THESIS

NATIVE BEE WATCH: ASSESSING THE EFFICACY OF A CITIZEN SCIENCE PROJECT MONITORING NATIVE BEES IN FORT COLLINS, COLORADO

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ABSTRACT

NATIVE BEE WATCH: ASSESSING THE EFFICACY OF A CITIZEN SCIENCE PROJECT MONITORING NATIVE BEES IN FORT COLLINS, COLORADO

As the world's human population continues to grow, urban areas continue to expand, and natural spaces become more fragmented leading to dilution and loss of natural resources. Of the organisms that depend on natural resources, pollinators could face significant impacts including habitat loss, fragmentation, and deterioration. Pollinators provide substantial ecosystem services such as plant reproduction and food production for human and animals. However, urban areas are rapidly expanding and understanding its impact on insects, such as bees, is critical.

One method to understand the effects of urbanization on ecosystems is to involve urban residents in exploring the components of the ecosystem around them by engaging, educating, and empowering urbanites through citizen science. Citizen science involves non-scientists in collecting data for a scientific research project and contributes data to a large database. Scientists are capitalizing on citizen scientist availability and enthusiasm to increase capacity, address funding shortcomings for research and satisfy the need to meet an outreach-related component. Data accuracy is one of the main concerns that scientists have with citizen science programs. Several studies have assessed the quality of citizen science data to comprehend the underlying problems and devise effective future protocols. However, the consensus is that researchers do not yet fully understand the error potential in citizen science data possibly because data accuracy does not have a reliable definition and there are few consistent metrics on data accuracy.

Knowing that pollinator conservation is an attractive issue for urban citizens, and recognizing the hurdles encountered with citizen science data, we launched Native Bee Watch, a citizen science project on urban pollinators in Fort Collins, Colorado, USA, specifically to determine whether citizen scientists can collect accurate data on native bees and develop a protocol that yields accurate data. Three gardens were monitored from the last week of May through mid-September in 2016 and in 2017. Citizen scientists completed a two-hour training and spent time with the researchers in the field to ensure data accuracy. Data was collected by using the Focal Plant Sampling Procedure that was modified from animal behavior studies. Citizen science data was compared with data collected by professional researchers. Spearman's Rank Correlation was used to compare the citizen science data and the researcher-only data. Spearman's Rank Correlation coefficients ranged 0.88 to 0.98 indicating a strong correlation between citizen science and researcher data. The results indicate that the training protocols for citizen scientists were effective in having them collect comparable data to researchers. An Urban Bee Habitat Quality index was obtained by multiplying rarified morphospecies estimate with abundance for each sampling period to determine the habitat quality using eight morphological groups of bees. The habitat quality of citizen science data and the habitat quality of researcher data was not significantly different. The Urban Bee Habitat Quality Index demonstrates that data collected by citizen scientists at a broad-level such as morphological categories can be used to evaluate habitat quality. Part of the training protocol for citizen scientists was continuous volunteer engagement through trainings, newsletters, and researchers working individually with citizen scientists. Results suggest the training protocols in this study were effective since the data collected by citizen scientists was significantly comparable to researcher data, indicating that citizen science can be a valuable tool to monitor native bees at a broad scale in urban areas.

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Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has.
– Margaret Mead

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1.1 Introduction

As the world's human population continues to grow, urban areas continue to expand, and natural spaces continue to become fragmented. Urban areas are defined as a community with a high density of people, homes, and other infrastructure (Niemelä 1999). As of 2014, over 54% of the population lives in urban areas across the globe. In North America, over 82% of the population resides in urban areas, a percentage that is expected to grow (Cohen 2003; United Nations 2014). Conserving and managing scarce natural resources in and around urban areas will become increasingly important with the growing human population. Of those natural resources, pollinators could face significant impacts including habitat loss, fragmentation, and deterioration (Goulson et al. 2015; Hennig and Ghazoul 2012).

Pollinators are vital to human survival. Though some plants can self-pollinate, most plants require cross-pollination, which is the transfer of pollen from one plant to another with the help of agents such as wind or animals. Given that roughly 75% of the more than 240,000 species of the world's flowering plants rely on pollinators for reproduction, expanding urban environments could reduce the number of animal pollinators available for plant reproduction in ecosystems (National Research Council 2007). Subsequently, one may expect a reduction in the variety of ecosystem services that support the production of food crops that pollinators provide (National Research Council 2007).

Most fruits, vegetables, nuts, and other plants that provide food, fiber, drugs, and fuel for humans, need insect pollination. Roughly 35% of global crops are dependent on pollinators for

reproduction (Klein et al. 2007). In other words, a large portion of the human diet, the most nutritious portion, including fruits, nuts, and vegetables, depends on pollinators. Economically, the crops pollinated by just insects are worth an estimated $2-3 billion annually (Losey and Vaughan 2006). In addition, pollinators provide indirect benefits to humans. For instance, livestock depends on pollinated plants such as alfalfa and clover for food. Pollinators also contribute to aesthetics, recreational values, and cultural activities, and they help maintain ecosystem integrity (Niemelä 1999). The widespread services provided by pollinators and the rapid rate at which urban areas are expanding makes understanding the impact of urbanization on insects, such as bees, necessary.

Habitat fragmentation, or the breaking of continuous habitat into pieces, is known to have negative effects on many animal populations, including bees (Sodhi and Ehrlich 2010). Urban areas may foster habitat for bees as they prefer small spaces with vegetation that can support their nesting and foraging activities. Backyards, flower gardens, and road edges are all examples of small habitat fragments in urban areas that can support bees (Tommasi et al. 2004). Within these areas, bare soil, building cavities, etc., can provide nesting sites for many solitary ground nesting bees. Plant diversity and floral abundance in urban areas can positively affect bee diversity and bee visits (Hennig and Ghazoul 2012). Encouraging robust urban ecosystems can therefore greatly enhance habitats for bees and other pollinators (Hennig and Ghazoul 2012; Niemelä 1999). One method of creating functional urban ecosystems is to involve urban residents. One such approach to engaging, educating, and empowering those residents is through citizen science. Citizen science is defined as involving non-scientists in collecting data for a scientific or research project and contributing to a large database (Trumbull et al. 2000).

1.1.1 The Benefits of Citizen Science

One of the longest running citizen science projects is the National Audubon Society's Christmas Bird Count, which started in 1900 (Silvertown 2009). The most common citizen science projects in history have been related to archaeology, astronomy, ornithology and natural history (Dickinson et al. 2010; Silvertown 2009). Citizen science has grown dramatically in popularity in the last two decades. Reasons for this increase include: 1) projects are more readily available for participants, 2) technological advances, such as using personal mobile devices to enter data, 3) greater recognition that scientists can capitalize on citizen scientists to increase capacity, and 4) funding sources for research often require an outreach-related component (Dickinson et al. 2010; Silvertown 2009).

Many benefits to utilizing citizen science exist, including:

- Helping to conserve and manage natural resources for the long-term. Citizens science creates "buy-in", and participants value the natural resource, which can lead to behavior changes that help solve conservation issues (Dickinson and Bonney 2012; Schultz 2011),
- Leading to longer-term, community-based actions to benefit ecosystem services, habitats, and species on a local scale (Danielsen et al. 2005),
- Increasing opportunities for humans to connect with nature in urban areas including different socioeconomic and diverse populations as urban growth has led to less opportunities for human-nature interactions (Hennig and Ghazoul 2012),
- Providing an effective way to increase research capacity with limited funding and resources (Dickinson et al. 2010; Kremen et al. 2011; Silvertown 2009),
- Promoting a way to educate, inform, raise awareness, and create positive behavior change in a community (Bell et al. 2008),

- Increasing scientific inquiry skills among citizens (Trumbull et al. 2000),
- Bridging the communication and knowledge gaps between scientists and the general public (Theobald et al. 2015),
- Providing large-scale monitoring and evaluation for broad-scale environmental issues such as biodiversity loss, climate change, and land-use change (Kremen et al. 2011; Theobald et al. 2015), and
- Informing policy makers on conservation, environmental issues, and decisions (Schmeller et al. 2009).

Primarily, citizen science has been viewed through either an ecological lens or a social lens instead of through a combination. To achieve all the benefits that citizen science has to offer, citizen science needs a comprehensive approach that includes both social and ecological research. A more comprehensive approach would increase the success of research programs including linking researchers and citizen volunteers, strengthening engagement and participation from volunteers and building stronger data sets to better understand the science (Theobald et al. 2015). This paper will examine citizen science through a social science and ecological perspective based on human dimensions of natural resources (HDNR) theories. Each perspective will look at the benefits, challenges, and case studies of applied citizen science while focusing on pollinators in urban areas whenever possible.

1.2 Ecological Perspective

Reviewing citizen science through an ecological perspective begins by examining the benefits and challenges to using citizen science to collect data on ecological topics including data accuracy and the value and use for citizen science data.

1.2.1 Data Accuracy

Data accuracy is one of the main concerns that scientists have with citizen science programs (Danielsen et al. 2005; Law et al. 2017). Researchers are starting to assess the quality of citizen science data compared to data collected by researchers. The general consensus is that researchers do not yet understand how much potential error exists in citizen science data (Dickinson et al. 2010). Categories for analyzing data accuracy include: 1) how data accuracy is defined by researchers, 2) types of data collected, and 3) beginner versus experienced volunteers.

Researchers define data accuracy in different ways and do not have consistent metrics to report on data accuracy. Aceves-Bueno et al. (2017) used mixed methods to compare reference data with citizen science data as they were reported by researchers in published journals. After examining 63 journal articles, they determined that between 51% and 62% of journal articles demonstrated accurate citizen science data (the percentage varied because they used multiple comparison methods). Some of the journal articles still described citizen science as a positive tool even if it did not yield accurate results. After examining the number of positive words within the abstracts, 73% of all the journal articles reported positive experiences by volunteers with citizen science, and 13% of the articles described citizen science as a negative experience for participants. These comparisons did not take into account the definition of data accuracy, as every researcher has their own definition. Significantly, 62% of the studies reported their results as not significant when comparing citizen science data to reference data. Researchers must better define what constitutes accurate data, collect reference data if feasible, and/or spend more time training and supervising citizen scientists to improve data accuracy. Since most of the results in the Aceves-Bueno (2017) study indicate only approximately one half of the time citizen science data was comparable to reference data, more research needs to be done to determine how

researchers can assess accuracy of citizen science data to improve citizen science programs (Aceves-Bueno et al. 2017).

Researchers are finding that some categories of data may be easier and more accurate for citizen scientists to collect. In some cases, research shows that citizen scientists can collect accurate data at a very broad taxonomic-level (i.e. orders, families, or generas) versus specific species (Crall et al. 2011). Other researchers have found that citizen scientists can collect accurate species-level data, but the abundance data lacks accuracy. Kremen et al. (2011) examined the efficacy of citizen scientist research. In their pollinator monitoring program, they compared data collected by citizen scientists with bee specimens collected by researchers. Their findings indicate that, although the sites monitored by citizen scientists and researchers were different, the trends in both sets were similar. The citizen scientists missed about half of the bee groups that the researchers collected in specimens. Their conclusion was that citizen scientists can record broad taxonomic-level data but perhaps not finer details such as genus or species-level data. However, this study did not train the citizen scientists to differentiate between bee species. Research from the Michigan Frog and Toad Survey found that volunteers collected accurate data on identifying frogs and toads to a species level, but the abundance data was not as accurate (Genet and Sargent 2003). To help improve data collection, citizen science projects should compile a list of specific species so volunteers can focus on a small list of species rather than trying to identify all species in a target area (McLaren and Cadman 1999).

In some cases, research has shown data accuracy depends on whether the citizen scientist has a previous background in science or research. Citizen scientists come from a wide variety of backgrounds and have a diverse skill set. The spectrum usually ranges from no previous biology or ecology experience to volunteers who have had a career or work experience in the field (Crall

et al. 2011). Volunteers who have skills in the field will influence the quality of the data as shown, for instance, in a study looking at macroinvertebrates in Minnesota streams (Nerbonne et al. 2008). A study on citizen scientists identifying a pre-defined group of bird species found that there were some differences between volunteers with no background on birds and volunteers that had bird identification experience. New volunteers' bird counts tended to be lower in terms of number of species and number of individuals counted in the first year, but if they returned the second year, their bird counts were more comparable. The researchers planned to increase training rigor to improve data accuracy and recommended that researchers utilize citizen science if they can provide rigorous training (McLaren and Cadman 1999). Other studies confirm that data collecting accuracy and efficiency increases with experience (Dickinson et al. 2009). Other research has shown that beginning volunteers having prior experience was not an issue, including the Michigan Frog and Toad Survey that assessed citizen science data quality (Genet and Sargent 2003).

Research on citizen science data collection has shown a lot of variability on whether citizen scientists can produce accurate data that is comparable to researchers. Reasons for the variability in citizen science data include varying training protocols, inconsistency in how researchers report data, lack of metrics on what is considered accurate data, and a diversity in skill levels of volunteers.

1.2.2 Value and Use for Citizen Science Data

One of the benefits of citizen science programs is that they can potentially save time and resources for researchers by increasing their capacity to collect data. For example, a study looking at nearly 400 citizen science programs shows that citizen scientists contribute approximately $2.5 billion of in-kind time annually with 1.3 million volunteers (Theobald et al.

2015). FeederWatch, a citizen science project at the Cornell Lab of Ornithology, estimates its citizen scientists contribute about $3 million a year of in-kind time (Dickinson et al. 2010). This value only accounts for a portion of the resources that go into a citizen science project, such as staff time and funding. With considerable time spent on training volunteers and volunteers collecting data, researchers want to be sure that the data being collected is useful and reliable.

