of signs at Monarch Waystations emerged as a key part of conservation outreach for Waystation volunteers, suggesting that this technique could be useful for other organizations as well. Informal outreach is valuable, but organizations and projects that want their volunteers to perform more formal outreach activities should provide guidance on how to do so. A recent survey of butterfly citizen scientists from across the United States found that the majority were not receiving information from their project about how to engage in formal outreach like contacting the media or giving public talks (Lewandowski & Oberhauser In Press B, Chapter 2).

There was no clear pattern of difference between habitat and citizen science volunteers' participation in conservation actions outside their projects, despite the fact that Waystation volunteers were more likely to be highly motivated by a desire to help monarchs. It is possible that this difference, while significant, was not large enough to noticeably impact volunteer behavior. Motivation alone is not fully responsible for an

individual's actions or behaviors; factors such as self-efficacy, knowledge, social norms, and situational barriers all play a role in determining whether someone takes action (Hines et al. 1987; Kollmuss & Agyeman 2002; Jensen 2002). The strong conservation focus of both Monarch Watch and the MLMP could supply their volunteers with encouragement and resources to engage in conservation beyond the extent that could be attributed to initial motivation. Bonney et al. (2009) suggested that the more involved a volunteer is in the full experience of scientific research, the more likely they are to change their behavior. The MLMP can be primarily categorized as a contributory citizen science project, meaning that the role of most volunteers is to collect data; some citizen science projects more actively involve volunteers in the design, dissemination, or creation of the project (Bonney et al. 2009). Future research is needed to determine if projects that involve their volunteers in such manners invoke heightened conservation actions among their participants by creating a stronger connection to nature or concern for conservation.

While volunteers who participated in either Monarch Watch or the MLMP were similar in their participation in conservation activities, volunteers from combination sites, who belonged to both programs, were consistently more likely to report participation in conservation activities. Holley (2010) uses the term "super volunteers" to describe the small number of crowd sourcing and citizen science volunteers who contribute the majority of data for a project, and Hames et al. (2012) use the similar concept of "super-volunteers" and "super citizen scientists" to describe citizen scientists who engaged in arduous, complex tasks for their project. Both of these descriptions pertain to the work a volunteer does within a single project, but "super volunteer" could also apply to the volunteers who participate in multiple projects that share a common goal, such as the volunteers from combination sites in this paper. These volunteers make substantial contributions to conservation, and we encourage citizen science and habitat conservation project leaders to recognize the work that they do across projects and to encourage participation in other projects. Positive feedback has been positively correlated with environmentally responsible behavior (reviewed in Hines et al. 1987), making it an easy, effective way to foster continued volunteer commitment to conservation.

Our work provides clear evidence of the conservation efforts of both habitat and citizen science volunteers as a part of, and external to, the programs with which they volunteer. Not only are they creating, improving, and protecting habitat for monarch butterflies and other wildlife, but they are also engaging in formal and informal outreach to promote conservation. Volunteers' willingness to participate in habitat protection and conservation education and outreach makes them substantial partners in conservation management.

Table 1. Percentage of each site type; types are not mutually exclusive. Bold site types with superscripts denote significant ($p \leq 0.05$) pairwise Fisher's Exact Tests with Bonferroni corrections. [1]Significant difference between Waystation and MLMP. [2]Significant difference between Waystation and Combination. [3]Signficant difference between MLMP and Combination.

Site Type	Waystation (n=789)	MLMP (n=48)	Combination (n=79)
Garden[1,2,3]	90.4	45.8	79.7
Old (former) field	11.7	22.9	19.0
Restored or reconstructed prairie[1]	7.6	22.9	12.7
Natural prairie or other natural habitat	9.8	8.3	11.4
Roadside	8.1	12.5	8.9
Agricultural (pasture, field, margin)	10.1	8.3	7.7
Nature preserve	5.4	10.4	8.9
Conservation Reserve Program (CRP)	1.3	4.2	1.3

Table 2. Percentage of respondents performing types of management; types are not mutually exclusive. Bold management types with superscripts denote significant ($p \leq 0.05$) pairwise Fisher's Exact Tests with Bonferroni corrections [1]Significant difference between Waystation and MLMP. There were no significant differences between Waystation and combination or between MLMP and combination sites.

Management Type	Waystation (n=716)	MLMP (n=47)	Combination (n=65)
Weeded[1]	87.7	59.6	76.9
Mowed	47.3	48.9	35.4
Fertilized[1]	34.9	10.6	23.1
"Spot sprayed" unwanted plant species	19.3	21.3	15.4
Tilled	9.1	2.1	10.8
Burned	5.9	10.6	9.2
None	3.8	10.6	9.2
Planted with an agricultural crop	3.2	4.3	1.5

Table 3. Changes in conservation action since joining project, by percentage of respondents. W= Waystation, M=MLMP, and C=combination. Bold action categories with superscripts denote significant ($p \leq 0.05$) pairwise Fisher's Exact Tests with Bonferroni corrections for the response category "more now" compared to "did before, no change" ("same" in the table), "plan to in the future", or "no plans to do this." [1]Significant difference between Waystation and MLMP. [2]Significant difference between Waystation and Combination. [3]Signficant difference between MLMP and Combination.

	W	**M**	**C**		**W**	**M**	**C**		**W**	**M**	**C**
	Decrease Herbicides				Decrease Insecticides				Plant		
	n=683	n=47	n=57		n=676	n=48	n=57		n=695	n=49	n=62
More	33	21	40	More	34	19	35	More	46	41	50
Same	63	68	58	Same	63	69	60	Same	52	45	50
Future	1	2	0	Future	0	2	0	Future	1	4	0
No Plans	3	9	2	No Plans	3	10	5	**No Plans[1]**	1	10	0
	Financial Donations				Post Signs				Involve Others		
	n=621	n=45	n=55		n=677	n=44	n=57		n=651	n=46	n=60
More	36	38	65	More	57	18	60	More	51	57	63
Same	20	11	20	Same	23	7	23	Same	23	17	30
Future[2]	22	9	13	**Future[1,3]**	14	36	9	Future	9	7	3
No Plans[2,3]	22	42	2	**No Plans[1,3]**	5	39	9	**No Plans[2]**	17	20	3

Table 3 continued

	Talk Informally				Encourage Planting				Give Presentations		
	n=679	n=47	n=59		n=689	n=48	n=61		n=629	n=46	n=54
More	59	62	69	More	54	58	59	More	24	17	52
Same	32	30	27	Same	40	27	39	Same	14	17	15
Future	3	4	3	Future	4	6	2	Future	16	22	15
No Plans	5	4	0	No Plans	2	8	0	**No Plans**[2,3]	45	43	19

	Contact Media				Speak Out				Advocate		
	n=609	n=44	n=52		n=619	n=46	n=50		n=641	n=48	n=52
More	16	11	48	More	20	20	44	More	30	27	54
Same[3]	12	25	10	Same	20	22	14	Same	36	40	31
Future[2]	16	11	12	Future	21	15	24	Future	15	6	10
No Plans[2,3]	56	52	31	**No Plans**[2,3]	38	43	18	**No Plans**[2,3]	19	27	6

Table 4. Importance of motivations in initial participation in MLMP or Waystation program. W= Waystation, M=MLMP, and C=combination. Bold action categories with superscripts denote significant ($p \leq 0.05$) pairwise Fisher's Exact Tests with Bonferroni corrections for the response category "very important" compared to "slightly important" or "not important." [1]Significant difference between Waystation and MLMP. [2]Significant difference between Waystation and Combination. [3]Signficant difference between MLMP and Combination.

	W	**M**	**C**
	Nature		
	n=714	n=49	n=63
Very Important	96	94	98
Slightly Important	3	6	2
Not Important	0.4	0	0

	W	**M**	**C**
	Being Outside		
	n=692	n=46	n=62
Very Important	78	80	79
Slightly Important	19	13	18
Not Important	3	7	3

	Monarchs		
	n=713	n=48	n=62
Very Important	96	85	92
Slightly Important[1]	4	15	8
Not Important	0.3	0	0

	Helping Monarchs		
	n=713	n=48	n=61
Very Important	96	83	95
Slightly Important[1]	4	15	3
Not Important	0	2	2

	Helping Scientists		
	n=649	n=49	n=61
Very Important	49	76	74
Slightly Important[1,2]	43	22	20
Not Important	9	2	7

	Learning about Science		
	n=650	n=47	n=60
Very Important	50	77	70
Slightly Important[1,2]	40	13	25
Not Important	11	11	5

Table 4 continued

	Learning Opportunities for Children		
	n=675	n=47	n=59
Very Important	62	43	73
Slightly Important[3]	25	38	14
Not Important	13	19	14

Figure 1a.

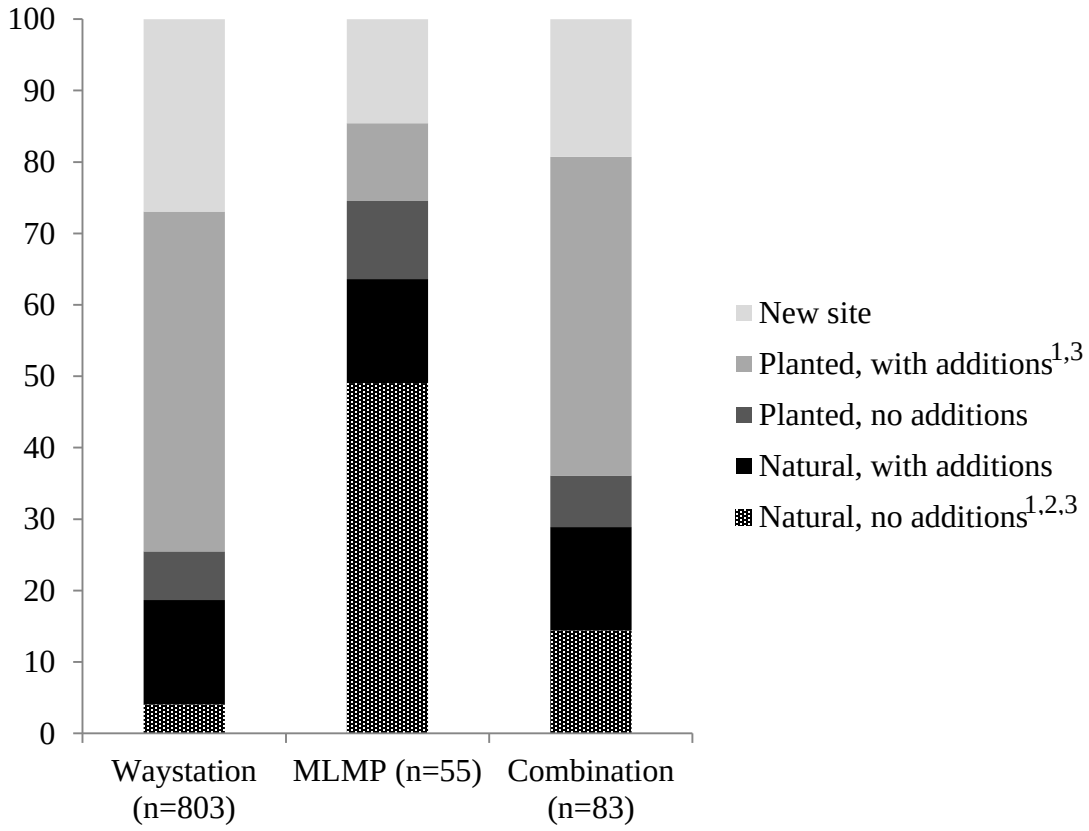

100
90
80
70
60
50
40
30
20
10
0
Waystation (n=803)
MLMP (n=55)
Combination (n=83)
New site
Planted, with additions[1,3]
Planted, no additions
Natural, with additions
Natural, no additions[1,2,3]

Figure 1b.

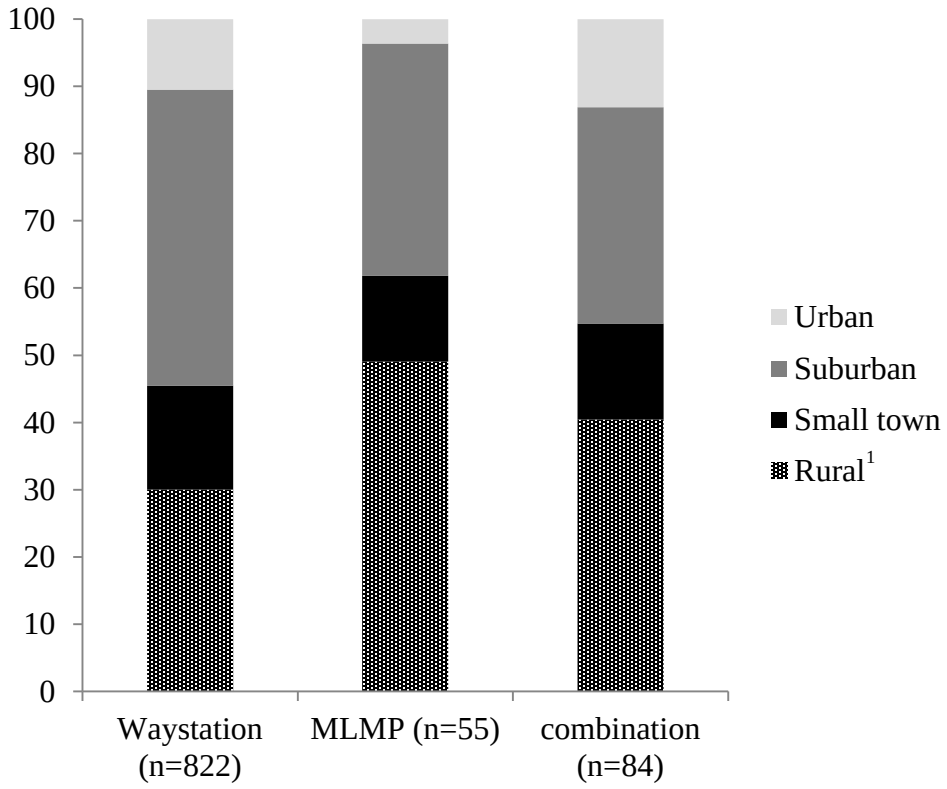

100
90
80
70
60
50
40
30
20
10
0
Waystation (n=822)
MLMP (n=55)
combination (n=84)
Urban
Suburban
Small town
Rural[1]

Figure 1c.

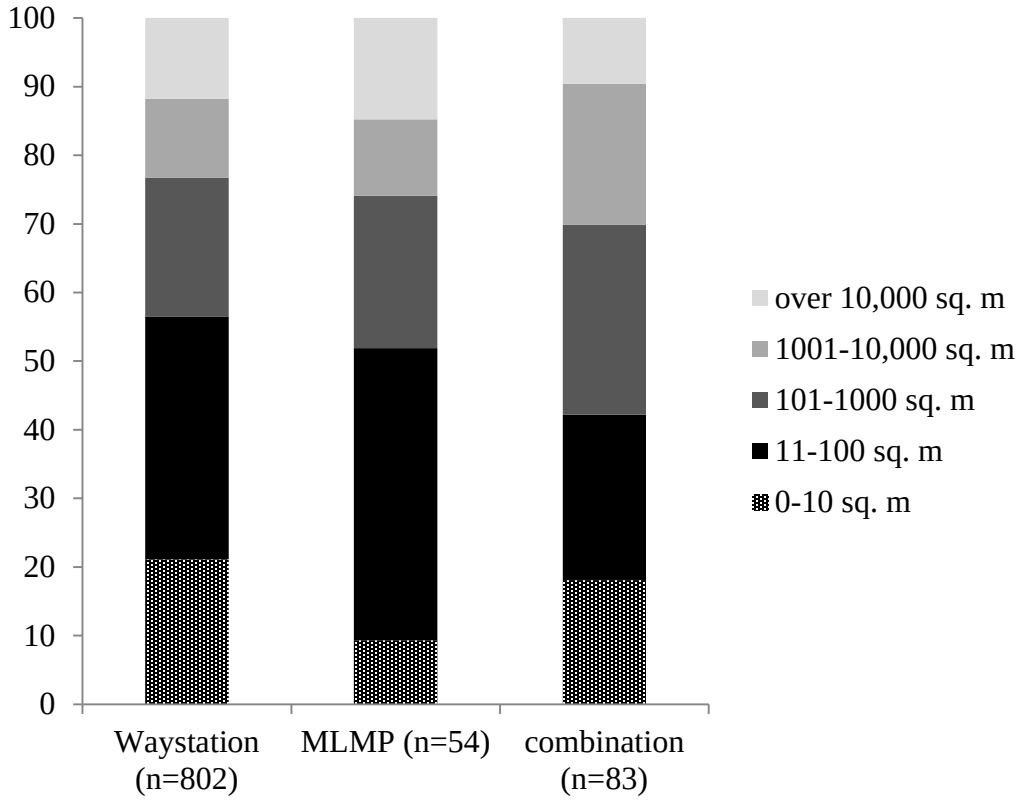


Figure 1a. Creation, 1b. Location, and 1c. Size of site by percentage. Superscripts denote significant ($p \leq 0.05$) pairwise Fisher's Exact Tests with Bonferroni corrections [1]Significant difference between Waystation and MLMP. [2]Significant difference between Waystation and Combination. [3]Signficant difference between MLMP and Combination.

Chapter 4: Evaluation of the conservation education efforts of the Monarch Larva Monitoring Project

Introduction

One of the benefits of nature-based citizen science projects is their potential to educate their volunteers about environmental or conservation issues and create pro-environmental behavior change among those volunteers. Butterfly citizen science projects in the United States tend to have a conservation education component; most share conservation information with their volunteers and many actively encourage their volunteers to participate in conservation actions (Lewandowski & Oberhauser In Press A, Chapter 1).

Our research has shown that most butterfly citizen scientists, including volunteers with the Monarch Larva Monitoring Project (MLMP) increase their involvement in conservation actions after joining citizen science, and that this increase is correlated with projects providing their volunteers with information on conservation issues, encouraging them to participate in conservation, and creating a sense of connection and community among volunteers (Lewandowski & Oberhauser In Press B, Chapter 2). These results are in keeping with theory and research from environmental education, which indicates that knowledge of issues and action strategies, behavioral incentives, positive feedback, and social connections can all influence behavior change (reviewed in Jensen 2002; Bamberg & Möser 2007).

While most MLMP volunteers report that they change their participation in monarch conservation in some way after joining the project, there are many aspects of conservation for which many or most volunteers do not change their actions (Chapter 3). This evaluation of the MLMP's programming explores how effectively the MLMP is using its education and outreach opportunities to support conservation actions among its volunteers.

Evaluation Objective & Audience

Here, I examine the conservation education programming of the MLMP, from summer 2013 to summer 2015, in order to inform MLMP staff and offer recommendations for improvement of the programming. MLMP staff includes full-time staff members in the University of Minnesota Monarch Lab, which runs the MLMP, as well as graduate students in the lab, including myself, who regularly contribute to the day-to-day operations and management of the project. The evaluation addresses the following questions:

1. To what extent is the MLMP providing its citizen scientists with educational content about key monarch conservation topics?
2. To what extent is the MLMP actively encouraging its citizen scientists to participate in monarch conservation?
3. To what extent is the MLMP working to create a sense of community or connection among volunteers, in order to promote monarch conservation?

MLMP Overview

The Monarch Larva Monitoring Project is a citizen science project run by the University of Minnesota's Monarch Lab. The purpose of the project is to understand how populations of the monarch butterfly (*Danaus plexippus*) vary in time and space. MLMP volunteer regularly survey patches of milkweed across North America to assess the density of monarch eggs and larvae, and submit their results online. Some volunteers participate in additional studies, such as rearing larvae to adulthood and recording rates and causes of mortality.

The MLMP's mission statement does not explicitly include conservation; however, MLMP resources routinely mention conservation, such as this statement on the project website, "your contributions will aid in conserving monarchs and their threatened migratory phenomenon, and advance our understanding of butterfly ecology in general" (MLMP 2015). Furthermore, the University of Minnesota Monarch Lab has a strong conservation focus, and Monarch Lab staff and students routinely engage in conservation

science, education, and outreach. Because of this conservation focus, the MLMP seeks to educate its volunteers about issues relevant to monarch conservation.

The North American population of the monarch butterfly has been declining recently, with a reduction of approximately 90% in the eastern population (Brower et al. 2012; Rendon-Salinas et al. 2015) and a somewhat less substantial decrease in the western population (reviewed in Jepsen & Black 2015). Monarchs face many conservation challenges, most notably habitat loss or alteration (Pleasants & Oberhauser 2013), disease (Satterfield et al. 2015), and climate change (Barve et al. 2012; Nail et al. 2015A). Because monarchs can use even small habitat patches, individual citizens have the potential to play a significant role in their population recovery (Shahani et al. 2015), and thus actions by participants in citizen science programs can make a difference.

MLMP Programming

There are four main components of MLMP programming that have the potential to educate volunteers about monarch conservation: volunteer training, e-newsletters, the project's website www.mlmp.org, and social media. These outputs also have the potential to be used to encourage MLMP volunteers to participate in conservation and to create connections between volunteers.

MLMP volunteers can learn how to monitor and submit data in a number of different ways. Many volunteers attend formal training sessions hosted either by the Monarch Lab or by a regional trainer; these training sessions can range in duration from a half day to several days. Others learn on their own, by reading instructions on the MLMP website or watching a series of online training videos that total approximately 45 minutes in length. In addition, some volunteers learn informally from others.

MLMP e-newsletters contain updates on the status of the monarch population, reminders about or notices of changes to MLMP protocols, features on MLMP volunteers, and information about monarch conservation. The newsletters are sent 4-8 times each year to both MLMP volunteers and non-volunteers. To receive the e-newsletter, recipients sign up by providing their email address. Individuals can sign up directly from the MLMP website, and newly registered volunteers receive an email with a

link the e-newsletter sign-up form. Newsletter recipients receive an email with a summary of that issue's articles; they can click on a link in any of the summaries to access the full newsletter. The newsletter is also available on the MLMP website, so it is accessible to those who do not receive it via email.

The MLMP website is the primary interface for volunteers to access the project. To submit data, volunteers must create an account and log in. In addition to a data entry interface, the website contains an overview of the project, datasheets and monitoring instructions, monitoring results, and general information about monarchs and monarch conservation. The website links to the general Monarch Lab website, www.monarchlab.org, which contains additional information on monarchs and conservation.

The MLMP has a Twitter account, @MLMPCitSci, and a Facebook account, www.facebook.com/monarchsMLMP, both of which are managed by MLMP staff. The social media pages are used to broadly share news and information about monarchs, milkweed, conservation, citizen science, and project updates.

Evaluation materials and methods

Data for this evaluation come from a number of sources. At training events, participants completed pre- and post-training questionnaires (Appendix 4), which provided the bulk of the data on training. An online evaluation is available for people who complete the online training. Additionally, a 2013 online survey sent to all MLMP volunteers (described in detail in Chapter 3) also yielded information pertaining to training and volunteering in groups. In 2015, MLMP staff members provided information about the goals and management of the MLMP. Finally, I analyzed the MLMP website, e-newsletters, and social media for monarch conservation content.

Program Outputs

Training

In our 2013 survey of MLMP participants, we asked volunteers how they had learned to monitor with MLMP. Of the 99 respondents, the majority (n=57, 58%) learned

through the online resources, while 37% (n=37) attended a training session and 20% (n=20) learned informally from someone else; options were not mutually exclusive. Of the 57 respondents who reported learning to monitor online, 47 cited online resources as their sole means of training.