What is needed are quantitative reviews of citizen science research. By reviewing published, peer-reviewed citizen science studies, metrics could be developed for measuring the frequency of citizen science research while also gauging citizen science data efficacy. Theobald et al. (2015) looked at almost 400 citizen science projects and found that only 12% of those projects had published the research. Even though 12% is low, citizen science projects can contribute significantly to bodies of research. Silvertown (2009) examined a popular citizen science project called the Christmas Bird Count, one of the longest running citizen science projects recorded. Groups of volunteers monitor birds in approximately 2,000 circles or plots every year providing long-term data on bird populations. With over 100 years of data, almost 350 papers and reports have been published using just this citizen science project data (Silvertown 2009). The longevity of the Christmas Bird Count provides more opportunity for researchers to publish this data while the other citizen science projects may not have enough long-term monitoring data to do the extensive analysis required to publish research.

In addition to publishing citizen science data, making the data available to the public is another outlet that serves multiple purposes. Greater data access can provide an education and outreach opportunity for the public and create transparency between researchers and the public, which may help motivate and retain citizen scientist volunteers (Crall et al. 2013; Dickinson and Bonney 2012). The Cornell Lab of Ornithology (CLO) has a public face on their website for

citizen scientists and the general public to use. Researchers and non-researchers can use the website to examine the data and see the direct impact of citizen science research. The website displays customizeable maps and graphs that indicate bird species locations. The CLO touts the success of their citizen science programs from this public-facing data website. The CLO encourages all citizen science programs to give the public the opportunity to explore citizen science data (Bonney et al. 2009). Making the raw data publically available is an opportunity to create transparency between researchers and the public and raises visibility of the citizen science program, but other risks could be involved. Much of the public lacks the background knowledge to understand or utilize the data, and the data could be misinterpreted. In addition, the time and resources needed to make data publicly available can exceed the capacity of citizen science programs.

However, it is not common for citizen science-collected data to be available to citizen scientists or the general public (Crall et al. 2011). Often scientists are hesitant to make their data public for a variety of reasons (Law et al. 2017). In some cases, the data needs to remain confidential if it involves human or lab animal subjects. Also, if species are endangered or threatened, researchers may want to reduce the risk of humans disturbing the species. Other researchers worry that having the data be made public opens up the opportunity for the data to misinterpreted (Law et al. 2017).

Besides publishing and presenting data publicly, researchers face additional challenges with citizen science data. Since citizen science programs have grown in popularity, researchers are often receiving data faster than they can process and analyze it. Most likely, more data management and analysis resources will be needed (Dickinson et al. 2010).

Another benefit of citizen science is that volunteers are able to collect data at large spatial and temporal scales (Bonney et al. 2009; Dickinson et al. 2010; Silvertown 2009). Generally, monitoring is one of two types: surveillance or target. Surveillance monitoring looks at all species or groups of species without a specific research objective. Target monitoring looks for specific species for a specific reason (i.e., species that may need protecting) (Nichols and Williams 2006). Both are benefical depending on the research goals. Dickinson et al. (2010) found citizen science is best used for looking at trends, abudance, distribution, and other broad-scale questions, which fall under surveillance monitoring. Surveillance monitoring can show new trends in species and biodiveristy over time that researchers may not otherwise know. Citizen science may not be the best option for smaller, local research addressing a specific hypothesis but can be complementary to smaller research projects (Dickinson et al. 2010). However, since target monitoring is best used with specific research goals in mind, it can often be easier to evaluate and analyze since the data was collected for a specific hypothesis (Nichols and Williams 2006).

Researchers must understand how to determine which approach to take. Perhaps one of the areas with the most potential is biodiversity because of changing climates, urbanization, and other environmental issues (Dickinson et al. 2010). For example, in the Christmas Bird Count, data collected for over 100 years has led to research on many areas in ornithology (Bonney et al. 2009; Silvertown 2009). A specific study used data from the Christmas Bird Count and another U.S. Geological Survey citizen science program called the Breeding Bird Survey to look at bird populations over 40 years. The populations of birds that were selected had a wide range of 1 million square kilometers and a population of over 500,000 (Silvertown 2009). The research indicated that populations had declined by 50% for 20 bird species (Butcher & Niven 2007).

After the study was published, it received even more visibility when it was part of an opinion article published in the New York Times (Klinkenborg 2007; Silvertown 2009).

Citizen science will become increasingly important in urban areas to understand the impacts humans have on urban ecosystems since populations are growing in urban areas. Coyote Watch is a program in the Denver Metro area in Colorado. Research has shown that Coyote Watch has impacted how humans think and interact with coyotes, while providing research on coyote-human conflicts, a growing issue in urban areas since coyotes are losing habitat (Adams 2014).

As citizen science programs grow, it is becoming more important for researchers to understand the value and uses of citizen science data. Understanding the value and capitalizing on the use of citizen science data can range from publishing papers to making the data public, managing data, and utilizing data to research complex issues such as biodiversity, climate change, and urbanization.

1.3 Social Science Perspective

Social scientists and related disciplines have taken a different approach to researching citizen science by focusing on the humans participating in the program. This approach is beneficial because by understanding human behavior, researchers can advance citizen science programs to appeal to the participating volunteers. The more invested the volunteers are in a program, the higher quality the work will be (Crall et al. 2013; Dickinson and Bonney 2012). Understanding motivations, behavior changes, and involving future generations in citizen science are critical components to advancing citizen science.

1.3.1 Understanding Motivations

Whether humans feel positive or negative towards animals or the environment, the affiliation is ingrained into human nature. Edward O. Wilson calls this connection "biophilia" and defined it as "innately emotional affiliation of human beings to other living organisms" (Wilson, 1984, p. 31). This concept should be acknowledged in the realm of citizen science because it is an integral part of human nature and can drive human attitudes, values, norms, and motivations. As with emotions, biophilia is not a cognitive function. It is challenging to measure and understand but is critical to conserving the environment (Guiney and Oberhauser 2009; Saunders 2003). Social scientists and ecopsychologists are exploring the connection of humans to nature through citizen science. Using surveys and interviews, a study of Minnesota Master Naturalist volunteers found that most volunteers felt a link to nature that began in their childhood. They were motivated to participate in citizen science because they wanted to contribute to helping the environment, learn more about nature, and teach other humans about nature. Citizen science fulfilled their need to be with nature (Guiney and Oberhauser 2009).

Another study looking at volunteer motivations found that the strongest motivation was "helping the environment or nature" (Bruyere & Rappe, 2007, p. 503; Guiney & Oberhauser 2009). Other motivations included "improving areas that volunteers use for their own recreation", "expressing their values", "learning about the natural environment", and "socializing with people with similar interests" (Bruyere & Rappe, 2007, p. 503). Ecopsychologists are also researching how nature can benefit human physical and mental health (Roszak et al. 1995). These benefits are often difficult to articulate through research. The Minnesota Master Naturalist program reported that volunteers were motivated by some of the added benefits such as exercise and stress reduction (Guiney and Oberhauser 2009). Other benefits that motivate volunteers

include aesthetics and appreciation of nature, learning about nature, and developing a spiritual connection with nature (Guiney and Oberhauser 2009). If these motivations are given a high priority by researchers that are developing citizen science programs, researchers may be able to improve recruitment, engagement, and retention, which will improve the quality of data and program efficacy (Crall et al. 2011).

1.3.2 Behavior Change

Understanding motivations can also help researchers understand behavior change in humans. Behavior change is needed to solve complex environmental issues, and generally, education alone is not enough for humans to change their behavior (Ehrlich & Kennedy 2005; McKenzie-Mohr et al. 2011; Schultz, 2011). In one citizen science project called Spotting the Weedy Invasive, researchers looked at behavior change after volunteers participated. Results showed that participants learned about invasive plants but did not change their behavior from their new knowledge. Participants retained invasive plant knowledge for up to six months, but only half shared their knowledge with others, and only 5-10% took a direct action related to invasive plants (Dickinson and Bonney 2012).

However, citizen science has potential for promoting behavior change. An example that has potential includes planning for biodiversity conservation in urban areas. The amount of turf grass in the United States is three times higher than irrigated corn, its largest crop (Milesi et al. 2005). Turf green lawns and golf courses have the potential to support biodiversity, especially for pollinators. Currently, clean-cut, turf grass areas such as lawns and golf courses are perceived as the ideal landscape, yet they support very little biodiversity. Green grass is a socially constructed trend that is deeply rooted in society and large industries such as the landscape and pest control industries. If researchers can understand human motivations, which includes norms, attitudes,

and values behind the clean-cut lawns, then that information can be used to promote behavior change from clean-cut lawns to ecologically functioning lawns that support urban biodiversity while also meeting the needs of humans. Since pollinators, especially native bees have small foraging ranges and are prominent in urban areas, this research has potential to make large impacts on local pollinator populations (Hall et al. 2017). Citizen science can play a role in understanding motivations to promote behavior change and providing education on how to landscape for ecologically functioning lawns. Small actions will make a big difference for issues such pollinators in urban areas (Bonney et al. 2009; Hall et al. 2017).

Another benefit of citizen science is increasing scientific literacy among participants. Volunteers go beyond just learning the facts needed to complete the data collection. They will use scientific processes and principles beyond the scope of the project (Trumbull et al. 2000). Scientific literacy benefits not only the citizen science program but will benefit the individual and society and may lead to behavior change (Dickinson and Bonney 2012).

1.3.3 Future Generations and Citizen Science

Reconnecting children and families to the natural environment is critical for human health and a sustainable environment. While there have been substantial efforts to reconnect kids to nature, including by the Children and Nature Network, the disconnect is still growing between children, adults, and spending time outside ("Children & Nature Network" n.d.). More research is needed to better understand how environmental education (EE) can impact children and how to integrate EE into society to reconnect children to nature. In addition, if children experience and appreciate nature as a child, they are more likely to participate in nature activities as an adult (Guiney and Oberhauser 2009). Citizen science has increased opportunities in urban areas. These urban experiences can be designed safely so that children can explore and also be taught the

skills needed to think about environmental issues. Citizen science provides hands-on learning experiences for children and skills that will benefit them through adulthood. Citizen science can also be an opportunity for families and schools to engage children with nature over a long period of time. Children can ask questions, observe the world around them, and know that they are making a difference. Although dedication on the part of teachers and parents is required, it can be a tool for continuous engagement with nature in urban areas. Community engagement will become more important because urban areas are containing more biodiversity as the human population increases and natural spaces decrease (Niemelä 1999). There is a greater need to learn more about how urban ecosystems are functioning at broad levels.

Concerns over children collecting accurate data has come into question (Dickinson et al. 2010). In one study, children in elementary school, grades three through seven, collected data on native and invasive crabs. The children were able to identify the gender of crab species with 80% to 95% accuracy depending on their grade level, which is a high accuracy rate compared to other citizen science projects. However, adult volunteers with some university education had a higher accuracy rate in determining the gender (Delaney et al. 2008). Children have been active in the Monarch Larva Monitoring Project, a citizen science program throughout the United States and Canada, that collects data on the egg and larva stage of the monarch butterfly and its host plant, milkweed. In addition to collecting valuable data that is helping researchers learn about monarch distribution and abundance, the program has helped adults and children gain an awareness and appreciation for monarch butterflies, a species that has declined significantly (Dickinson and Bonney 2012). The study reports that children were successful in collecting accurate data. In many cases, adults were very involved and engaged in helping children collect accurate data. The children also learned about the scientific process, collaboration, and other social skills

(Kountoupes and Oberhauser 2008). The research from this project has led to published journal articles on many aspects of monarch butterfly ecology and biology. The success of this project could be used as a model to involve children in other pollinator monitoring citizen science projects.

1.4 Recommendations and Future Research

Although citizen science has many success stories, room exists for future research and improvement. From an ecological perspective, researchers are interested in knowing about the data quality. Recommendations on furthering research on data quality include comparing citizen science data to reference data and developing consistent metrics to measure success prior to collecting data (Aceves-Bueno et al. 2017; Dickinson et al. 2010). Noting the expertise level of the citizen scientists is important and researchers should explore how to capitalize on the skill set the citizen scientists bring to the program. Perhaps pairing a beginner citizen scientist with a volunteer who has previous monitoring experience could increase efficiency and accuracy (Crall et al. 2011). Researchers should also focus on what types of data are best collected by citizen scientists, whether species identification versus abundance, broad-level data versus specific hypothesis data, or surveillance versus targeted data (Crall et al. 2011; Kremen et al. 2011). Ecological researchers should also better understand the value and use that citizen science has to offer. This understanding includes publishing literature, making citizen science data publicly available, and capitalizing on how citizen science can help solve complex conservation issues such as biodiversity and climate change (Dickinson and Bonney 2012; Silvertown 2009; Theobald et al. 2015). From a social science perspective, understanding attitudes, norms and values can help researchers understand motivations of citizen scientists and is definitely an area that needs further research (Ehrlich & Kennedy, 2005; Schultz, 2011). In addition, researchers

should explore how citizen science can be used as a tool to foster behavior change and increase scientific literacy (Bonney et al., 2009; Dickinson & Bonney, 2012; Trumbull et al., 2000). Citizen science may also provide a way to reconnect children with nature, but it is an area that needs research to explore how best to faciliate children collecting data in a meaningful way (Dickinson and Bonney 2012).

A lot of cross-over exists between the ecological and social perspectives on the challenges, benefits, and research needs of citizen science. For example, understanding the motivations of citizen scientists can help retain them from year to year (Bruyere and Rappe 2007). The citizen scientists will gain more experience collecting data more accurately and could aid newer volunteers. Another example could be researching the long-term impacts of citizen science programs on children. If citizen science helps to instill a connection to nature, then that child could grow up to advocate for conservation by being a policy maker, scientist, journalist, etc.