Neither the online training videos nor the monitoring datasheets' instructions contain significant mention of monarch conservation. In contrast, the in-person training sessions conducted by MLMP staff cover the recent decline in the monarch population, the role of habitat loss and pesticide use in that decline, and the importance of creating and maintaining monarch habitat. The discussion of other conservation issues, such as disease and climate change, varies from event to event.

Between 2013 and 2015, 46 individuals completed the questionnaire about the online training. When asked to what extent the training had taught them about monarch biology, prepared them to monitor for monarchs, and prepared them to engage in monarch conservation, most responded with "greatly" or "moderately" (Figure 1a).

The MLMP administered pre- and post- training questionnaires at 11 in-person training events between 2013 and 2015. These trainings were conducted in Minnesota, Texas, Nevada, and Idaho; they were attended by a total of 316 individuals.

In the pre-training questionnaire, participants were asked to describe their learning goals for the training (Figure 2). The most prevalent learning goals were related to monarch biology, including life cycle, rearing, identification, and migration. Many learning goals also centered on conservation, including learning how to help monarchs or create habitat. Relatively few participants cited learning about citizen science or how to monitor with the MLMP as a learning goal.

The post-training questionnaire asked to what extent the training had taught participants about monarch biology, prepared them to monitor for monarchs, and prepared them to engage in monarch conservation (Figure 1b). Fisher's exact tests revealed that the results of these questions were not significantly different for people who had taken the online compared to in-person training ($p>0.05$). Participants were also asked about their plans to create habitat for monarchs and advocate for monarch conservation. In both cases, 45% of participants reported that they planned to begin the

year they took the training and over a third reported that they planned to continue or increase their existing efforts in these areas (Figure 3).

E-newsletter

The number of individuals who subscribe to the MLMP e-newsletter increased from 1060 at the beginning of 2013 to 1381 when the summer 2015 newsletter was released. The percentage of recipients who opened the email containing the newsletter summary remained fairly steady, with an average of 40%; around 14% of recipients generally clicked through to the full version of the newsletter. Because anyone can register to receive the MLMP e-newsletter, it is unknown what proportion of recipients or of those who read the newsletter are MLMP volunteers.

Of the 12 e-newsletters released during the time period covered by this evaluation, 11 contained at least one story that was relevant to, or specifically focused on, monarch conservation. Most of these conservation-related stories centered on habitat loss, habitat conservation, and the importance of host and nectar plants for monarchs, as well as the role of disease in both monarch and milkweed populations (Figure 4).

Most articles were purely factual, either generally describing conservation topics or highlighting the actions of specific volunteers who had engaged in monarch conservation. A few articles specifically called for action on the part of readers by encouraging them to make monetary donations, initiate media coverage, or plant host and nectar plants for monarchs.

Website

In addition to archiving copies of the e-newsletters, the MLMP website contains a variety of information on monarch conservation. The main page makes clear the project's goal of conserving monarchs and the monarch migration. The website also contains a list of journal articles that make use of MLMP data, and several of those have a conservation focus; the majority of the articles are available to download from the website. Visitors to the website may also view or download the North American Monarch Conservation Plan (Commission for Environmental Cooperation 2008), a tri-national report that details the

historical and current threats to the monarch butterfly and the strategies being used to combat them. In addition, the MLMP website contains several resources to assist volunteers with conservation education and outreach, including educational posters and a handout on how to reach out to the media, which was added in 2014.

Several potential sources of conservation information on the MLMP website are substantially out of date as of August 2015. For example, there are PowerPoint presentations available for download on monarch biology and MLMP goals that were made in 2003. Many key issues in monarch conservation have emerged since then, including the rapid decline in the Mexican overwintering population (Brower et al. 2012), the role of the non-native *Asclepias curassavica* in monarch disease prevalence (Satterfield et al. 2015), and the impact of planting genetically modified, herbicide-resistant crops on monarch habitat (Pleasants & Oberhauser 2013). The website also contains a blog, which has the potential to be used to disseminate conservation information, but which has not been updated since 2011.

The navigation menu on the top of the MLMP website contains a link to the Monarch Lab website, www.monarchlab.org (Figure 5). The Monarch Lab website contains a variety of information on monarch conservation, including a description of conservation threats and action strategies, as well as population status updates, copies of conservation-related research publications, and links to external conservation resources.

Social Media

The MLMP joined Facebook in January 2012; by August 2015, over 1600 Facebook users had liked the general MLMP Facebook page, meaning that MLMP posts would appear in their account's News Feed. In March 2015, the MLMP created a Twitter account. By August 2015, the account had over 250 followers (Twitter users who have "subscribed" to tweets from the MLMP). The MLMP's Facebook and Twitter accounts are public, so it is not necessary to like or follow the organization in order to read its social media posts.

The goals and intended audiences for the Twitter and Facebook accounts are slightly different. According to MLMP staff, the goal of the MLMP Twitter account is to

maintain and increase monarch and citizen science knowledge within the MLMP community, and to encourage people to join MLMP; its primary audience is MLMP volunteers and existing citizen scientists from other projects who might be recruited for MLMP. The Facebook account is primarily intended to provide resources and knowledge for those who facilitate or run MLMP activities, such as staff at nature centers that host an MLMP monitoring site. It is not known how many Facebook and Twitter followers are existing MLMP volunteers, but MLMP social media staff believe that the majority of users who regularly interact with the MLMP on Facebook are existing volunteers, while the Twitter account is followed by a broader audience.

While the MLMP's social media goals do not specifically include promoting conservation, MLMP staff actively share monarch conservation information through both venues. MLMP's Facebook account is used more heavily to relay conservation information, while the Twitter account is more focused on citizen science. Both accounts most frequently relay conservation information about creating monarch habitat and the importance of native nectar and host plants. MLMP staff also use social media to share information on monarch population updates, habitat loss, disease, and pesticides. Neither account provides information on climate change or on how members of the public can engage in conservation outreach of their own or make financial contributions.

MLMP staff members do not usually use social media to directly encourage people to participate in conservation. While the Facebook and Twitter accounts might describe opportunities to engage in conservation or highlight the work of volunteers who practice monarch conservation, posts generally do not directly request that people take conservation action, nor do they offer incentives to those who do so.

Social media offer individuals opportunities to meet and interact online, and people have the option of replying to comments made by others and engaging in dialogue with them. Knowing this, MLMP staff attempt to build connections between social media followers, especially on Twitter. Staff report that social media seems to be a useful tool in building connections between individuals and the MLMP, but they are uncertain of the strength or number of connections formed between individuals.

Recommendations

The MLMP provides its volunteers with monarch conservation information through all four of the outputs considered here: training, e-newsletters, website, and social media. However, there is room for growth in the breadth and depth of topics covered. Furthermore, there is untapped potential for actively encouraging volunteers to engage in conservation and helping them to connect with each other and develop a sense of community.

MLMP education outputs focus more on some conservation topics than on others. For instance, the importance of habitat conservation, and specifically of native nectar and milkweed plants, was consistently addressed across almost all MLMP programming. One possible explanation for this focus on habitat is the fact that the MLMP is a site-based monitoring project, meaning that volunteers interact with one piece of land on a weekly basis, which provides clear opportunities for maintaining or improving that area of habitat. Additionally, this focus aligns with the central message being communicated to the public about monarch conservation, which is the need for more monarch habitat (Borders & Lee-Mader 2015). The exception to the MLMP's habitat focus was the online training video, which could perhaps be improved by adding a segment on habitat conservation or by providing links to existing resources at the end of the video or on the webpage that contains the video.

While issues of habitat conservation were well-covered, the topic of climate change was seldom addressed in the MLMP's outputs. Climate change is listed as one of five factors contributing to the decline of monarchs in the North American Monarch Conservation Plan (Commission for Environmental Cooperation 2008), and recent work has addressed the potential effects of climate change on monarchs (Zalucki et al. 2015; Nail et al. 2015), suggesting that climate change might be a relevant topic for MLMP's conservation education outputs.

Information on making financial donations to conservation and engaging in outreach about monarch conservation were also seldom found in MLMP materials. If MLMP staff feel it is appropriate to request or encourage citizen science volunteers to make financial donations, they could do so through social media, e-newsletters, or by

posting instructions on how to donate on the project website. Both the MLMP website and the e-newsletter would be appropriate venues for information on how to engage in conservation outreach, such as tips on how to conduct garden tours or downloadable PowerPoint presentations for use at public talks. Links to this type of information could also be posted on both Twitter and Facebook.

In our previous work on butterfly citizen science, 57% of volunteers reported that they preferred to receive conservation information from their project through online communications, such as email and social media, and 24% stated that they preferred to receive conservation information through their project's website (Lewandowski & Oberhauser In Press B, Chapter 2). This strong preference for online conservation content, coupled with the large number of volunteers who complete their training and enter their data online, highlights the importance of making monarch conservation information easily accessible through the MLMP website, e-newsletter, and social media accounts. The breadth of content in the e-newsletters and on social media could be widened, and there are a number of ways in which the MLMP website could be improved. For instance, the website could be changed by replacing out-of-date content with more current information, expanding the number of topics covered, or consistently and clearly directing website visitors to the Monarch Lab website, which contains extensive information on monarch conservation.

Most of the references to conservation in the MLMP's outputs are purely informational, but previous work has shown that exposure to educational information is not the only factor that is correlated with increased engagement in butterfly conservation among citizen scientists; direct encouragement from a project is also relevant (Lewandowski & Oberhauser In Press B, Chapter 2). Furthermore, MLMP Director Karen Oberhauser has acknowledged the project's role in encouraging conservation; in one of the few instances of a direct call to action, she wrote, "It's my hope that the MLMP does not become a tool that simply records the demise of monarchs. Rather, it should be a tool that energizes people to do what they can, and helps us understand the best ways to help monarchs survive in a changing world" (Oberhauser 2013, p2). Her

statement was preceded in the text by a list of things MLMP volunteers can do for monarchs.

While direct appeals for participation in monarch conservation are not common among MLMP outputs, there are a number of indirect forms of encouragement. For instance, MLMP newsletters routinely highlight the conservation efforts of citizen scientists, suggesting that such actions are appreciated or acclaimed by MLMP staff. Social media posts that contain stories about individual conservation actions are framed in a positive light, and some might take the mere sharing of such stories as tacit encouragement to engage in similar behaviors.

If the MLMP chooses to engage in more direct forms of encouragement, it could easily do so with appeals in e-newsletters and on social media. If the blog on the MLMP website is revitalized, it could also be used as a place to encourage volunteers to engage in conservation, including activities like creating habitat with native plants, following specific rearing conditions to minimize disease, and testing adult monarchs for disease. Direct appeals for conservation action during in-person trainings might be considered less appropriate than in other venues, considering that attendees often pay a registration fee in order to attend these educational courses and might not want the trainers to stray from purely factual teachings. On the other hand, since conservation was the second most common learning goal for training attendees, they might be receptive to direct requests to engage in conservation.

In addition to active encouragement from a project, a sense of connection or community with other volunteers can has also been linked to increased engagement in conservation by butterfly citizen scientists (Lewandowski & Oberhauser In Press B, Chapter 2). In-person trainings provide opportunities for prospective volunteers to meet and interact, and highlighting individuals in an e-newsletter has the potential to make people feel a connection to someone they've never met; both of these activities should be maintained or increased. MLMP staff use social media to create connections as well. In our 2013 survey of MLMP volunteers, the importance of a strong online presence was emphasized by a respondent, who wrote "In 1981 when I was 10 and just starting to rear monarchs, I had no way to be in contact with other people interested in this. It is soooo

much better now with the internet you can connect with groups and be involved in ways I never imagined." Notably, our 2013 survey also revealed that over half (55%) engaged in monitoring activities in groups. Collecting MLMP data in groups provides volunteers with an opportunity to form connections with each other outside of the MLMP's educational efforts. To encourage more group work or connections between closely located volunteers, the MLMP could facilitate meetings between volunteers who live in the same region.