Specifically, with pollinators in urban areas, many research opportunities exist to explore combining ecology and social science. Since pollinators are in everyone's backyards, citizen science can be easily accessible to interested participants. Pollinators can be a challenging subject for citizen scientists to collect data because of the species diversity, smaller sizes, and the nature of their biology. More "calibration and rigorous comparison" is needed between researchers and citizen scientists (National Research Council (U.S.) & Committee on the Status of Pollinators in North America, 2007, p. 143). Specific research opportunities and recommendations that include both the ecological and social science perspective include:

- Comparing citizen science data to research data or reference data routinely to check accuracy. Researchers can also improve accuracy by spending additional time with the citizen scientists

outside of the initial training sessions and provide opportunities to test citizens on their knowledge of the subject (Crall et al. 2011).

- Educating citizen scientists about creating pollinator habitat in their backyards and following that education with citizen science training on how they can monitor the pollinators that visit their habitat. This effort could lead to research on trends of pollinators populations in urban areas.
- Providing voucher specimens to increase data accuracy (Crall et al. 2011). Specifically, bees are difficult to identify because of the diversity in taxa. Providing voucher specimens will help citizen scientists learn to recognize certain morphological groups of bees.
- Researching attitudes, norms, and values to understand how humans perceive bees. Often bees are perceived in negative ways because they are a stinging insect. If the perception can be changed, then these improved perceptions could help with bee conservation.
- Determining what type of data citizen scientists should collect on pollinators. This includes everything from the counting eggs and larva of the migratory monarch butterfly, to identifying birds, bees, and other insects to assess diversity and abundance, to looking for bee nesting sites (Kountoupes and Oberhauser 2008).

This list is a small selection of future research opportunities with urban pollinators and citizen science. Since small urban spaces are becoming critical habitat for pollinators, it is important to involve researchers and citizens in helping to provide solutions to pollinator conservation (Hall et al. 2017).

1.5 Conclusion

The literature presented in this paper represents a small percentage of all citizen science programs and research. Yet this percentage is growing as citizen science programs have gained

popularity recently (Dickinson et al. 2010; Silvertown 2009). With the success stories of citizen science, criticism among researchers also exists and should be taken into consideration. Citizen science may not be the most appropriate tool for all research, but it has potential for many applications such as biodiversity monitoring at large spatial and temporal scales (Dickinson and Bonney 2012; Graham et al. Field 2015; Theobald et al. 2015). Some researchers argue that citizen science programs and research have barely tapped into the full potential that exists (Dickinson and Bonney 2012). Dickinson et al. (2010) reports that "the value of citizen science to applied and basic ecology has not been fully realized and articulated; increasing involvement of leading ecologists in prioritizing research goals, evaluating data quality, and informing sampling methodologies will advance the field." Perhaps one of the most critical components to exploring the full potential of citizen science is to better incorporate the ecological perspective with the social science perspective. Collaboration between the two fields will provide the most benefit to citizen science programs, the humans involved, the ecosystems, and solving conservation challenges such as pollinator health in urban areas, by doing what each perspective is incapable of doing on its own: using the strengths of each perspective to potentially improve the weaknesses of the other.

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CHAPTER 2: ASSESSING THE EFFICACY OF CITIZEN SCIENTISTS MONITORING NATIVE BEES

2.1 Introduction

As the world's human population continues to grow, urban areas continue to expand, and natural spaces become more fragmented leading to dilution and loss of natural resources. In North America alone, over 82% of the population resides in urban areas, a percentage that is expected to grow (Cohen 2003; United Nations, Department of Economic and Social Affairs, and Population Division 2014). Of the organisms that depend on natural resources, pollinators could face significant impacts including habitat loss, fragmentation, and deterioration (Goulson et al. 2015; Hennig and Ghazoul 2012). Conserving and managing scarce natural resources in and around urban areas will become increasingly important with the growing population. Pollinators are vital to human survival. Even though some plants can self-pollinate, most plants benefit from cross-pollination (transferring pollen from one plant to another plant of the same species, with the help of agents such as wind or animals). Given that roughly 75% of the more than 240,000 species of the world's flowering plants rely on animal pollinators for reproduction, expanding urban areas could reduce the number of pollinators available for successful plant reproduction in ecosystems.

Most fruits, vegetables, nuts, and other plants that provide food, fiber, drugs, and fuel for humans, need insect pollination. Roughly 35% of global crops are dependent on pollinators for reproduction (Klein et al. 2007). Economically, insect-pollinated crops have an annual worth of about $2-3 billion (Losey and Vaughan 2006; Gallai et al. 2009; Calderone 2012; Koh et al. 2016). In addition, pollinators provide indirect benefits to humans including livestock forage,

such as alfalfa and clover. Pollinators also contribute to aesthetics, recreational values, and cultural activities, and they help maintain ecosystem integrity (Niemelä 1999). Subsequently, with continued urbanization, one may expect a reduction in ecosystem services and functions (National Research Council (U.S.) and Committee on the Status of Pollinators in North America 2007). The widespread services provided by pollinators and the rapid rate at which urban areas are expanding makes understanding the impact of urbanization on insects, such as bees, necessary.

While urbanization is expanding, the human connections to nature remain steady, and our desire to interact with nature is on the rise. One method of understanding the effects of urbanization on ecosystems is to involve urban residents in exploring the components of the ecosystem around them by engaging, educating, and empowering urbanites through citizen science (Krasny et al. 2014). Citizen science is defined as involving non-scientists in collecting data for a scientific or research project and contributing to a large database (Cooper et al. 2014; Jue and Daniels 2015; Theobald et al. 2015; Trumbull et al. 2000). Citizen science has grown dramatically in popularity in the last two decades as a result of more projects being readily available for participants; technological advances such as data entry on portable computers devices allowing easier data collection and entry by non-experts; greater recognition that scientists can capitalize on citizen scientist availability and enthusiasm to increase capacity; increased research funding shortfalls; and the need to meet an outreach-related component (Dickinson et al. 2010). The social component of citizen science offers countless tangible and intangible benefits including facilitating behavior change towards environmental issues, developing long-term community-based conservation programs to benefit ecosystem services and habitats, increasing opportunities for adults and children to interact with nature, increasing

scientific literacy, bridging communication gaps between scientists and researchers, and providing additional avenues to inform policy makers on conservation and environmental issues (Dickinson and Bonney 2012; Schultz 2011; Danielsen et al. 2005; Bell et al. 2008; Theobald et al. 2015; Trumbull et al. 2000; Schmeller et al. 2009).

Data accuracy is one of the main concerns that scientists have with citizen science programs (Danielsen et al. 2005; Law et al. 2017), and several studies have assessed the quality of citizen science data in an attempt to comprehend the underlying problems and develop effective future protocols (Birkin and Goulson 2015; Burgess et al. 2017; Callaghan et al. 2017; Kremen et al. 2011; McDonough MacKenzie et al. 2017; Rüdisser et al. 2017). McDonough MacKenzie et al. (2017), in their volunteer-sampled plant phenology found a disparity between citizens' self-assessed and actual identification skills, suggesting the importance of evaluating this difference before launching data collection. However, the general consensus is that researchers do not yet fully understand the error potential in citizen science data possibly because data accuracy does not have a reliable definition and there are few consistent metrics on data accuracy (Dickinson et al. 2010). A study assessing citizen science journal articles revealed that only approximately half of the published articles reported having accurate data from citizen scientists but this study did not define data accuracy (Aceves-Bueno et al. 2017). Burgess et al. (2017), while identifying broad barriers for publishing citizen science data, note that not all projects are suited for citizen scientists. Some of the suggested barriers include insufficient awareness among scientists about suitable citizen sciences projects, data quality inconsistency, and bias among scientists for certain data sources (such as age and educational levels of citizen scientists). Given the importance of pollinators, a few different citizen science projects have started including the Great Sunflower Project (Domroese and Johnson 2017) and the Urban

Pollination Project (Potter and LeBuhn 2015). Kremen et al. (2011) reported that citizen scientists can record broad-level data but perhaps not finer details such as genus or species-level data. Birkin and Goulson (2015) suggested the importance of engaging citizens during the study to maintain interest and commitment.

With this background, recognizing the hurdles encountered with citizen science data and knowing that pollinator conservation is an attractive issue for urban citizens, we launched Native Bee Watch, a citizen science project on urban pollinators in Fort Collins, Colorado, USA, specifically to (i) determine whether citizen scientists can collect accurate data on native bees, and (ii) develop a protocol that yields us accurate data. At present, there are no recorded studies on native bee species in Fort Collins implying that data from our study will be novel for this location and will help urban policy development that could conserve and sustain pollinator diversity.

2.2 Methods

2.2.1 Study Area

This study took place in the City of Fort Collins, a fast-growing urban center along the northern Colorado Front Range. Three public gardens located throughout the city were monitored. The gardens were chosen because they are all easily accessed by the public, so citizen scientists could access them. The Gardens at Spring Creek is a city-owned, 18-acre botanical garden located along the Spring Creek corridor. Nix Farm Natural Area is a city-owned, 27.5-acre historic site off the Poudre River trail system, surrounded mostly by undeveloped land. The Plant Select® Demonstration Garden is a portion of the Colorado State University (CSU) Annual Flower Trial Garden, a 2.9-acre research and public garden near the CSU campus. At each garden, variable length transects were identified along a public walkway that had flowers

blooming throughout the season. Transects varied in length due to the size of the gardens and available public walkways.

2.2.2 Citizen Scientists and Researchers

"Citizen Scientists" were community volunteers interested in monitoring bees. "Researchers" were laboratory personnel with bee identification experience. "Citizen Science Leaders" (CSL) were returning volunteers in 2017. Seven Citizen Scientists from 2016 returned in 2017 as CSLs to initiate additional weekly monitoring sessions.

2.2.3 Monitoring Frequency and Duration

Gardens were monitored on a weekly basis from the last week in May until the last week of September in 2016 and through mid-September in 2017. A "Citizen Science Session" consisted of 1-4 volunteers, working in pairs when possible, to monitor the gardens with a researcher on-site. A "Researcher-Only Session" was defined as an individual from the CSU laboratory conducting the monitoring session. A CSL Session consisted of a returning volunteer and up to one additional volunteer monitoring without a researcher on-site. CSL volunteers monitored without a researcher on-site because they had bee monitoring experience from last season. Citizen science monitoring occurred on alternating weeks, and researcher-only monitoring occurred during the off-weeks, allowing for paired volunteer and researcher data sets.

2.2.4 Citizen Science Activities

2.2.4.1. Recruiting

Volunteers were recruited through emails to various networks within Colorado State University and the City of Fort Collins, flyers were posted in public places such as libraries and restaurants around Fort Collins, information was placed on our project website, NativeBeeWatch.WordPress.com and the City of Fort Collins website, and word-of-mouth.

Community outreach events on pollinator conservation held each year also helped to recruit volunteers. The target goal was to recruit 30 adult citizen scientist volunteers to participate in bee diversity monitoring. The recruiting goal was set higher than the capacity for the training program because we anticipated some volunteers would drop out.

2.2.4.2. Training

Training entailed a two-hour interactive workshop introducing pollinators, learning identification characteristics of bees, flies and wasps, and creating pollinator habitats in backyards. Volunteers received a field guide geared towards the research project summarizing verbal and pictorial identification characteristics to differentiate bees, wasps, and flies, and an easy key to identify bee morphological groups (Appendix A; Figures 2.1, 2.2, and 2.3). Each volunteer also examined voucher specimens and took photos to compare with the pictures in their copy of the field guide. A researcher worked closely with the volunteers examining the voucher specimens to help them learn the characteristics of each category. In addition to training with voucher specimens, volunteers trained with a researcher in the field prior to the commencement of the season's monitoring sessions.

2.2.4.3. Engagement

Biweekly newsletters were emailed to volunteers to remind volunteers they were monitoring during the upcoming week. Newsletters also contained tips to identify bees, interesting bee or insect sightings while monitoring, current research, and other relevant information to keep volunteers engaged in the project. The project website served as a tool to keep volunteers informed about the project. The volunteer appreciation event at the end of the season thanked volunteers for their work.

2.2.5 Monitoring and Data Collection

Each monitoring session lasted up to two hours from 9AM-11AM, as mornings are an active time for bees (Kearns and Inouye 1993). Monitoring occurred only on sunny, non-windy days (Kremen et al. 2011). Researchers and citizen scientists selected their monitoring days based on their availability. Up to four volunteers participated in each citizen science monitoring session with an on-site researcher. Volunteers monitored the transect in pairs sharing the responsibilities for observing the bees, starting and stopping a timer, recording the data, and referencing the field guide when needed, pausing the timer when they needed to consult the field guide. Volunteers submitted the hard copy data to the accompanying researcher. Researchers entered data electronically and verified data entry to minimize transcribing errors. During the researcher-only monitoring sessions, a researcher repeated transects completed during the citizen science monitoring sessions.

2.2.6 Bee Monitoring

Data was collected by using the Focal Plant Sampling Procedure that was modified from other animal behavior studies (Altmann 1974; Arathi et al. 1997; Arathi et al. 2000). The data collector, a volunteer or a researcher, walked the transect stopping at each flowering plant along the way. All bees pollinating a flower on the plant, as described in the field guide, were recorded for a two-minute period. Over the two-minute period, the number of bees and morphological type of bee pollinating the plant was recorded. Flower visitors, including bees not visibly pollinating the plant, were not recorded.

2.2.7 Statistical Analysis:

Using the statistical software, R, Spearman's Rank Correlation was measured for the citizen scientist data set with the researcher-only data set (2016 and 2017) and the researchers-

only data with the citizen science leader data (2017 only). Actual numbers and proportions of bees in the eight morphological categories were used for the analysis. The comparison was repeated by excluding honey bees from the data.

2.2.8 Prediction of Habitat Quality

While there are over 20,000 species of bees described globally and over 4,000 of them are found in North America (Michener 2007), the simplified arrangement of classifying bees into morphospecies (Figure 2.1) allows for non-taxonomists to record bee abundance and morphospecies diversity. However, a readily available measure for bee habitat quality does not exist. Species (in our case, morphospecies) richness is a measure of diversity, and the abundance data for each category can integrate information on ecosystem services and functions (Gotelli and Colwell 2001; Schwartz et al. 2000). Together, these two measures can provide a window into habitat quality (Rüdisser et al. 2017). Using the morphospecies abundance and diversity data recorded by citizen scientists and researchers, an Urban Bee Habitat Quality (UBHQ) index was calculated and measured by these two groups. In addition, habitat quality for bees could vary across the season of sampling. When observers are only recording the morphospecies of bees and their abundance on flowering plants, as in our study, an estimate of habitat quality is obtained by multiplying rarified morphospecies estimate (MS_{est}) with abundance (Ab) for each sampling period. By modifying methods described by Rüdisser et al. (2017) to fit the morphospecies counts from our study, we calculated UBHQ across the different sampling periods separately for the citizen science data and for the researcher data. Rarefaction in our analyses estimated the expected number of morphospecies from an individual sample period-based rarefaction curve. Such rarefaction curves describe the dependence of the species number on the accumulated

number of individuals (Gotelli and Colwell 2001). MS_{est} was computed using EstimateS (Version 9.1 (Colwell 2013), and UBHQ was calculated as follows:

$$UBHQ_i = \frac{MS_{est,i} - MS_{est,min}}{MS_{est,max} - MS_{est,min}} \times \frac{Ab_i - Ab_{min}}{Ab_{max} - Ab_{min}}$$

where $MS_{est,i}$ is the rarefied morphospecies richness at sampling period "i", and Ab_i is the abundance during the corresponding sampling period. UBHQ ranges from 0 to 1, where 0 indicates poor quality and 1 indicates good quality. Estimates of habitat quality using this formula has been validated for butterflies in a recent study by Rüdisser et al. (2017). Wilcoxon's matched pair comparison of the UBHQ values over the sampling period was completed to determine whether the quality predicted by citizen scientist data was similar to that predicted by the researcher data.

2.3 Results

2.3.1 Volunteer Retention

The volunteer retention rate was calculated using the number of enrolled volunteers that took the initial training divided by the number of volunteers that followed through with at least one bee monitoring session during the summer. In 2016, the volunteer retention rate was 78.5% and in 2017 the rate was 86%. The retention rate of volunteers who returned from 2016 to 2017 was 28%. Table 2.1 summarizes the volunteer retention statistics.

2.3.2 Focal Plant Sampling Summary

Table 2.2 shows the average number of focal plant samples per session, as well as the totals for Citizen Science, Researcher-Only, and Citizen Science Leader sessions for 2016 and 2017. There were 50 sampling sessions in 2016 and 56 sampling sessions in 2017 (Table 2.2). Tables 2.3, 2.4, and 2.5 indicates the average number of focal plant samples per session and number of sessions at each garden.

2.3.3 Number of Bees Observed

In 2016, 3,722 bees were observed in total, and 6,499 bees were observed in 2017. Table 2.7 summarizes the number of bees in each morphological category. The CSL category only had 12 monitoring sessions compared to 21 researcher-only sessions and 23 citizen science sessions, so the number of bees observed is considerably lower.

2.3.4 Spearman's Rank Correlation

All correlations were analyzed with honey bees and without honey bees (Figures 2.8 through 2.13). Since honey bees accounted for over half of the bees observed, the correlations without honey bees provided more information on how close the other seven morphological categories were correlated. In 2016, the Spearman's rank correlation coefficient was 0.92 including honey bees and 0.88 without honey bees. In 2017, the correlation was 0.98 for both analyses with honey bees and without.

2.3.5 Morphological Category Number and Proportion Comparisons

For most of the morphological groups, the number of bees and proportion of bee groups observed was similar between citizen scientists and researchers. Figures 2.4 and 2.7 show some discrepancies in abundance data. Looking at the morphological comparisons between citizen scientists and researchers, the biggest difference between the number of bees observed by citizen scientists and researchers occurred in 2017 with the number of honey bees. Citizen scientists observed 501 more honey bees than the researchers over the course of the season. Citizen scientists observed 43 more honey bees than researchers in 2016. The differences between citizen science and researcher-only bee counts in the other seven morphological categories varied from 1 to 97. The proportion of bee groups observed were also comparable between citizen scientist and researcher data.

2.3.6 Urban Bee Habitat Quality

The habitat quality estimates determined from Citizen Scientist data was not significantly different from the estimates calculated from Researcher data as seen in Figure 2.14. Wilcoxon matched pairs comparison of the habitat quality values was not significantly different between the two sets for 2016 and 2017 (2016: Citizen Scientist vs Researcher UBHQ for All bees: $p = 0.68$, $n = 8$; UBHQ for native bees: $p = 0.87$, $n = 8$; 2017: Citizen Scientist vs Researcher UBHQ for All bees: $p = 0.67$, $n = 8$; UBHQ for native bees: $p = 0.4$, $n = 8$).

2.4 Discussion

2.4.1 Volunteer Engagement

Maintaining volunteer engagement and interest throughout the season is critical to ensure that they stay engaged and motivated to produce high quality work (Crall et al. 2013; Dickinson and Bonney 2012; Birkin and Goulson 2015). Continuous volunteer engagement was achieved through a variety of communication methods including having researchers spend one-on-one time with volunteers, sending out biweekly e-newsletters in the summer season and monthly newsletters in the off-season, maintaining a project website, and holding a volunteer appreciation event at the end of the season.

Research has shown that data collection accuracy can improved by having the professional or researcher spend additional time with the citizen scientist outside of the initial training sessions (Crall et al. 2011). For this project, a researcher was on-site for all monitoring sessions to field questions and check data accuracy periodically. Whereas, these efforts were an initial investment, seven volunteers that monitored in 2016 returned to monitor in 2017. Those volunteers were required to retake the initial training workshop and participate in one monitoring session with a researcher at the beginning of the season to reinforce data accuracy. After

retraining, those volunteers could monitor without a researcher on site. These volunteers, called Citizen Science Leaders could monitor outside of the scheduled weekly sessions. Citizen Science Leaders paired with newer volunteers and mentored with them to improve their skills. The observational data collected from Citizen Science Leaders provides an additional data set to compare against the researcher-only data set. Over time, if volunteers stay engaged and data accuracy remains consistent or improved, monitoring becomes more robust and less reliant on researchers or experts to assist in the field. A study by Nerbonne et al. (2008) demonstrated that volunteers doing bird counts with no experience had less accurate data, but if they returned for a second and third year, the data was more accurate.

Overall, we think volunteer engagement and consistent communication with the citizen scientists was a critical component to ensuring accurate data collection for this study. Having a researcher on-site not only helped with accurate data collection, but also provided the volunteers with additional training and learning opportunities as they worked with a professional in the field.

2.4.2 Data Accuracy

Since researchers do not fully understand the potential for errors in citizen science data, further emphasis should be placed on having consistent metrics when assessing data accuracy (Aceves-Bueno et al. 2017; Dickinson et al. 2010). Having consistent metrics can help identify problem areas that could be addressed through further training. For example, the morphological group called “Tiny Dark Bees” had less observations by citizen scientists in 2016 than the researchers. Training in 2017 further emphasized the “Tiny Dark Bee” category through photos and voucher species, possibly contributing to more comparable numbers and proportions in 2017.

2.4.3 Broad-level Data

The Spearman's Rank Correlations suggests that citizen scientists can collect broad-level data comparable to a researcher. Kremen (2011) found similar results when comparing citizen science data to collected bee specimens. The Urban Bee Habitat Quality Index demonstrates that data collected by citizen scientists at a broad-level such as morphological categories can be used to evaluate habitat quality. This model could evaluate habitat quality on different spatial and temporal scales that collect abundance and species richness data.

Future research could examine the accuracy of citizen scientists collecting data at a finer taxonomic level. This information could be useful when looking at biodiversity, abundance, and richness. Citizen scientists could potentially learn to identify rare genera or species with significant more training and mentoring with a researcher. Even though some research suggests citizen scientists should only collect broad-level taxonomic data, other research shows that citizen scientists collected accurate taxonomic information, but the abundance data inaccurate (Genet and Sargent 2003). One reason for the abundance difference in honey bees observed by citizen scientists in 2017 is that there were more citizen science sampling sessions than researcher-only sessions including at the beginning and end of the season when honey bees were more prevalent than native bees. Citizen scientists generally had higher numbers than researcher-only data, most likely because there were more citizen science sampling sessions in both years. Some differences in the numbers of bees observed is expected because citizen scientists did monitor on different weeks, and factors such as weather could impact the number of bees observed from one week to the next. Further research could expand on assessing the accuracy of abundance if the citizen scientists and researchers completed the same methodology, but also sampled on the same day.

2.4.4 Further Research

To ensure citizen scientists collect accurate data, it is important keep them engaged and motivated (Dickinson and Bonney 2012; Crall et al. 2013; Birkin and Goulson 2015). Volunteer motivations should be taken into consideration when developing a citizen science project (Bruyere and Rappe 2007; Guiney and Oberhauser 2009). In addition, education and career backgrounds could help researchers assess how much that affects a volunteer's scientific inquiry and data collection skills (Nerbonne et al. 2008; Crall et al. 2011). Future research to expand on this study could survey volunteers to understand their motivations, values, norms, and attitudes towards pollinator conservation and citizen science (Burgess et al. 2017).