The MLMP is using its programming to share educational content about some key conservation issues with volunteers. The conservation education efforts of the project could be strengthened by expanding coverage of topics like climate change and conducting outreach. To foment conservation change among its volunteers, MLMP should also increase the extent to which it actively encourages conservation and assists volunteers in connecting with one another. Expanding its programming in these areas has the potential to increase the role of MLMP volunteers in conservation.

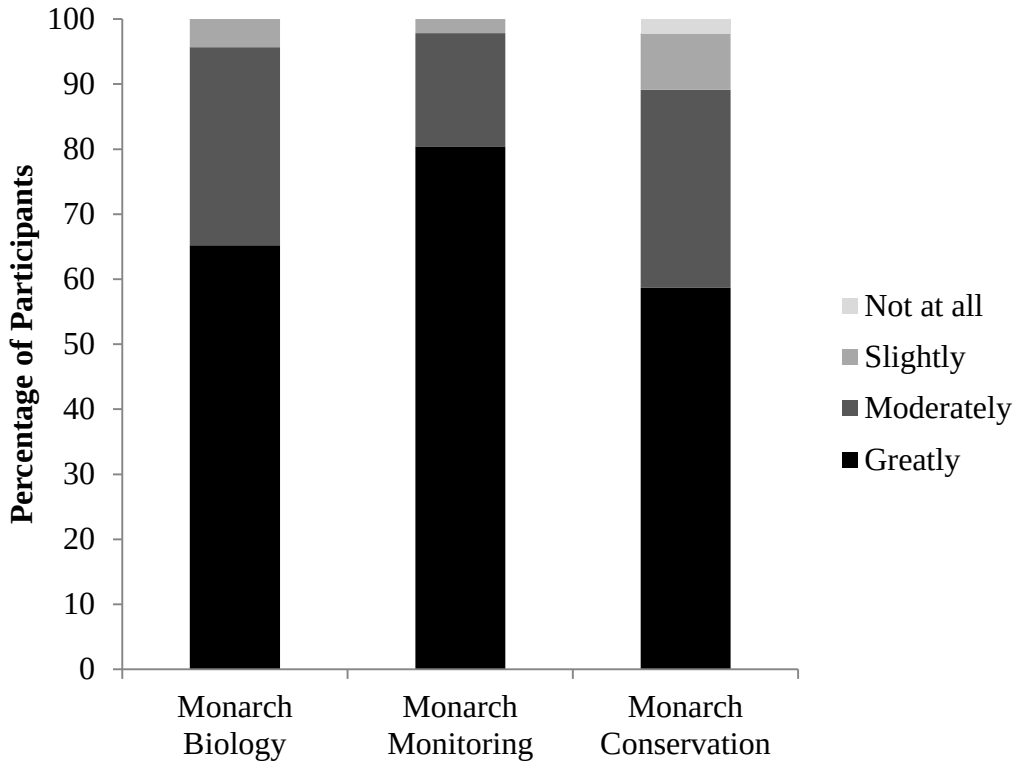


Figure 1a. Percentage of online training participants who reported that the training had taught them about monarch biology, monarch monitoring, and monarch conservation. N=46

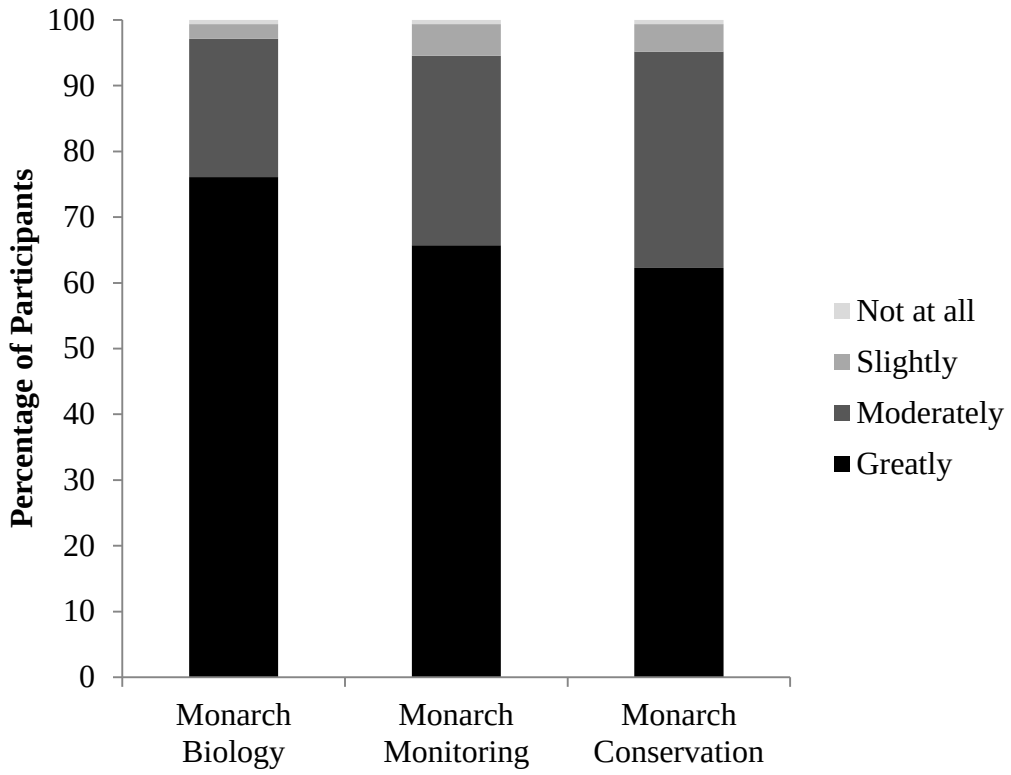


Figure 1b. Percentage of in-person training participants who reported that the training had taught them about monarch biology, monarch monitoring, and monarch conservation. N=314

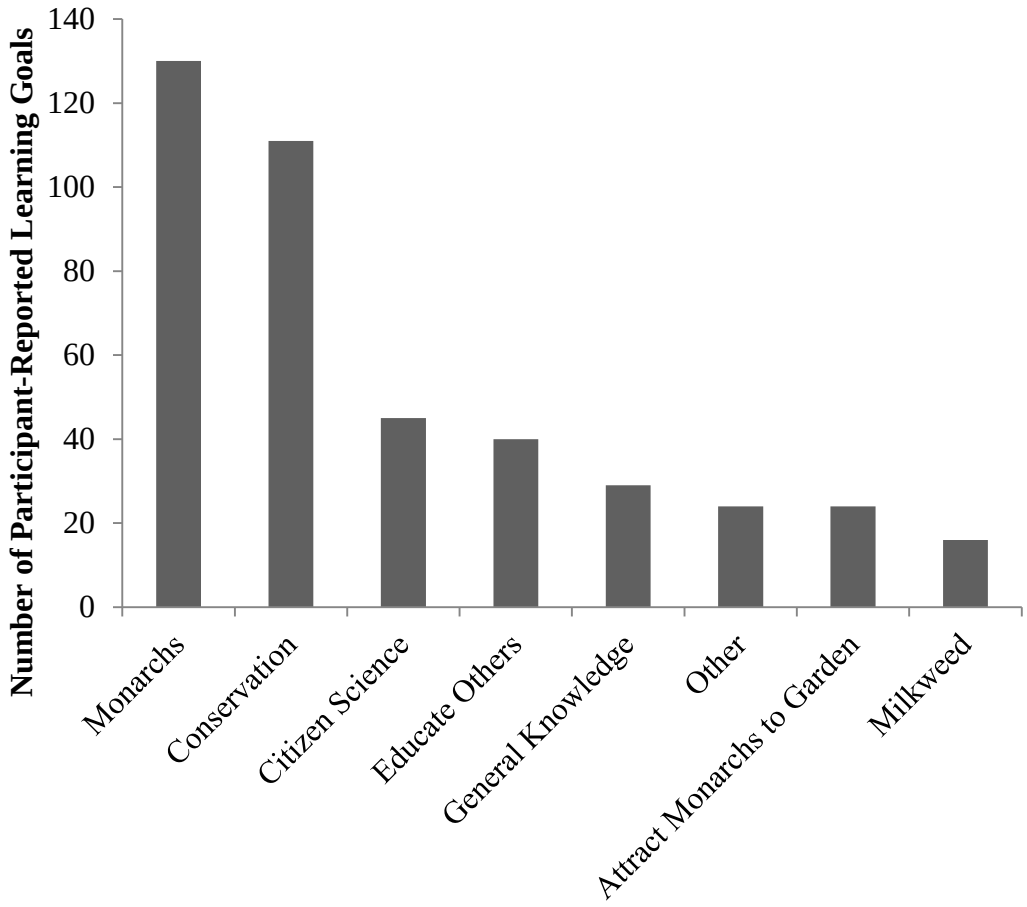


Figure 2. Participant learning goals reported in the pre-training questionnaire. Some participants had multiple learning goals.

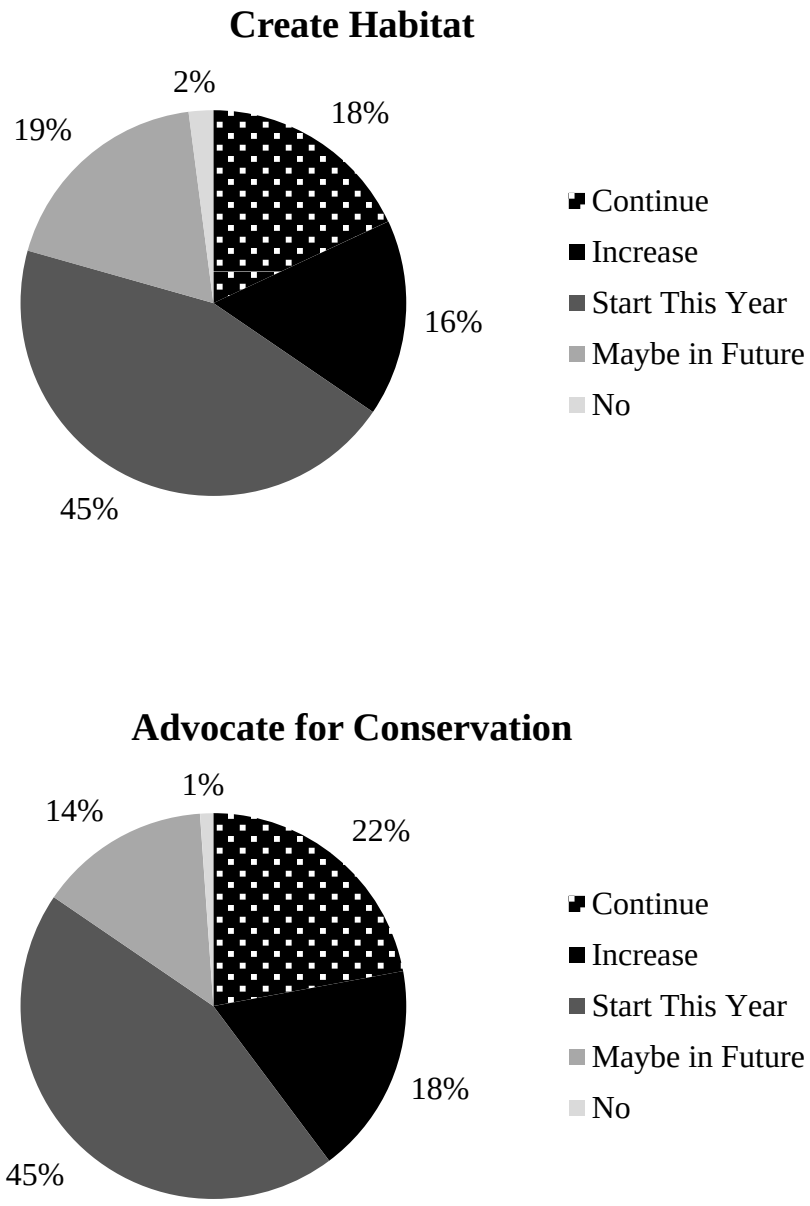


Figure 3. Percentage of participants who plan to engage in conservation by creating habitat and advocating for conservation. Data are from post-training questionnaire; n=194.

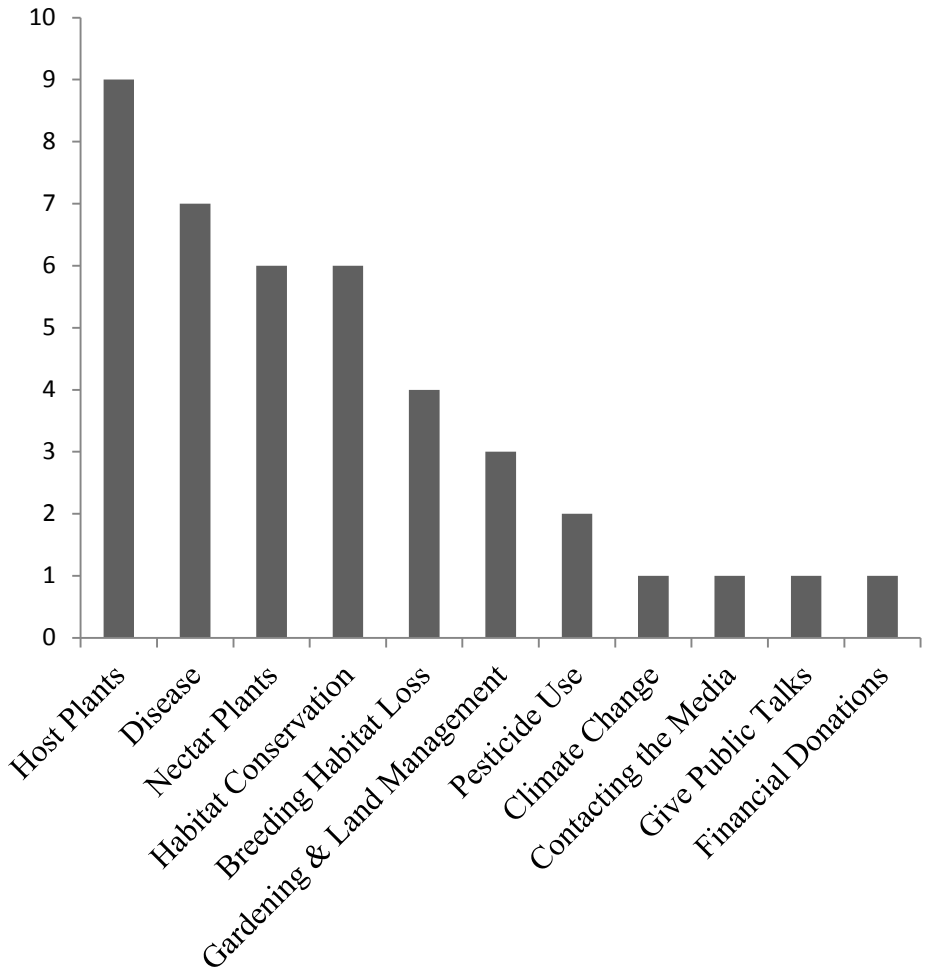


Figure 4. Number of stories mentioning conservation topics in MLMP newsletters from 2013 to 2015.

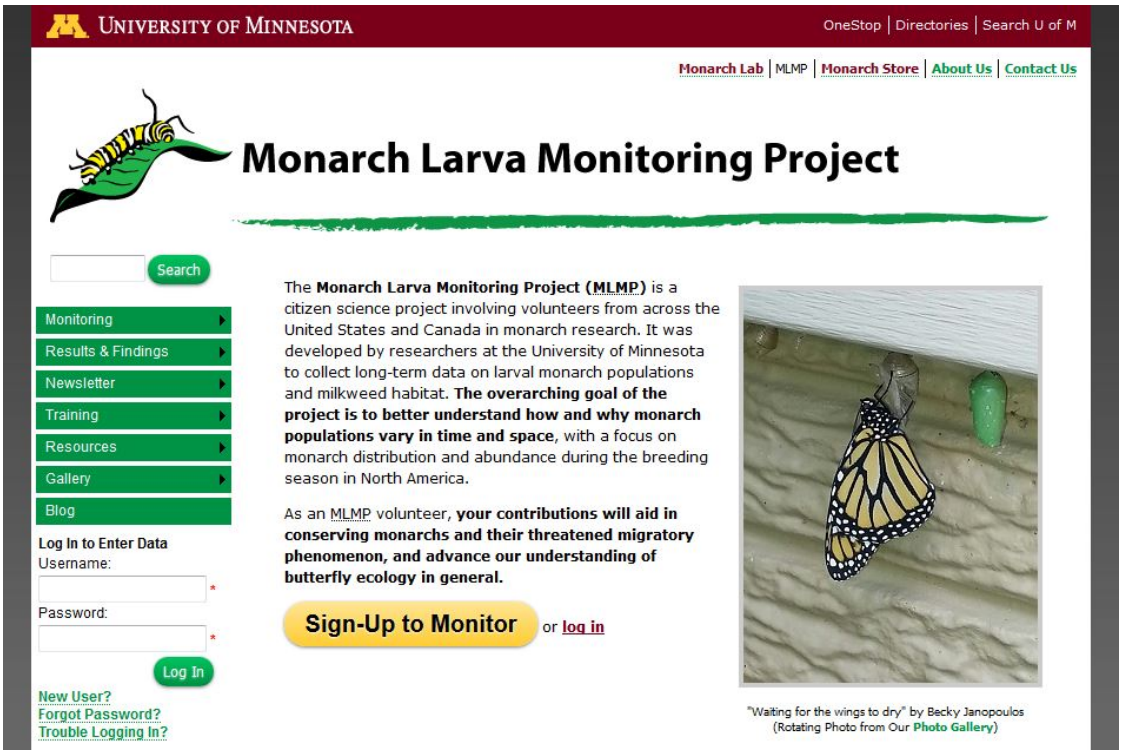


Figure 5. Screenshot of the top portion of MLMP website. The link to the Monarch Lab website is along the top right.

Conclusion

Throughout my research, communication emerged as a central theme; communication serves as both an input and an output when considering citizen scientists' participation in conservation. Communication between project managers and volunteers can foster volunteers' engagement in conservation and provide managers with guidance and feedback for the improvement of citizen science projects. Communication between volunteers, either facilitated by the project or not, has the potential to create social ties between volunteers and support the sharing of practical conservation information. Finally, communication from volunteers to other members of the public who do not participate in citizen science can make an extremely valuable contribution to conservation education and outreach.

Chapters 1 and 2 provided information about how butterfly citizen science projects are currently communicating with volunteers, and how they can improve their communication efforts. The communication strategies of citizen science projects need to take into account both content, such as ensuring they provide information on a full range of conservation topics, as well as method of delivery. Butterfly citizen scientists, for example, showed a clear preference for receiving conservation information through online channels (Lewandowski & Oberhauser In Press B, Chapter 2). There are a number of media that project managers can use to foster feedback, questions, and other communications from volunteers; these include online surveys, questionnaires at in-person events, social media, and email.

Providing butterfly citizen science volunteers with a way to contact each other was found to be correlated with volunteers developing a sense of connection with each, which in turn has the potential to influence conservation action (Lewandowski & Oberhauser In Press B, Chapter 2). While communication between volunteers certainly does not need to be facilitated by a project, doing so can be a fairly straightforward task for project managers with clear benefits to conservation, the project, and the citizen science volunteers.

It is evident from both Chapters 2 and 3 that butterfly citizen science volunteers are engaging in conservation education and outreach, as are habitat volunteers. This communication from volunteers to other members of the public has the potential to play a pivotal role in conservation outreach. As with communication between volunteers, communications between volunteers and the rest of the public does not need to be facilitated by a citizen science project. However, there are ways in which project managers can assist volunteers in their communication efforts. Providing educational materials such as handouts, presentation slides, or visual aids can eliminate barriers that volunteers might face in finding high quality resources, and providing information on how to engage in outreach, such as tips for giving a talk or contacting the media, can be of use as well.

Citizen science is often viewed as a means to engage the public in science (e.g. Conrad & Hilchey 2011; Dickinson et al. 2012; Bonney et al. 2015), and Bickford et al. (2012) cite citizen science as a way for professional scientists to communicate with the public specifically about conservation. However, explicit recommendations for communicating about conservation with the public are few and far between (but see Nadkarni 2004; Shanley & López 2009; Bickford et al. 2012). Furthermore, research on citizen scientists communicating about conservation or environmental issues is even sparser (Johnson et al. 2014; Lewandowski & Oberhauser In Press B, Chapter 2). This dissertation only begins to fill in the gaps in our knowledge about the role of communication in promoting conservation action among citizen scientists and the behaviors of the volunteers. However, the results of my research provide strong evidence that communication strategies that involve project-specific conservation information, active encouragement to engage in conservation, and resources for volunteers to connect with each other can be effective in promoting conservation actions among citizen scientists, and that citizen scientists themselves can have a role in communicating with the public about conservation. Considering the impact of communication on citizen scientists' contributions to conservation will allow researchers and citizen science practitioners to more fully understand and support those contributions. Given the

increasing popularity of citizen science in the field of conservation, any strategy that has the capacity to strengthen the conservation outputs of citizen scientists is a valuable tool.

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Appendix 1: Online Questionnaire for Project Leaders (Chapter 1)

Online Questionnaire

Thank you for taking the time to help with this survey! You have been asked to participate in the survey because you are listed as a project leader for a butterfly citizen science project.

The survey focuses on the conservation and educational components of citizen science projects that deal with monarchs or butterflies in general. Your perspective is valuable, and the information you provide here will contribute to our research at the University of Minnesota on the role that citizen science projects have in promoting conservation activities among their volunteers.

Participation in this survey is voluntary and will take about 15 minutes. The risks and benefits associated with participation are minimal. Your decision to take or not take this survey will not affect your relationship with the University of Minnesota or the Monarch Lab. Your answers will be completely anonymous. If you have any questions or comments, please feel free to contact Eva Lewandowski at lewan121@umn.edu. Thank you,

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What organism is the focus of your citizen science project?

- ❍ Monarchs
- ❍ Butterflies in general
- ❍ Other (please list) _____

What activities do citizen science volunteers do for your project? Check all that apply.

- ❑ Record individual butterfly sightings
- ❑ Conduct one-time butterfly counts or surveys
- ❑ Repeated monitoring for butterflies (at any life stage)
- ❑ Collect habitat or environmental data (plant species present, temperature, rainfall, etc.)
- ❑ Other (please describe) _____

Is monarch or butterfly conservation part of your citizen science project's mission or long-term goals?

- ❍ Yes
- ❍ No

What are the goals of your organization?

What are the goals of your citizen science project?

Does participation in your citizen science project require volunteers to engage in activities that directly impact monarch or butterfly conservation, such as planting nectar or host plants?

- ❍ Yes
- ❍ No
- ❍ Sometimes/It depends

Do you provide your citizen science volunteers with information about monarch or butterfly conservation topics?

- ❍ Yes
- ❍ No

Does your citizen science project actively encourage its participants to engage in conservation activities outside of your project?

- ❍ Yes
- ❍ No

How do you provide your citizen science volunteers with information about the following threats to monarch or butterfly populations? Check all that apply.

	Print materials (handouts, newsletter, pamphlets, etc.)	**Project website**	**Direct online communication (email updates, e-newsletters, etc.)**	**In person during training or other events**	**Do not supply information on this topic**
Breeding habitat loss	❑	❑	❑	❑	❑
Overwintering habitat loss	❑	❑	❑	❑	❑
Disease and parasites	❑	❑	❑	❑	❑
Climate change	❑	❑	❑	❑	❑
Pesticide use	❑	❑	❑	❑	❑

How do you provide your citizen science volunteers with information about the following monarch or butterfly conservation activities? Check all that apply.