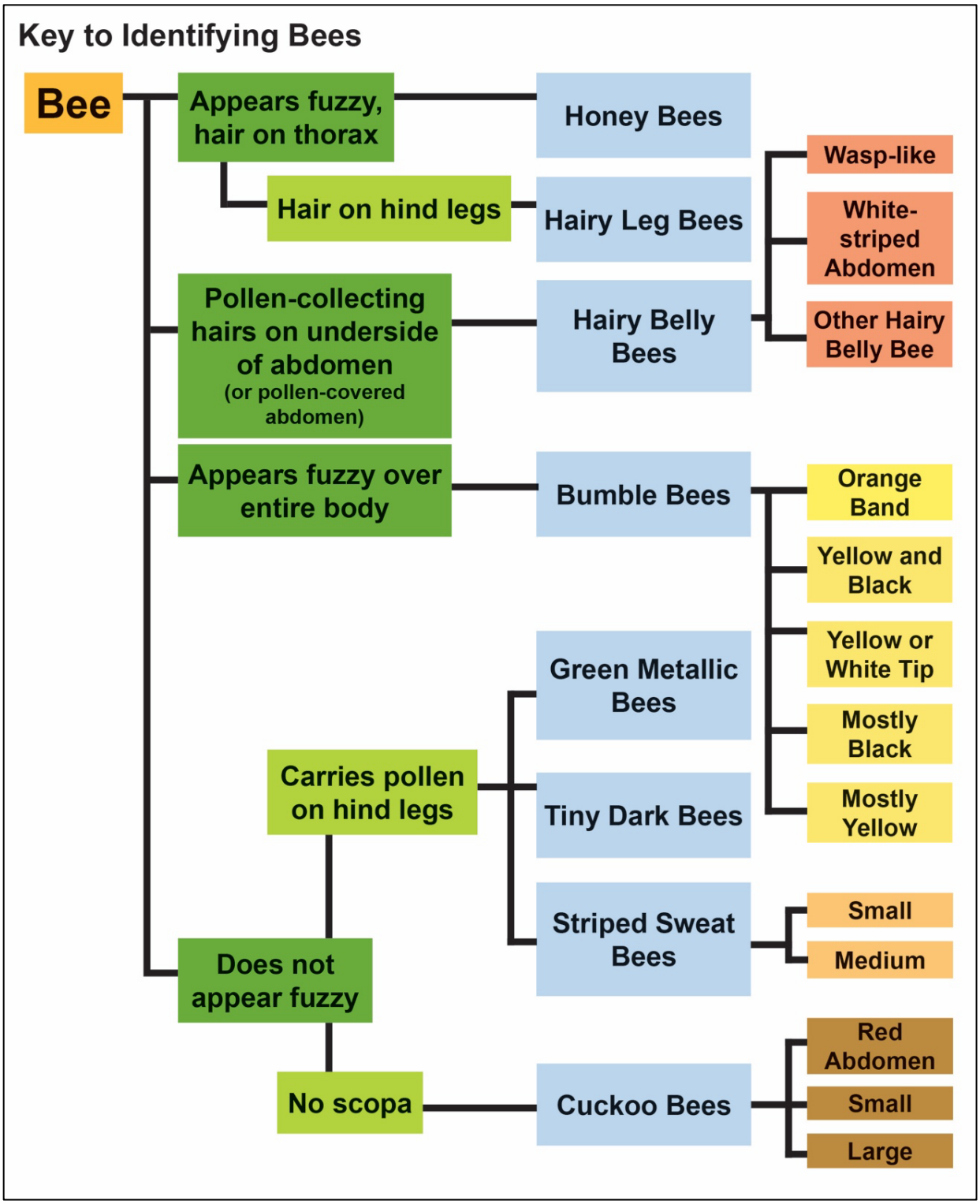

Figure 2.1. Key to the eight morphological bee groups

Bee Groups and Scientific Classification				
Bee Group	**Bee Subgroup**	**Common Name**	**Scientific Name**	**Family**
Honey bee	NA	Honey bee	*Apis mellifera*	Apidae
Hairy leg bee	NA	Digger bee Flower bee Long-horned bee Sunflower bee	*Anthophora* sp. *Diadasia* sp. *Melissodes* sp. *Svastra* sp.	Apidae Apidae Apidae Apidae
Hairy belly bee	Wasp-like	Wool carder bee Resin bee	*Anthidium* sp. *Megachile* sp.	Megachilidae Megachilidae
	White-striped	Leafcutter bee	*Megachile* sp.	Megachilidae
	Other hairy belly bees	Mason bee	*Megachile* sp. *Osmia* sp. *Hoplitis* sp.	Megachilidae Megachilidae Megachilidae
Bumble bee	Orange band	Hunt's bumble bee Central bumble bee	*Bombus huntii* *Bombus centralis*	Apidae Apidae
	Yellow and black	Brown belted bumble bee Morrison's bumble bee Nevada bumble bee	*Bombus griseocollis* *Bombus morrisoni* *Bombus nevadensis*	Apidae Apidae Apidae
	White or yellow tip	Western bumble bee	*Bombus occidentalis*	Apidae
	Mostly black	Cuckoo bumble bee	*Bombus insularis*	Apidae
	Mostly yellow	Golden northern bumble bee	*Bombus fervidus*	Apidae
Green metallic bee	NA	Sweat bee	*Agapostemon* sp. *Augochlorella* sp.	Halictidae Halictidae
Tiny dark bee	NA	Small carpenter bee Small carpenter bee Yellow-faced bee	*Ceratina neomexicanum* *Ceratina* sp. *Hylaeus* sp. *Lasioglossum* sp.	Apidae Apidae Colletidae Halictidae
Striped sweat bee	Small	Sweat bee Sweat bee, other	*Halictus* sp. *Lasioglossum* sp.	Halictidae Halictidae
	Medium	Sweat bee Sweat bee, other	*Halictus* sp. *Lasioglossum* sp.	Halictidae Halictidae
Cuckoo bee	Red abdomen	Cuckoo bee Cuckoo bee	*Nomada* sp. *Sphecodes* sp.	Apidae Halictidae
	Small	Cuckoo bee Cuckoo bee Cuckoo bee	*Epeolus* sp. *Nomada* sp. *Sphecodes* sp.	Apidae Apidae Halictidae
	Large	Cuckoo bee Cuckoo bee Cuckoo bee	*Epeolus* sp. *Nomada* sp. *Sphecodes* sp.	Apidae Apidae Halictidae
Note: This is not an inclusive list of all bees found in these categories or in Colorado. These are some of the more common bees observed.				

Figure 2.2. The taxonomic families and genera for the eight morphological bee groups.

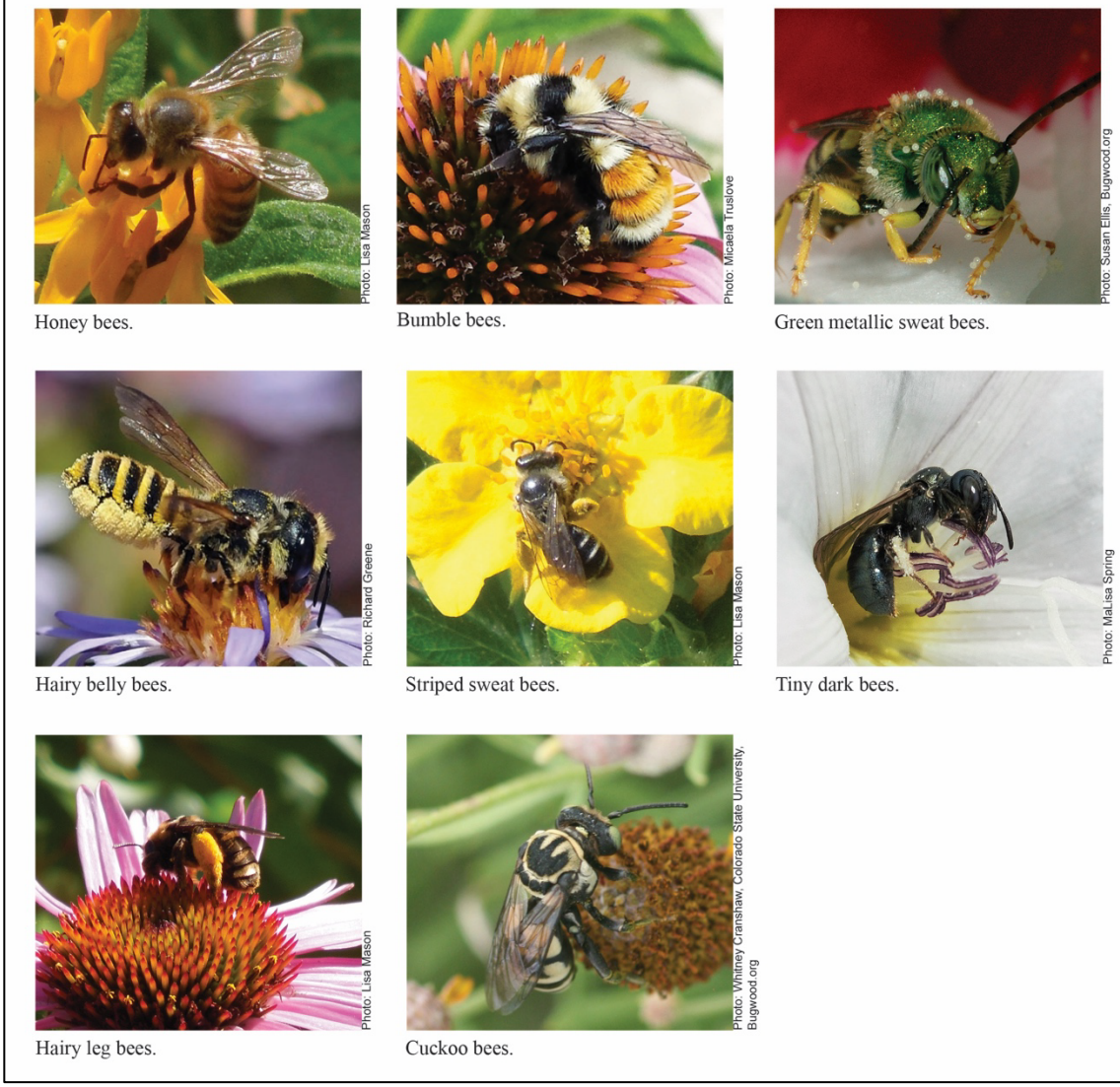

Figure 2.3. Example photographs of each morphological category.

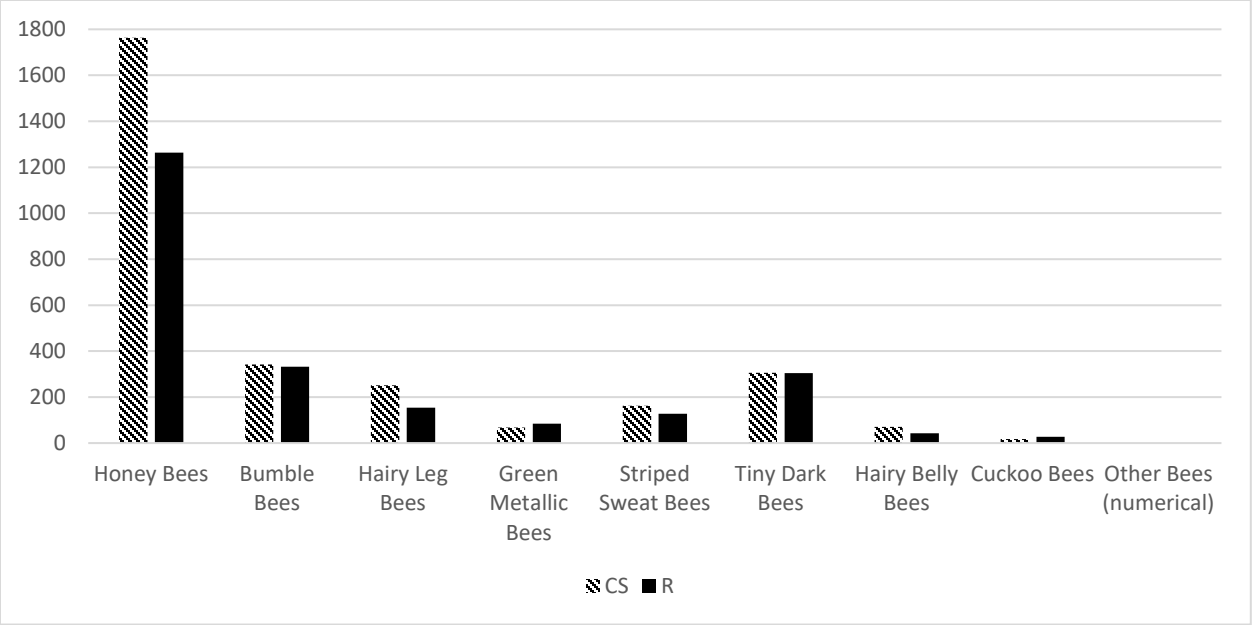

Figure 2.4. Number of bees comparing Citizen Science (CS) sessions to Researcher-only (R) sessions in 2017.

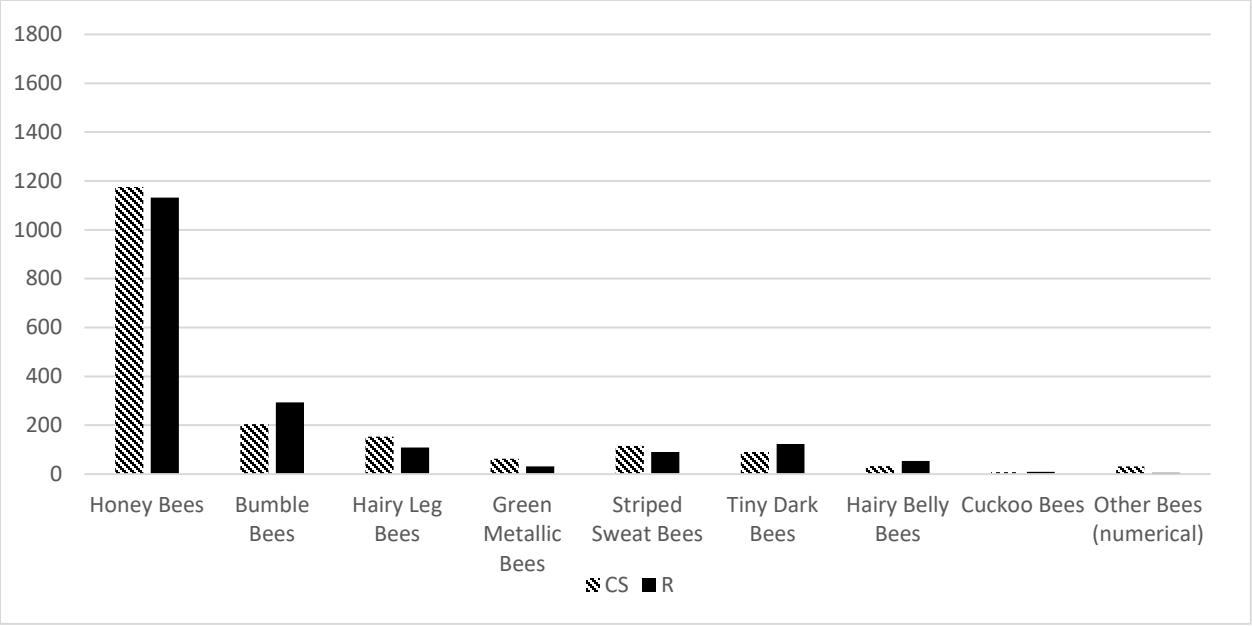

Figure 2.5. Number of bees comparing Citizen Science sessions (CS) to Researcher-only (R) sessions in 2016.

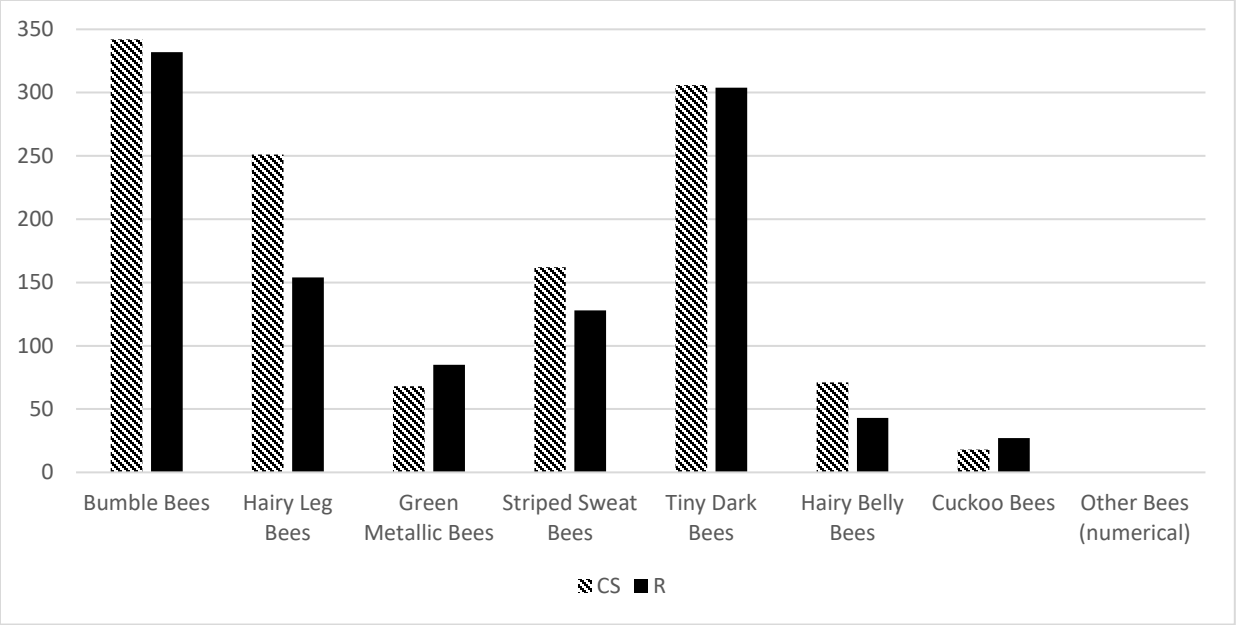

Figure 2.6. Number of bees comparing Citizen Science sessions (CS) to Researcher-only (R) sessions in 2017 without including honey bees.