	Print materials (handouts, newsletter, pamphlets, etc.)	**Project website**	**Direct online communication (email updates, e-newsletters, etc.)**	**In person during training or other events**	**Do not supply information on this topic**
Planting native nectar plants	❑	❑	❑	❑	❑
Planting native host plants	❑	❑	❑	❑	❑
Butterfly-friendly gardening strategies (fewer pesticides, herbicides, mowings)	❑	❑	❑	❑	❑
Habitat conservation	❑	❑	❑	❑	❑
Contacting the media	❑	❑	❑	❑	❑
Giving public talks or presentations	❑	❑	❑	❑	❑
Opportunities for financial contributions	❑	❑	❑	❑	❑

What methods do you use to encourage participation in conservation activities outside of your project? Check all that apply.

- ❑ In-person requests at trainings or other events
- ❑ Written requests via email or mailings
- ❑ Acknowledgment of people who engage in conservation activities in newsletters, on the website, at project meetings or trainings
- ❑ Contests or prize drawings for individuals who engage in conservation
- ❑ Other (please describe) _____
- ❑ None

Do you believe that participation in your citizen science project increases participants' engagement in conservation behaviors? Please explain.

Do you provide your citizen science volunteers with information about other environmental or nature-based citizen science projects?

❍ Yes
❍ No

When your citizen science volunteers want to contact your project staff, how often do they use the following methods?

	Always	**Most of the Time**	**Sometimes**	**Rarely**	**Never**	**Not available**
Telephone	❍	❍	❍	❍	❍	❍
Email	❍	❍	❍	❍	❍	❍
Online help or discussion forum	❍	❍	❍	❍	❍	❍
Mail	❍	❍	❍	❍	❍	❍

How do you communicate information about your project to your citizen science volunteers? Check all that apply.

❑ In person
❑ Email
❑ Mailings
❑ Project website

Do your citizen science volunteers work together (in pairs or groups) for your project?

❍ No, never
❍ Yes, sometimes
❍ Yes, always

When volunteers work together, do they work with the same people each time?

❍ Yes, the groups remain mostly or completely the same over time
❍ No, the groups change frequently
❍ Don't know

When volunteers work together, how big is their group? Check all that apply.

❑ Less than five people
❑ Six to ten people
❑ More than ten people

What resources do you provide to help your citizen science volunteers contact each other? Check all that apply.

- ❑ List of volunteers' phone numbers
- ❑ List of volunteers' email addresses
- ❑ Online discussion forum or list-serve
- ❑ Other (please describe) _____
- ❑ None

Do you intentionally foster or attempt to create a sense of community among your citizen science volunteers? If yes, please explain or give an example.

Do you think your volunteers feel that they are part of a community as a result of your citizen science project?

- ❍ Yes
- ❍ No

Do you attempt to measure or record changes in behavior or knowledge in your citizen science volunteers?

- ❍ Yes
- ❍ No

What type of training does your citizen science project use for its participants? Check all that apply.

- ❑ In person training
- ❑ Interactive or multimedia online training (videos, quizzes, games, etc.)
- ❑ Written training materials in print or online

Do you provide your citizen science volunteers with feedback on their work during their training?

- ❍ Yes
- ❍ No

Do you provide your citizen science volunteers with feedback on their work during their participation in the project?

- ❍ Yes
- ❍ No

How old is your citizen science project?

How many citizen science volunteers does your project have?

How many FTE (full-time equivalent) paid staff work on your citizen science project?

What is the geographic scope of your citizen science project?

- ❍ Local (within one state)
- ❍ Regional (within several states)
- ❍ National (within most of or the entire country)
- ❍ International (within more than one country)

How many months do most citizen science volunteers participate in the project each year? If there is a great deal of variation in the length of participation based on geographic location or types of volunteer activities, please describe it in the box below.

- ❍ Less than 1 month
- ❍ 1-4 months
- ❍ 5-8 months
- ❍ 9-12 months
- ❍ Highly variable (please describe) _____

Is your citizen science project affiliated with any of the following? Check all that apply.

- ❑ A college or university
- ❑ A non-profit organization
- ❑ A nature center or park
- ❑ No affiliation
- ❑ Other (please describe) _____

Is there anything else you would like to share with us about the educational components of your project or about your volunteers' conservation activities?

Appendix 2: Online Questionnaire for Citizen Scientists and Results of Stepwise Model Selection (Chapter 2)

Online Questionnaire

Thank you for taking the time to help with this survey! You have received this link because you are listed as a participant in a butterfly-related citizen science project. Citizen science projects rely on volunteers from the public to monitor and record data, which are then used for scientific research. Some butterfly citizen science projects are interested in all or many species, while others focus on just one species, such as the monarch. If you believe you have received this survey in error and do not participate in a butterfly-related citizen science project, please do not complete the survey. If you are a participant in a butterfly citizen science project, please answer the following questions. It should only take about 10-15 minutes to complete the entire survey. Your input is valuable, and your responses will make an important contribution to our research at the University of Minnesota into the impact of participation in butterfly citizen science projects.

Participation in this survey is completely voluntary; the risks and benefits associated with participation are minimal. Your decision to take or not take this survey will not affect your relationship with the University of Minnesota or any other organization. Your answers will be completely anonymous. If you have any comments or concerns, don't hesitate to contact Eva Lewandowski at lewan121@umn.edu.

Thank you,
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For what citizen science projects do you currently collect butterfly-related data? For example, some citizen science projects that involve butterflies include the Monarch Larva Monitoring Project, North American Butterfly Association, and your local butterfly monitoring network or club.

How many years have you been involved in butterfly citizen science projects?

For the rest of this survey, please think about only one butterfly citizen science project with which you are currently involved. If you only volunteer with one butterfly citizen science project, please think about that project as you complete the survey. If you

currently participate in more than one, choose the project that you are the most familiar with. Please think only about that project as you complete the rest of the survey.

What organism is the focus of your citizen science project?

❍ Butterflies in general
❍ Monarchs
❍ Other (please describe) _____

What activities do you do as part of your butterfly citizen science project? Check all that apply.

❑ Record individual butterfly sightings
❑ Conduct one-time butterfly counts or surveys
❑ Conduct repeated monitoring for butterflies (at any life stage)
❑ Collect habitat or environmental data (plant species present, temperature, rainfall, etc.)
❑ Other (please describe) _____

What is the geographic scope of the entire citizen science project?

❍ Local (within one state)
❍ Regional (within several states)
❍ National (within most of or the entire country)
❍ International (within multiple countries)
❍ Not sure

Does participating in your citizen science project require you to do any of the following?

	Yes	**No**
Plant nectar and/or host plants	❍	❍
Display signs about butterflies or the citizen science project	❍	❍
Limit your use of insecticides or herbicides	❍	❍
Give presentations about your work with the citizen science project	❍	❍

What type of training did you go through in order to participate in your citizen science project? Check all that apply.

❑ In person training
❑ Interactive or multimedia online training (videos, quizzes, games, etc.)
❑ Written training materials in print or online

During your training for this citizen science project, did you receive any feedback on your progress learning or performing project tasks?

- ❍ Yes
- ❍ No

Since you began participating in your citizen science project, have you received any feedback on your performance of project tasks?

- ❍ Yes
- ❍ No

To what extent are you involved with the following butterfly-related activities? Use a time right before you began participating in your citizen science project as a reference point for these questions.

	Did before and haven't changed	**More involved now**	**Less involved now**	**Plan to in the future**	**Don't now and don't plan to**
Support butterfly conservation programs financially	❍	❍	❍	❍	❍
Display signs to promote butterfly habitat	❍	❍	❍	❍	❍
Collect data on butterflies and report them to citizen science projects	❍	❍	❍	❍	❍
Limit use of insecticides or advocate for decreased insecticide use	❍	❍	❍	❍	❍
Limit use of herbicides or advocate for decreased herbicide use	❍	❍	❍	❍	❍
Plant nectar plants and/or host plants	❍	❍	❍	❍	❍

To what extent do you involve others in butterfly conservation by engaging in the following activities? Use a time right before you became involved in your citizen science project as a reference point for these questions.

	Did before and haven't changed	**More involved now**	**Less involved now**	**Plan to in the future**	**Don't now and don't plan to**
Involve others in monitoring or conservation	❍	❍	❍	❍	❍
Talk informally with others about butterflies or conservation work	❍	❍	❍	❍	❍
Give presentations or talks about butterflies	❍	❍	❍	❍	❍
Describe your butterfly work to the local media	❍	❍	❍	❍	❍
Speak out against development projects that may affect butterfly habitat	❍	❍	❍	❍	❍
Advocate for more environmentally friendly land management practices	❍	❍	❍	❍	❍
Encourage others to plant host and/or nectar plants	❍	❍	❍	❍	❍

Does your citizen science project actively encourage you to engage in conservation activities outside of your project?

❍ Yes
❍ No

Does your citizen science project provide you with information about butterfly conservation topics?

❍ Yes
❍ No

Has your citizen science project provided you with information about the following threats to butterfly populations?

	Yes	**No**
Breeding habitat loss	❍	❍
Overwintering habitat loss	❍	❍
Disease and parasites	❍	❍
Climate change	❍	❍
Pesticide use	❍	❍

Has your citizen science project provide you with information about the following butterfly conservation activities?

	Yes	**No**
Planting native nectar plants	❍	❍
Planting native host plants	❍	❍
Butterfly-friendly gardening strategies (fewer pesticides, herbicides, mowings)	❍	❍
Habitat conservation	❍	❍
Contacting the media	❍	❍
Giving public talks or presentations	❍	❍
Opportunities for financial contributions	❍	❍

What is the primary way you receive information from your citizen science project about threats to butterflies and butterfly conservation?

❍ Project website
❍ Online communications (e-newsletter, email, social media, etc.)
❍ Print materials (newsletter, handouts, pamphlets, etc.)
❍ In person during training or other events
❍ Do not receive information from the project on this topic

How do you most want to receive information from your citizen science project about threats to butterflies and butterfly conservation?

- ❍ Project website
- ❍ Online communications (e-newsletter, email, social media, etc.)
- ❍ Print materials (newsletter, handouts, pamphlets, etc.)
- ❍ In person during training or other events
- ❍ Do not want to receive information from the project on this topic

When you collect citizen science data for your project, do you work with others, either in a pair or in a group?

- ❍ No, never
- ❍ Yes, sometimes
- ❍ Yes, always

With whom do you collect butterfly citizen science data? Please check all that apply.

- ❑ On my own
- ❑ With family members
- ❑ Nature center group
- ❑ School group
- ❑ Informal group (such as friends and neighbors)
- ❑ Community club
- ❑ Other (please describe) _____

Do you collect butterfly citizen scientist data with children?

- ❍ Yes, every time or most of the time
- ❍ Occasionally
- ❍ No

When you work with others to collect citizen science data, do you work with the same people each time?

- ❍ Yes, the groups remain mostly or completely the same over time
- ❍ No, the groups change frequently

When you work with others to collect citizen science data, how big is the group? Check all that apply.

- ❑ Less than five people
- ❑ Six to ten people
- ❑ More than ten people

What resources does your citizen science project provide to help you contact other volunteers? Check all that apply.

- ❑ List of volunteers' telephone numbers
- ❑ List of volunteers' email addresses
- ❑ Online discussion forum or list serve
- ❑ Other (please describe) _____
- ❑ None

To what extent does volunteering with your citizen science project make you feel a sense of community?

- ❍ A great deal
- ❍ Somewhat
- ❍ Not very much
- ❍ Not at all

How connected do you feel to other butterfly citizen science volunteers?

- ❍ Very connected
- ❍ Somewhat connected
- ❍ Not at all connected

How important a part of your life is participating in your citizen science project?

- ❍ Extremely important
- ❍ Very important
- ❍ Somewhat important
- ❍ Neither important nor unimportant
- ❍ Somewhat unimportant

How many months do you participate in your citizen science project each year?

- ❍ Less than 1
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5
- ❍ 6
- ❍ 7
- ❍ 8
- ❍ 9
- ❍ 10
- ❍ 11
- ❍ 12

For this question, please think only about the months that you participate in your citizen science project. On average, about how many hours do you spend on your citizen science project each month?

Is there anything else you would like to share about your participation in butterfly citizen science projects or how it has impacted you?

Results of stepwise model selection based on AIC_c values

Table 1. Model selection for change in conservation action

Action	Predictors	AICc	ΔAICc
Decrease herbicides (n=109)	cons.info+yrs+time.comm+enc+conn+comm	243.02	0
	cons.info+yrs+time.comm+enc+conn	230.19	12.84
	[1]cons.info+yrs+enc+conn	**224.78**	**18.25**
	[2]cons.info+yrs+conn	225.73	17.30
Decrease insecticides (n=109)	cons.info+yrs+time.comm+enc+conn+comm	239.46	0
	cons.info+yrs+time.comm+enc+conn	229.03	10.43
	[1]cons.info+yrs+enc+conn	**223.48**	**15.97**
	[2]cons.info+yrs+conn	224.52	14.94
Plant (n=113)	cons.info.host + cons.info.nectar+yrs+time.comm+enc+conn+comm	226.40	0
	cons.info.host + cons.info.nectar +yrs+time.comm+enc+conn	217.11	9.29
	cons.info.host + cons.info.nectar +yrs+time.comm+conn	213.52	12.88
	cons.info.host + cons.info.nectar +yrs+time.comm	209.30	17.10
	cons.info.host + cons.info.nectar +time.comm	204.66	21.74
	[1]cons.info.host +time.comm	**200.69**	**25.71**
Involve others in cons. or monitoring (n=111)	cons.info+yrs+time.comm+enc+conn+comm	195.28	0
	cons.info+yrs+time.comm+enc+comm	187.75	7.53
	[2]cons.info+yrs+time.comm +comm	183.02	12.26
	[1]yrs+time.comm +comm	**181.24**	**14.04**
	[2]time.comm +comm	181.29	13.99
Talk informally with others (n=114)	cons.info+yrs+time.comm+enc+conn+comm	197.26	0
	cons.info+yrs+time.comm+enc+comm	187.44	9.81
	cons.info+time.comm+enc+comm	182.60	14.66
	[2]cons.info+enc+comm	179.96	17.29
	[1]cons.info+enc	**179.14**	**18.12**
	[2]enc	179.38	17.88
Encourage	cons.info.host + cons.info.nectar +yrs+time.comm+enc+conn+comm	243.21	0

Planting (n=114)	cons.info.host + cons.info.nectar +yrs+time.comm+enc+conn	234.27	8.93
	cons.info.host + cons.info.nectar +yrs+time.comm+enc	226.95	16.25
	cons.info.host +yrs+time.comm+enc	222.81	20.40
	[2]cons.info.host +yrs+time.comm	221.10	22.11
	[1]cons.info.host +time.comm	**219.82**	**23.38**
	[2]cons.info.host	220.06	23.15
Give Public Talks (n=110)	cons.info+yrs+time.comm+enc+conn+comm	291.04	0
	cons.info+yrs+time.comm+ conn+comm	285.21	5.83
	cons.info+yrs+time.comm+ conn	281.43	9.61
	cons.info+yrs+conn	277.28	13.76
	[1]yrs+conn	**274.91**	**16.13**
Display signs (n=110)	cons.info+yrs+time.comm+enc+conn+comm	286.91	0
	cons.info+yrs+time.comm+conn+comm	282.35	4.55
	cons.info+yrs+time.comm+conn	280.83	6.08
	[1]cons.info+yrs+time.comm	**277.20**	**9.71**
Contact the Media (n=110)	cons.info+yrs+time.comm+enc+conn+comm	270.92	0
	cons.info+yrs+time.comm+enc+comm	262.80	8.12
	cons.info+yrs+enc+comm	257.69	13.23
	[1]cons.info+yrs+comm	**253.78**	**17.14**
	[2]cons.info+yrs	253.95	16.97
Advocate for env. friendly managment (n=112)	cons.info+yrs+time.comm+enc+conn+comm	303.20	0
	cons.info+yrs+enc+conn+comm	297.61	5.59
	cons.info+yrs+enc+ comm	293.64	9.56
	[2]cons.info+yrs+enc	287.12	16.08
	[1]yrs+enc	**285.86**	**17.34**
Speak out against developme nt (n=109)	cons.info+yrs+time.comm+enc+conn+comm	299.49	0
	cons.info+yrs+time.comm+enc+conn	293.33	6.17
	cons.info+yrs+time.comm+enc	289.51	9.99
	[2]yrs+time.comm+enc	286.79	12.70
	[2]time.comm+enc	286.24	13.26

	[1]enc	**286.01**	**13.48**
Donate financially (n=108)	cons.info+yrs+time.comm+enc+conn+comm	266.10	0
	yrs+time.comm+enc+conn+comm	262.57	3.53
	[1]yrs+time.comm+enc+ comm	**260.43**	**5.67**
	[2]yrs+enc+comm	261.91	4.20

[1]Indicates the most supported model for each set of models. [2]Indicates other models that are well-supported by the data, based on a difference in AIC_c values of less than 2.

Table 2. Model selection for connection to other volunteers

Connection to other volunteers	Predictors	AICc	ΔAICc
only for those who work in groups (n=71)	contact+same.people	152.45	0
	[1]**contact**	**148.56**	**3.89**
	same.people	154.99	+2.54

[1]Indicates the most supported model for each set of models.

Appendix 3: Online Questionnaire for Volunteers, Regression Results, and Additional Site Characteristics (Chapter 3)

Online Questionnaire

Survey questions used to collect data for this research project are included. Questions that were not used in the paper have been removed. Introductory and concluding comments, as well as researcher contact details, have also been removed.

Do you have one or more certified Monarch Waystations?

- o I have ONE certified Monarch Waystation
- o I have MORE THAN ONE certified Monarch Waystation (please specify how many in box below)
- o I do not have a certified Monarch Waystation

If more than one, how many Waystations do you have?

Do you have one or more MLMP monitoring sites?

- o I have ONE MLMP monitoring site
- o I have MORE THAN ONE MLMP monitoring site (please specify how many in box below)
- o I do not have an MLMP monitoring site

If more than one, how many MLMP sites do you have?

For all questions that refer to "your site", you will need to choose ONLY ONE of your monarch habitat sites. If you have a site that is both a Waystation and MLMP site, please choose it, otherwise choose the site that you are most knowledgeable about (history of the site, plant diversity, land management, etc.).

If your Waystation and MLMP site are at the same location, but one covers a larger area than the other, answer the questions thinking about the larger of the two areas. For example, if your Waystation covers more area than the part of it that you monitor for the MLMP, answer the questions about the entire Waystation.

What is the location of your site?

City/Township:
County:
State:

Latitude (if known):
Longitude (if known):

How would you describe the general area in which your site is located? (Choose the answer that fits best)

- o Rural

- Small town
- Suburban
- Urban

Which of the following border your site? (Choose all that apply)

- Lawns
- Agricultural fields
- Other "old field" (not currently used for crops)
- Residential building(s)
- Industrial or commercial building(s)
- Roads
- Grassland
- Body of water (lake, pond, river)
- Deciduous woods
- Evergreen woods
- School
- Park

Is there at least one small to medium sized area (1-1000 sq meters - up to the size of half a tennis court) with milkweed growing within 1 km (0.6 miles) outside of your site?

- There is no other milkweed within 1 km (0.6 miles) of my site.
- There is at least one small to medium sized area with milkweed within 1 km of my site
- I don't know (Optional) Comments

Is there at least one large to very large sized area (1001-10,000 sq meters) with milkweed growing within 1 km (0.6 miles) outside of your site?

- There is no other milkweed within 1 km (0.6 miles) of my site.
- There is at least one large to very large area with milkweed growing within 1 km (0.6 miles) of my site
- I don't know (Optional) Comments

What is the size of your site?

- 0-10 sq. meters (~0-100 sq feet) - a small garden
- 11-100 sq meters (~100-1000 sq feet) - up to the size of half a tennis court
- 101-1000 sq meters (~1000-11,000 sq feet) - up to the size of the infield of a baseball diamond 1001-10,000 sq meters (~.25-2.5 acres) - up to the size of 2 football fields
- Over 10,000 sq meters (2.5+ acres) - large fields and bigger The exact area of my site is (if known)

What type of site is it? (Choose all that apply)

- Garden
- CRP land (Conservation Reserve Program)
- Other "old field" (not currently used for crops)

- Pasture
- Restored or reconstructed prairie
- Natural prairie or other natural habitat
- Nature preserve
- Roadside (ditch or strip next to a road)
- Agricultural field (please specify crop in comment box below)
- Agricultural margin (road ditch, buffer zone)

Describe type if it is not listed above, or provide more details about your site

How was your site established? (Choose one)

- o It grew naturally and milkweed or nectar plants HAVE NOT been added to it (by myself or someone else)
- o It grew naturally but milkweed or nectar plants HAVE been added to it (by myself or someone else)
- o The site was planted by humans before it became a Waystation or an MLMP site, and milkweed or nectar plants HAVE NOT been added to it since it became a Waystation or an MLMP site
- o The site was planted by humans before it became a Waystation or an MLMP site, and milkweed or nectar plants HAVE been added to it since it became a Waystation or an MLMP site
- o This is a new site that was developed to be a Waystation or an MLMP site (humans planted ALL milkweed and/or nectar plants) (Optional) Please comment on how your site was established

Which of the following are found within your site? This includes the entire area that contains milkweed. (Choose all that apply)

- Flowering plants (forbs other than milkweed)
- Native grass
- Lawn grass
- Shrubs (less than 3 m tall)
- Trees (more than 3 m tall)
- Natural body of water (pond, lake, or river)
- Human-provided water (birdbath, pond, etc.) Other (please describe)

What species of milkweed grow at your site? (Choose all that apply)

Not all milkweed species are listed below. We have included common species and other species prioritized by the Monarch Joint Venture.

- *A. angustifolia* (Arizona milkweed)
- *A. asperula* (antelopehorns milkweed)
- *A. californica* (California milkweed)
- *A. cordifolia* (heartleaf milkweed)
- *A. curassavica* (tropical milkweed)
- *A. eriocarpa* (woolly pod milkweed)
- *A. erosa* (desert milkweed)
- *A. exaltata* (poke milkweed)

- *A. fascicularis* (Mexican whorled milkweed)
- *A. humistrata* (sandhill/pinewoods milkweed)
- *A. incarnata* (swamp milkweed)
- *A. oenotheroides* (zizotes milkweed)
- *A. perennis* (aquatic milkweed)
- *A. speciosa* (showy milkweed)
- *A. subulata* (rush milkweed)
- *A. syriaca* (common milkweed)
- *A. tuberosa* (butterfly weed)
- *A. variegata* (white milkweed)
- *A. verticillata* (whorled milkweed)
- *A. vestita* (woolly milkweed)
- *A. viridis* (green antelopehorns milkweed)

Who owns your site property? (Choose one)

- o School
- o Local or county government State government
- o Federal government Me or my family
- o Privately owned by someone else Non-governmental organization Nature center
- o Small business Large corporation I don't know
- o Other (please specify)

Who manages your site, if anyone? (Choose all that apply)

- No one
- Me or my family
- Friend, neighbor, or other volunteer
- County agency
- State agency
- Federal agency
- Private contractor: gardener or landscaper
- Private contractor: pesticide applicator
- Private landowner
- Permanent staff members of owner organization/company
- Seasonal staff members of owner organization/company
- I don't know Other (please specify)

Please indicate any forms of management that occur at your site.