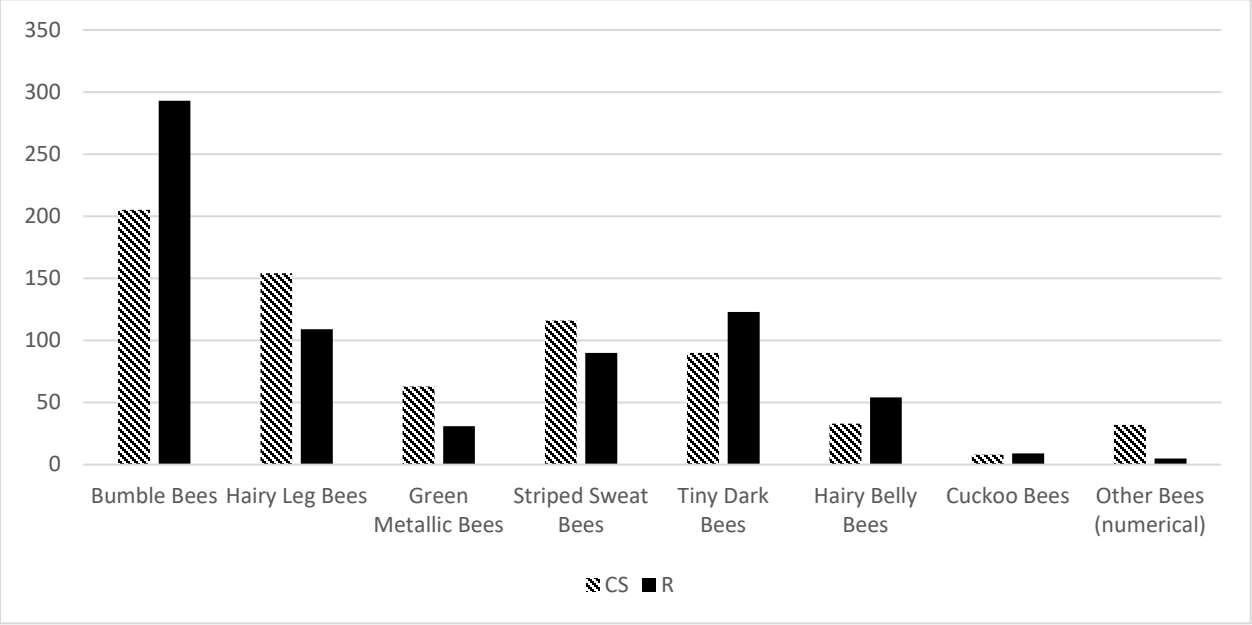

Figure 2.7. Number of bees comparing Citizen Science sessions (CS) to Researcher-only (R) sessions in 2016 without including honey bees.

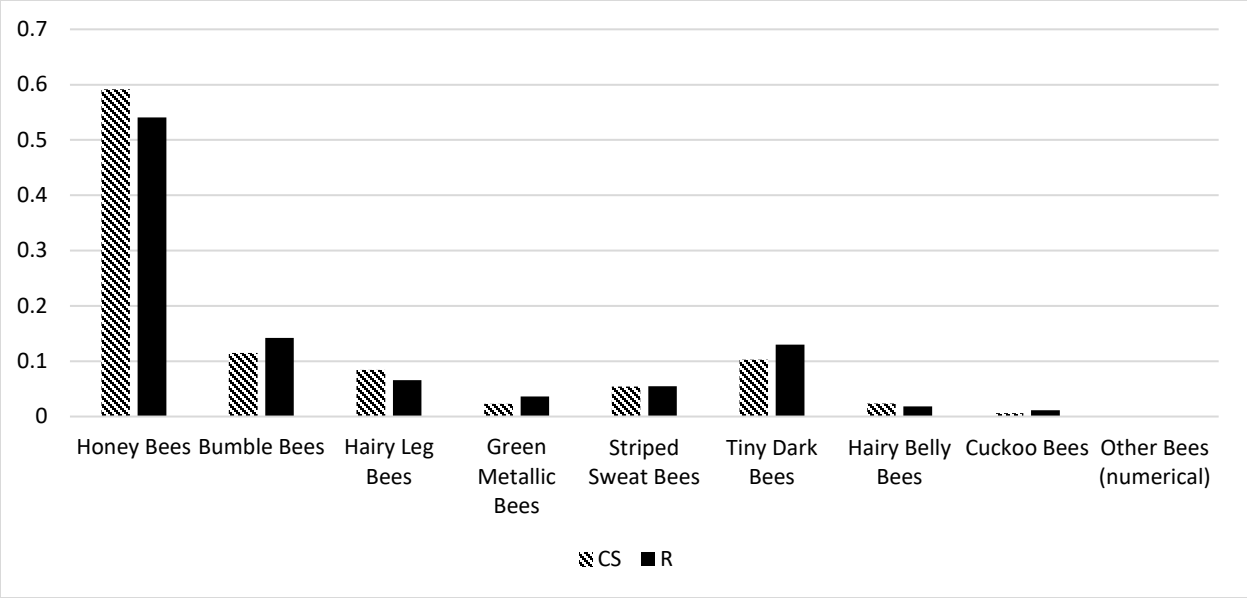

Figure 2.8. Proportion of bees observed comparing Citizen Science sessions (CS) to Researcher-only (R) sessions in 2017 (Spearman's $\rho = 0.98$, $p < 0.05$).

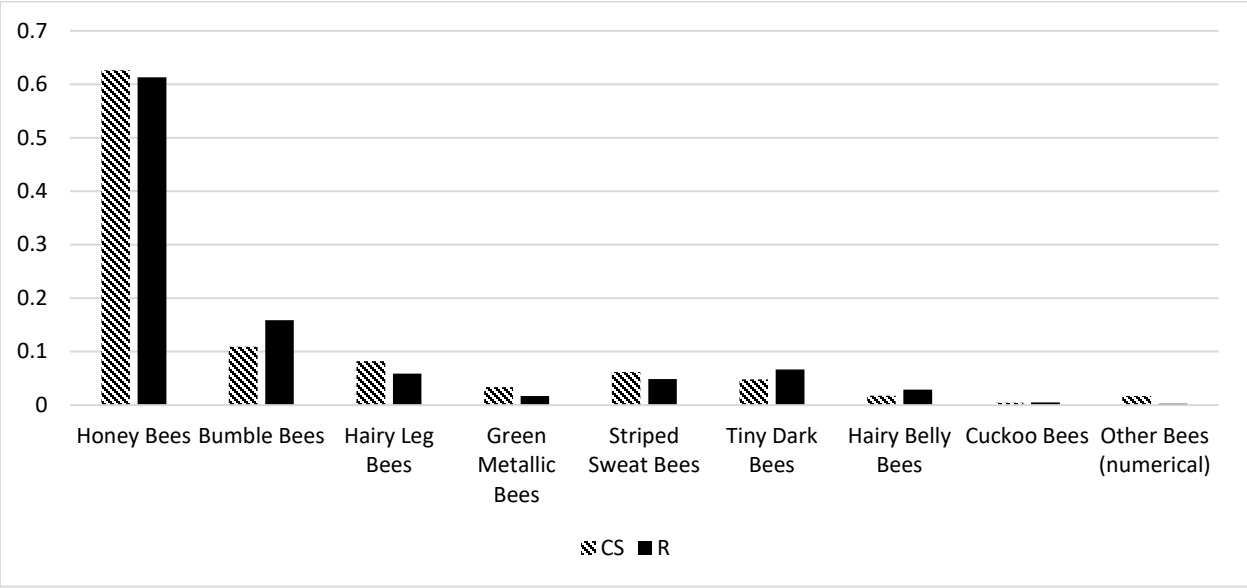

Figure 2.9. Proportion of bees observed comparing Citizen Science sessions (CS) to Researcher-only (R) sessions in 2016 (Spearman's $\rho = 0.92$, $p < 0.05$).

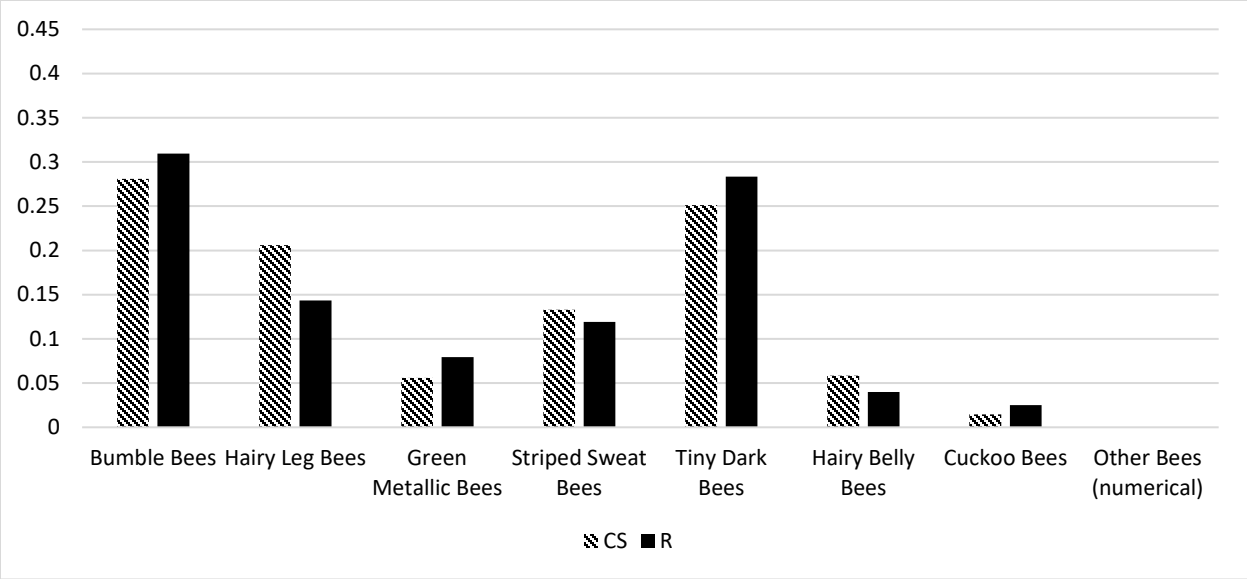

Figure 2.10. Proportion of bees observed comparing Citizen Science (CS) sessions to Researcher-only (R) sessions in 2017 without including honey bees (Spearman's $\rho = 0.98$, $p < 0.05$).

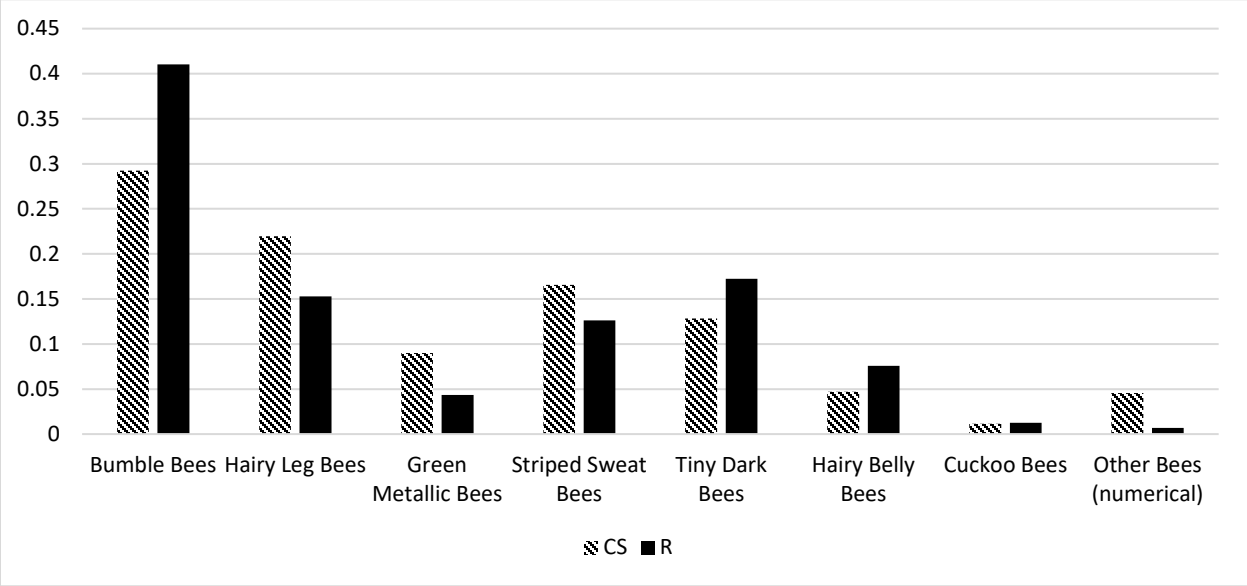

Figure 2.11. Proportion of bees observed comparing Citizen Science (CS) sessions to Researcher-only (R) sessions in 2016 without including honey bees (Spearman's $\rho = 0.88$, $p < 0.05$).

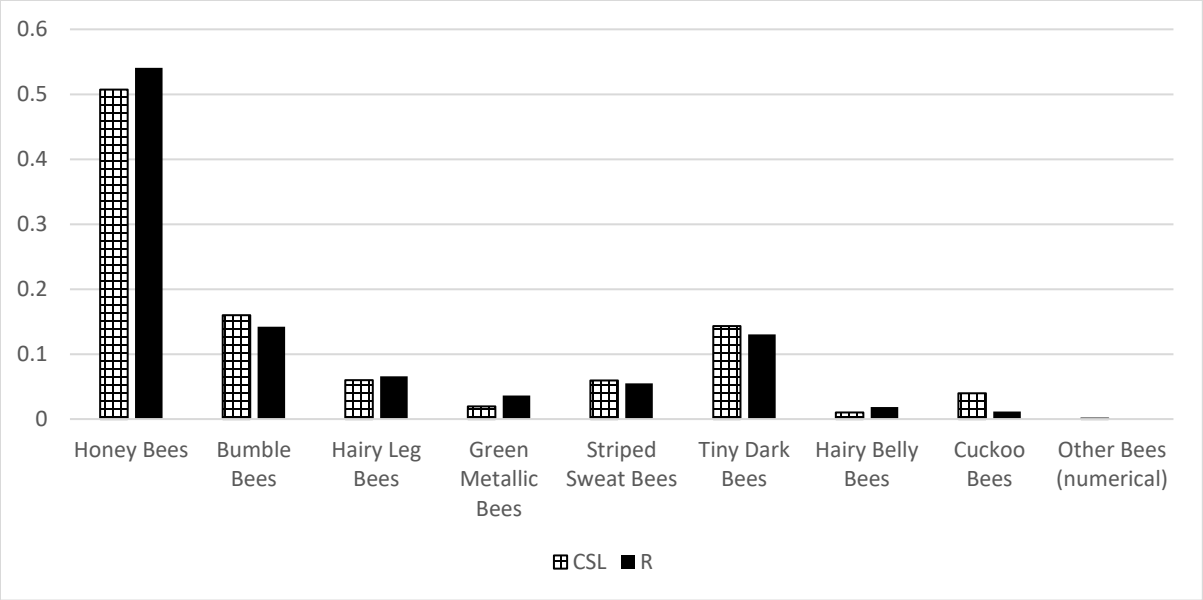

Figure 2.12. Proportion of bees observed comparing Citizen Science Leader (CSL) sessions to Researcher-only (R) sessions in 2017 (Spearman's $\rho = 0.95$, $p < 0.05$).

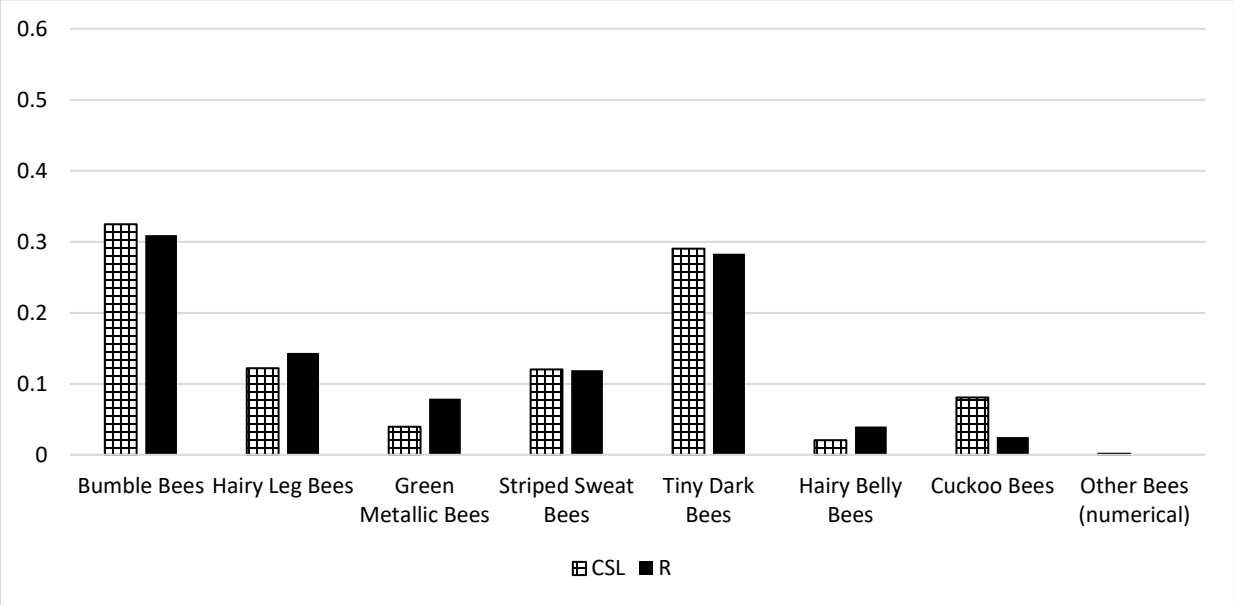

Figure 2.13. Proportion of bees observed comparing Citizen Science Leader (CSL) sessions to Researcher-only (R) sessions in 2016 without honey bees (Spearman's $\rho = 0.93$, $p < 0.05$).

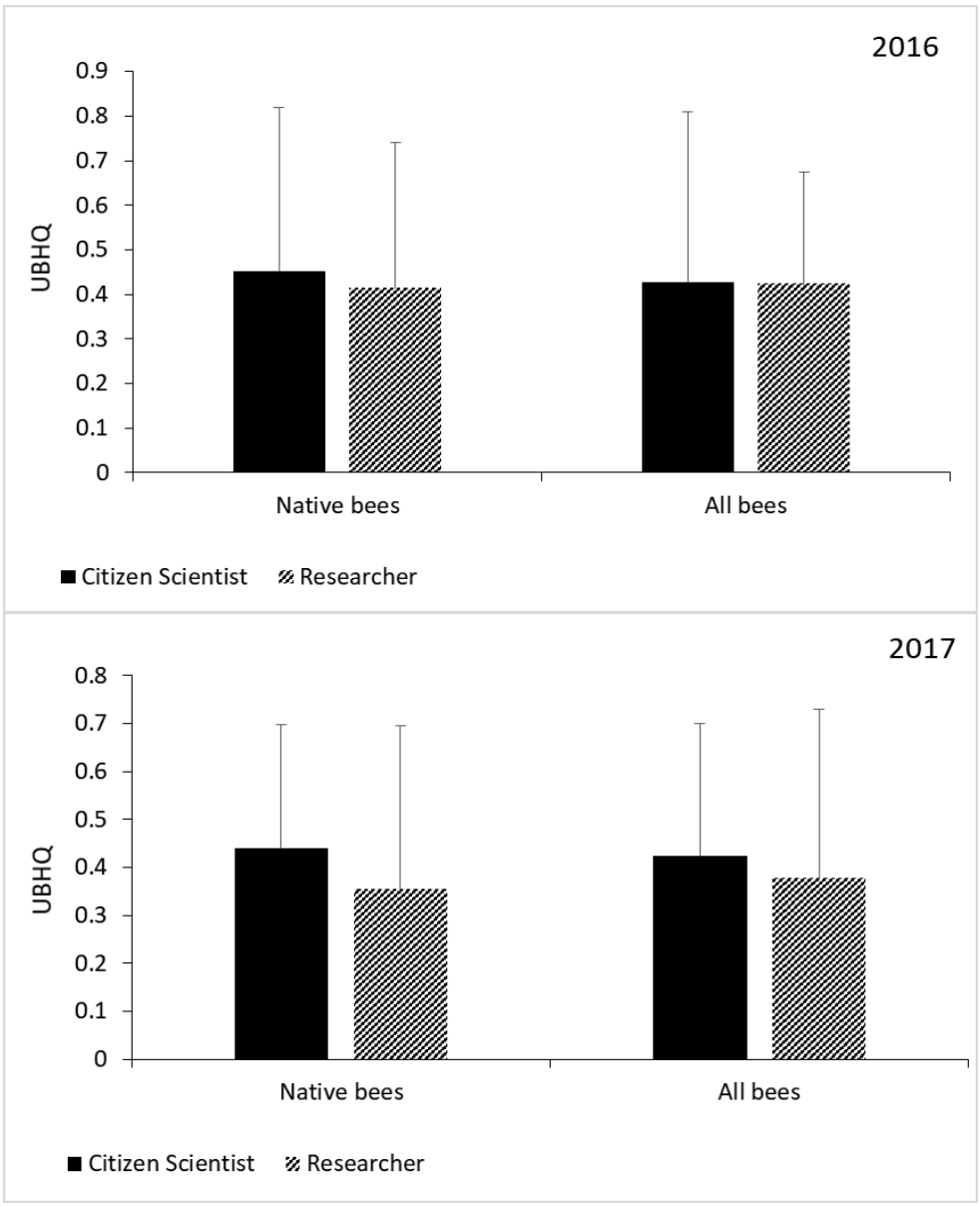

Figure 2.14. Urban Bee Habitat Quality (UBHQ) Index estimates from Citizen Scientist and Researcher data for all bees and for native bees only. The mean ± SD of the UBHQ values were calculated for a period of 8 sampling periods between may through September of the bee activity season.

Table 2.1. Summary of volunteer retention.

	2016	2017
Number of volunteers that participated in training	28	29
Number of volunteers that monitored	22	25
Volunteer retention rate	78.50%	86%
Returning number of volunteers from 2016 to 2017	NA	7
Returning volunteer retention rate	NA	28%

Table 2.2. Total sampling session for all gardens in 2016 and 2017.

	2016 Citizen Science sessions	2016 Researcher-Only sessions	2016 Total	2017 Citizen Science sessions	2017 Researcher-only sessions	2017 Citizen Science Leader sessions	2017 Total
Number of Focal Plant Sampling Sessions	27	23	50	23	21	12	56
Average number of Focal Plant Samples Per Session	33.6	30.22	31.1	43.48	32.2	33	36.22
Total Number of Focal Plant	907	695	1602	1,000	676	396	2,072

Table 2.3. Summary of the sampling days and number of Focal Plant Sampling observations at Nix Farm in 2016 and 2017.

	2016 Researcher-Only	2016 Citizen Science	2017 Researcher-Only	2017 Citizen Science	2017 Citizen Science Leader
Number of Focal Plant Sampling Sessions	7	8	8	7	4
Average number of Focal Plant Samples Per Session	19.60	26.87	20.63	33.29	31
Total Number of Focal Plant Samplings Per Season	137	215	165	233	124

Table 2.4. Summary of the sampling days and number of Focal Plant Sampling observations at the Gardens on Spring Creek in 2016 and 2017.

	2016 Researcher-Only	2016 Citizen Science	2017 Researcher-Only	2017 Citizen Science	2017 Citizen Science Leader
Number of Focal Plant Sampling Sessions	8	10	6	8	6
Average Number of Focal Plant Samples Per Sessions	32.4	32.37	42.83	44.63	36.83
Total Number of Focal Plant Samplings Per Season	259	324	257	357	221

Table 2.5. Summary of the sampling days and number of Focal Plant Sampling observations at the Colorado State University Trial Gardens in 2016 and 2017.

	2016 Researcher-Only	2016 Citizen Science	2017 Researcher-Only	2017 Citizen Science	2017 Citizen Science Leader
Number of Focal Plant Sampling Sessions	8	9	7	8	2
Average Number of Focal Plant Samples Per Sessions	37.4	40.1	36.28	51.25	25.5
Total Number of Focal Plant Samplings Per Season	299	368	254	410	51

Table 2.6. Total number of bees counted at all gardens in 2016 and 2017.

	2016 Citizen Science	2016 Researcher-Only	2017 Citizen Science	2017 Researcher-Only	2017 Citizen Science Leaders
Honey Bees	1,210	1,139	1,764	1,263	599
Bumble Bees	206	293	342	332	189
Hairy Leg Bees	155	109	251	154	71
Green Metallic Bees	64	31	68	85	23
Striped Sweat Bees	120	90	162	128	70
Tiny Dark Bees	90	123	306	304	169
Hairy Belly Bees	34	54	71	43	12
Cuckoo Bees	8	9	18	27	47
Other Bees	32	5	0	0	1
Total Bees	1,919	1,853	2,982	2,336	1,181

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APPENDIX A: NATIVE BEE WATCH: A COLORADO CITIZEN SCIENCE FIELD GUIDE

The field guide was developed as a tool for citizen scientists to use in the field to ensure data accuracy. The guide covers project details; pollination biology; life history of solitary, eusocial, and primitively eusocial bees; identification of non-bee pollinators; differentiating bees from flies and wasps; and a key to eight morphological species of bees.

Native Bee Watch

A Colorado Citizen Science Field Guide

Lisa Mason, Boris Kondratieff, Arathi H. S.
Colorado State University

Adapted from the Xerces Society's California Pollinator Project: Citizen Science Pollinator Monitoring Guide, 2010, by Katharina Ullmann, Mace Vaughan, Claire Kremen, Tiffany Shih, and Matthew Shepherd.