- No management occurs at my site
- Mowed 1-2 times per year
- Mowed more than 2 times per year
- Fertilized 1 or more times per year
- Weeded/removed unwanted plants (without herbicide)
- Planted with an agricultural crop (milkweed is a "weed" in this site)
- Burned every year
- Burned every 2-3 years

- Burned with a frequency of less than once every three years
- "Spot sprayed" unwanted plant species
- Tilled
- Other (please describe

How important were each of these factors in your initial motivation to participate in the Monarch Waystation program or the MLMP?

	Very Important	**Slightly Important**	**Not Important**
Interest in nature	o	o	o
Interest in monarchs	o	o	o
Desire to help monarchs	o	o	o
Desire to be outside	o	o	o
Desire to help scientists	o	o	o
Desire to provide learning opportunities for children	o	o	o

Please describe how your relationship or connectedness to the natural world has changed since you began participating in the Monarch Waystation program or the Monarch Larva Monitoring Project. (describe if more, less, or no more or less connected)

To what extent are YOU involved with the following monarch or other butterfly related activities? Use a time right before you began participating in the MLMP or the Monarch Waystation Program as a base point for these questions. (Choose one answer for each row)

	Did before and haven't changed	**Move involved now**	**Plan to in the future**	**Less involved now**	**Don't now and don't plan to**
Support monarch conservation programs financially	o	o	o	o	o
Display signs to promote monarch habitat	o	o	o	o	o
Collect data on monarchs and report to	o	o	o	o	o

monarch citizen science programs					
Collect data on monarchs and keep records for myself	o	o	o	o	o
Participate in butterfly counts (NABA or a butterfly monitoring network)	o	o	o	o	o
Report individual butterfly or moth sightings (BAMONA, e-Butterfly, etc.)	o	o	o	o	o
Collect and rear wild monarchs	o	o	o	o	o
Limit use of insecticides or advocate for decreased insecticide use	o	o	o	o	o
Limit use of herbicides or advocate for decreased herbicide use	o	o	o	o	o
Plant nectar plants and/or milkweed on your site or elsewhere	o	o	o	o	o

To what extent do you involve others with the following monarch or other butterfly related activities? Use a time right before you began participating in the MLMP or the Monarch Waystation program as a base point for these answers.

	Did before and haven't changed	**Move involved now**	**Plan to in the future**	**Less involved now**	**Don't now and don't plan to**
Involve others in monitoring or conservation	o	o	o	o	o
Talk informally with others about monarchs or conservation work	o	o	o	o	o
Give presentations or talks to youth groups	o	o	o	o	o
Give presentations or talks to community groups	o	o	o	o	o
Describe work to local media	o	o	o	o	o
Speak out against development projects that may affect monarch habitat	o	o	o	o	o
Advocate for more environmentally friendly land management practices	o	o	o	o	o
Encourage others to plant milkweed and/or nectar plants	o	o	o	o	o

What do you do when you have questions about monarch conservation or citizen science? (Choose all that apply)

- I refer to citizen science project websites regularly
- I refer to citizen science project websites every once in a while I email project coordinators with questions/concerns
- I use books or printed materials (Please list the most useful ones in the comment box below) I use online resources (Please list the most useful ones in the comment box below)
- I look for in-person training events I ask local experts or trainers

Please list the resources that have been the most useful to you

Is there anything you would like to share about your involvement with monarchs or your site? We would like "stories" of the importance of your involvement to you.

Do you have any questions about the Monarch Waystation program or the MLMP, or about monarchs in general, that you would like us to answer (or try to answer)? If so, please list them here and include your name and contact information on the next page to receive a response to your question(s).

Table 1. Regression Results for Log Number of Milkweed Species

ln(#milkweed sp)~ site.size + created.type + vol.type

Variable	Estimate	Std. Error	t value	Pr(>|t|)	Significance
(Intercept)	0.7298	0.08625	8.462	< 2e-16	0.001
Size (linear)	0.17483	0.04479	3.904	0.000102	0.001
Size (quadratic)	-0.1640	0.04257	-3.852	0.000126	0.001
Size (cubic)	0.01528	0.04144	0.369	0.712425	
Size (quadric)	-0.0011	0.03893	-0.028	0.977466	
Created (created)	0.29864	0.07444	4.012	6.53E-05	0.001
vol.type (MLMP)	-0.4448	0.09666	-4.602	4.79E-06	0.001
vol.type(Waystation)	-0.0104	0.06184	-0.168	0.86674	

Multiple R-squared: 0.1021, Adjusted R-squared: 0.09503
F-statistic: 14.53 on 7 and 895 DF, p-value: < 2.2e-16

Additional Site Characteristics

Table 2. Percentage of each type of site border; types are not mutually exclusive.

Border Type	Waystation (n=823)	MLMP (n=55)	Combination (n=85)
Lawns	74.5	52.7	62.4
Residential	54.6	49.1	45.9
Roads	53.1	56.4	56.5
Deciduous woods	44.2	70.9	52.9
Garden	43.4	27.3	45.9
Water	26.7	38.2	29.4
Evergreen woods	22.4	27.3	29.4
Old (former) field	20.7	32.7	28.2
Agricultural field	16.2	14.5	21.2
Grasslands	15.1	18.2	21.2
Park	9.2	10.9	12.9
School	8.9	1.8	10.6
Industrial	5.7	3.6	12.9

Table 3. Biotic and abiotic components of sites by percentage; components are not mutually exclusive.

Components	Waystation (n=813)	MLMP (n=55)	Combination (n=85)
Flowering plants	99.5	100.0	96.5
Shrubs	87.3	72.7	80.0
Trees	83.5	81.8	85.9
Human-provided water	76.8	32.7	63.5
Lawn grass	73.7	52.7	57.6
Native grass	62.7	85.5	72.9
Natural water	24.6	25.5	23.5

Appendix 4: Pre- and Post-Training Questionnaires (Chapter 4)

Pre-Training Questionnaire

Monarch Monitoring Workshop (Location, Date)

Presenter Information

Pre-workshop survey

Our goals in this workshop are to

1) Provide information about monarch biology and monitoring programs, and

2) Engage more people in monarch monitoring programs.

We hope that, as a result of your participation in this workshop, monarchs and monarch habitat will be better understood and thus conserved. To help us understand the impacts of the workshop, we hope that you will fill out short surveys immediately before and after the workshop, and in 6 to 12 months.

You may choose not to include your name on the survey if you wish to remain anonymous. The surveys are completely voluntary. Your willingness to fill out the surveys will not affect your relationship with any of the sponsoring organizations or individuals. If you have any questions about the surveys, please feel free to ask one of the workshop presenters.

There are TWO pages of this survey. Please be sure to fill both of them out.

Please fill in the boxes with the appropriate information. This information will be used as a unique identifier to link your responses from each survey, if you choose not to disclose your name.

The month of your birthday: (01-12)	**The day of your birthday (01-31)**	
	The last four digits of your cell phone number:	
☐☐	☐☐	☐☐☐☐

1. What is your current job (if you are currently employed)? _____
2. If you are retired, what was your job? _____

3. What are your learning goals for this workshop?

4. Please indicate **natural resource activities** that you are/were involved with **as a part of your job**. (Use space provided to describe activities) Check all that apply
   - ☐ None
   - ☐ Project Management or Administration
   - ☐ Education or interpretation
   - ☐ Monitoring or Citizen Science
   - ☐ Stewardship (natural resource management activities)
   - ☐ Program Support (other tasks supporting natural resource activities)

5. Please indicate natural resource **volunteer activities** you have been involved with. (Check all that apply)
   - ☐ None
   - ☐ Master Naturalist
   - ☐ Master Gardener
   - ☐ Program Support (other tasks supporting natural resource activities)
   - ☐ Stewardship (land management activities)
   - ☐ Monarch Waystations
   - ☐ Citizen Science

     <u>Monarchs</u>

     ☐ Monarch Watch Tagging
     ☐ Monarch Larva Monitoring Project
     ☐ Journey North
     ☐ Project Monarch Health
     ☐ NABA Butterfly Count

     <u>Others</u>

     ☐ Bird Counts (general)
     ☐ Vertebrate monitoring (bird, amphibian, turtle)
     ☐ Invasive species
     ☐ Water quality
     ☐ Native plant monitoring
     ☐ Other insects
     ☐ Other, please specify:
   - ☐ Other volunteer activities, please describe

6. Have you raised, observed, or studied monarchs? (check all that apply)
    - ☐ Raised monarchs in a classroom or with kids
    - ☐ Raised monarchs in my home
    - ☐ Observed monarchs in a garden/neighborhood/natural area
    - ☐ Studied monarchs, please explain:

7. Please explain how you will use what you learn in this workshop.
    - ☐ In your work as a government employee of a land management agency, explain:
    - ☐ In your work with a non-governmental organization, explain:
    - ☐ In your work at a school, explain:
    - ☐ In your volunteer/extracurricular work, explain:
    - ☐ Other, explain:

8. If you would like us to be able to contact you directly regarding questions, concerns, or monarch monitoring and conservation activities, provide your name, email, and phone here.

    Name: _____
    Email: _____
    Phone: _____
    Preferred method of communication: _____

Post-Training Questionnaire

Monarch Monitoring Workshop (Location, Date)

Presenter

POST-WORKSHOP

There are TWO pages of this survey. Please be sure to fill both of them out.

Please fill in the boxes with the appropriate information. This information will be used as a unique identifier to link your responses from each survey, if you choose not to disclose your name.

The month of your birthday: (01-12)	**The day of your birthday (01-31)**	**The last four digits of your cell phone number**
☐☐	☐☐	☐☐☐☐

1. How satisfied were you with this workshop?
   - ☐ Very DISSATISFIED
   - ☐ Somewhat DISSATISFIED
   - ☐ Neutral
   - ☐ Somewhat satisfied
   - ☐ Very satisfied

2. How well did this workshop meet your expectations?
   - ☐ Less than I expected
   - ☐ About what I expected
   - ☐ Exceeded my expectations

To what extent did this workshop:

Teach you about monarch biology?	*Prepare you to engage in monarch monitoring activities?*	*Prepare you to engage in monarch conservation activities,* ***other than monitoring?***
☐ Not at all	☐ Not at all	☐ Not at all
☐ To a slight extent	☐ To a slight extent	☐ To a slight extent
☐ To a moderate extent	☐ To a moderate extent	☐ To a moderate extent
☐ To a great extent	☐ To a great extent	☐ To a great extent

3. Please comment on how this workshop taught you about monarchs, monarch conservation, and monarch monitoring.
   a. Which components were particularly useful?
      - ☐ All components were useful
      - ☐ Monarch information: (please circle) Biology, Migration, Other
      - ☐ Hands-on monarch activities

- ☐ Citizen Science information: (please circle) project overview, protocols, field practice
- ☐ Habitat information
- ☐ Field activities
- ☐ Other: (please describe)_____

b. Which components were not useful?

- ☐ All components were useful
- ☐ Monarch information: (please circle) Biology, Migration, Other
- ☐ Hands-on monarch activities
- ☐ Citizen Science information: (please circle) project overview, protocols, field practice
- ☐ Habitat information
- ☐ Field activities
- ☐ Other: (please describe)_____

4. Please indicate your involvement with monarch monitoring and conservation

	Already involved, plan to **continue**	Already involved, plan to **increase**	Plan to start **this year**	Maybe some day	Sorry, not interested
Install a monarch garden/waystation					
Monitor for MLMP					
Report to Journey North					
Monarch Watch Tagging					
Sample for Project Monarch Health					
NABA butterfly counts					
Be an advocate for monarch conservation					

Use this space to provide further detail for you plans in monarch conservation:

5. How can we support your continued involvement with monarch monitoring and other conservation activities? (provide email updates, further training, phone support, regional contacts/experts, etc.)

6. What was your favorite thing about this workshop?

7. Do you have suggestions for future monarch monitoring workshops? (things to add or expand on, things to leave out or condense, other…)

8. If you have any questions that require direct contact or wish for us to contact you regarding monarch monitoring and conservation activities, please provide your questions/concerns, and contact information here.

Name: _____

Email: _____

Phone: _____

Preferred method of communication: _____