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USDA United States Department of Agriculture
Natural Resources Conservation Service

Thank you for participating in this project! We greatly appreciate your contribution to research and helping Fort Collins become a bee-friendly community. We hope you learn a lot, meet new friends, and have fun this summer!

For more information, visit: NativeBeeWatch.WordPress.com

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Front and back cover photos taken by Lisa Mason.

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Why Are Bees Important? About the Project

All bees are important pollinators and not just honey bees! They provide ecosystems services or benefits to humans. Pollinators benefit humans by providing 1/3rd of our food including fruits, vegetables, and nuts—the most nutritious part of our diet.

Pollinators are critical for ecosystem and human health, but their populations are declining due to many reasons including:

- Habitat and nutrition loss due to urbanization and monocropping
- Parasites and disease
- Pesticide and chemical use
- Climate change

It is often a variety of interactions between these factors that contributes to population declines. Specifically, this project is looking at urbanization and how it affects the biodiversity and abundance of bees.

Did You Know?

- 75% of more than 240,000 plant species rely on pollinators for reproduction!
- The global production of crops that depend on pollinators is an industry worth up to US $577 billion annually
- Bees help to pollinate 1/3rd of the human diet
- They pollinate over 70 crops
- In addition to crops, they pollinate the food for livestock that contributes to the meat and dairy industry

In North America, 82% of the human population lives in urban areas, and this percentage is expected to increase. Urbanization leads to the loss of wild and natural spaces. Changes to the landscape can destroy, degrade, or fragment critical habitat. However, many of the solitary, native bees have small foraging areas. Urban areas can also have a high diversity of flowering plants. Could these urbanized areas with high flowering diversity benefit wild bee populations?

Photo: Lisa Mason

Figure 1. A honey bee pollinating a Red Rocks® penstemon.

Some research has been done in the United States and Europe, but we need more targeted research studies to understand how urban areas can support bee diversity.

This is why we need your help! We are collecting baseline biodiversity and abundance data on what bee species currently live in the area. The data collected will provide information not only on the biodiversity and abundance, but also on what factors could be positively or negatively affecting the bees in urban areas. This ultimately will lead to recommendations for urban/city planners and homeowners on how we can enhance bee habitats!

Photo: Lisa Mason

Figure 2. Volunteers monitor bees at the Plant Select garden in the CSU's Flower Trial Gardens.

Did You Know?

- There are an estimated 20,000 bee species worldwide
- There are over 4,000 bee species in North America
- There are over 900 species in Colorado
- 437 bee species have been recorded in Larimer County
- Bees rely on pollen or nectar for their entire life cycle

Volunteer Responsibilities

Volunteer Requirements

To participate in the program, volunteers are required to:

- Be at least 18 years old
- Attend a training session
- Commit to attending four bee monitoring sessions that will last about two hours each
- Have a strong interest in learning about bees, plants and urban ecosystems

Check NativeBeeWatch.WordPress.com for information on how to get involved and attend a training workshop.

No previous bee identification experience is needed. All skills will be taught at the training workshop and in the field with a researcher.

Photo: Victoria Halligan

Figure 3. CSU student, Colton O'Brien teaches volunteers how to identify bees using illustrations and actual specimens.

Methods in this field guide were created to be used in Fort Collins, but can be implemented in any area in Colorado.

Field Preparation


Photo: Lisa Mason

Figure 4. A citizen scientist monitors bees at the Gardens on Spring Creek in Fort Collins, Colorado.

Since you will be working outside, you need to be prepared for a variety of conditions. In this chapter, we explain what you'll need to wear, bring, and know to conduct your surveys comfortably and safely. The City of Fort Collins Nature in the City Initiative provides the following recommendations:

What to wear

- **Hiking boots or tennis shoes** – Good footwear is essential, especially when you are walking off trail through vegetation to access the sampling point.
- **Long pants** – We recommend that you wear long pants to protect your legs from vegetation and insects as you walk to the sampling point.
- **Jacket or sweatshirt** – Early mornings can be chilly. Make sure you have a jacket or sweatshirt to protect against the cold. Layers are important.
- **Hat and/or sunglasses** – Be sure to protect your face and eyes: summers can be bright and hot.
- **Sunscreen** – Be sure to use plenty of sun protection to avoid getting burned.
- **Mosquito repellent** – You may also want to wear insect repellent to avoid mosquito bites.

What to bring

- **Backpack** – Carry your data sheets, field guides/ID booklets, maps, and other field gear.
- **Water bottle** – Carry plenty of drinking water to keep from getting dehydrated as you conduct your surveys.
- **Data sheets and instructions** – Bring extra copies of the data sheets in case one gets lost or damaged.
- **Timepiece** – Bring a watch or phone to time yourself while you conduct surveys.
- **Pencil** – Bring extra pencils; they tend to get lost easily.
- **Field guide** – Bring this field guide and other field guides to help identify species that you see.

Safety in the field

You should always feel safe and comfortable as you conduct your surveys. When you go out on a sampling session, always let one of the researchers, a friend and/or family member know where and how long you expect to be in the field. Bring a cell phone so you can contact others if you need. Always be aware of your surroundings. Never approach wild animals, especially if they seem to be acting strangely. Check the weather before you go out. Don't work in adverse weather conditions – bees aren't out while it's raining, so you shouldn't be either!

If you have allergies or other medical conditions that might require that you take medication, bring your medications with you.

We would never want you to do anything that is beyond your comfort level. Don't conduct your survey if you don't feel safe! If you feel concerned about field conditions during any time, please tell the researcher.

About Flowers

Only record data of a bee visiting the reproductive parts of a flower. If the bee is on the reproductive part of the plant, it is probably collecting pollen or nectar. You may not be able to see the reproductive parts of the flower, but the bee should be inside the flower. You may see pollen grains on the body of the bee. If the bees are flying or on other parts of the flower such as leaves, stems, or petals, they may not be pollinating.

Pollinating a Flower

Not Pollinating

Figure 5. Bees are pollinating flowers only when they are visiting the reproductive flower parts. If the bee is on the petals, leaves, or stem, the bee is not pollinating.

Reproductive Parts of a Flower

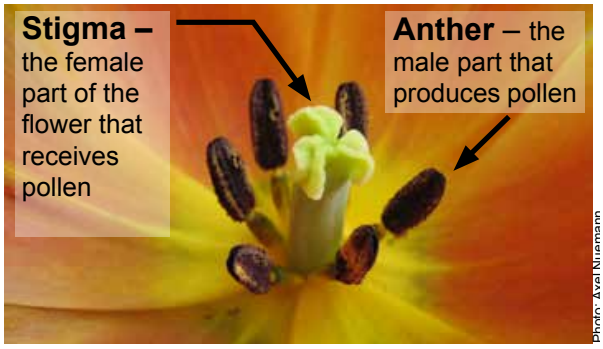


Figure 6. Bees are pollinating flowers only when they are visiting the reproductive flower parts. Look inside a flower to see the anthers and the stigma. Note the pollen on the anthers. That pollen needs to be transferred to another flower of the same species or the same plant.

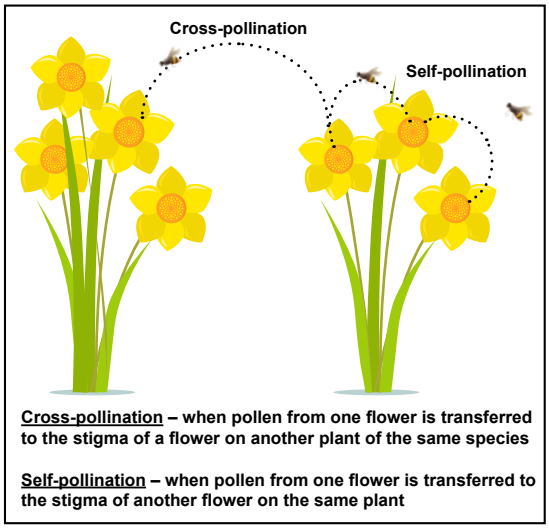


Figure 7. Cross-pollination versus self-pollination.

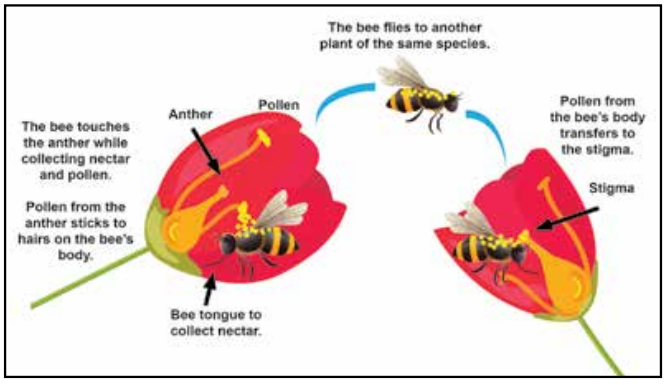


Figure 8. Pollen transfer by bees.

Tips for Observing Bees on Flowers

- Choose a small observation area where you can focus on and record everything. Observe a small area and collect accurate data rather than a large area where bee observations could be missed.
- Observe all flowers, small and large, along the defined transect. Include invasive plant species such as bindweed, which produces trumpet-shaped flowers that bees visit.
- Look closely inside flowers, but be careful to not disturb bees or other insects visiting the flowers by standing too close or making quick movements.
- Be aware of your shadow – a shadow that is in front of you and covers the flower may disturb the bees.
- Consistency is important throughout observing and collecting data.

About Bees

Bees are a fascinating group of insects! Most people are familiar with the non-native European honey bee, *Apis mellifera*. The European honey bee was introduced to North America in 1622. They are one of the few truly social species of bees in world that are known as eusocial bees (see page 10). Most native species of bees are solitary and build nests underground or in cavities. Some bee species are primitively eusocial meaning they share characteristics of eusocial and solitary bees.

Solitary Bees

Of all the diverse bee species, about 90% of them are solitary. Of those bees, about 70% live underground and the other 30% are cavity nesters. During the life cycle, a female bee builds a nest underground or in a cavity. She will collect pollen and nectar to bring back to the nest. All the collected pollen and nectar is made into a ball called "bee bread" which will be all the food needed for one growing bee. The female lays an egg on the bee bread and seals up the nest. After the egg hatches, the larva will go through full metamorphosis from a larva, then a pupa to an adult before emerging from the nest. Solitary bees live for one season and do not interact with any other bees of the same species except briefly for mating.


Photo: MaLisa Spring

Figure 9. A larva on top of a ball of pollen and nectar called "bee bread".


Photo: MaLisa Spring

Figure 10. A developing pupa.


Photo: MaLisa Spring

Figure 11. An adult bee emerging from the nest.

Some solitary bees share a communal colony and are known as parasocial bees. Many females of the same generation use the same nest, but individuals create their own cell within the communal nest. They practice mutual tolerance; they do not interact with each other or share social bee behaviors. Green metallic sweat bees (*Agapostemon* spp.) are an example of a bee that share communal nests.

Underground Nesters

Photo: MaLisa Spring

Figure 12. A solitary bee in the Colletidae family emerging from her underground nest.

Cavity Nesters

Photo: MaLisa Spring

Figure 13. A human-made bee home for cavity-nesting bees.

Photo: MaLisa Spring

Figure 14. Underground solitary bee nests.

Photo: MaLisa Spring

Figure 15. A *Ceratina* sp. in a cavity nest.

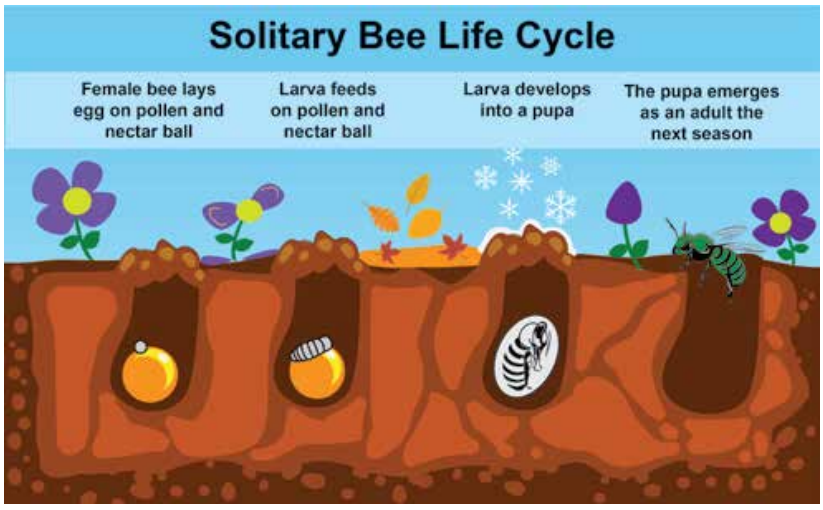


Figure 16. Solitary bee life cycle.

Eusocial Bees

Eusocial bees, such as the European honey bee (*Apis mellifera),* live together in groups with one queen, female worker bees, and seasonally produced male drone bees. Honey bees live in manmade hives. Feral honey bee colonies occur in the wild inside natural hollow spaces such as tree trunks. Unlike solitary bees that live only one season, honey bees live through the winter. A colony may have 20,000 to 80,000 worker bees and hundreds of drones.

The three main characteristics of eusocial insects are: (1) overlapping generations, (2) cooperative brood care, and (3) reproductive division of labor. Overlapping generations occur when younger and older generations work in a colony at the same time. Honey bees are often tasked to do different jobs depending on their age, known as age polyethism. For example, a young bee up to 11 days old will secrete brood food. A middle-aged bee from 11 - 21 days old will secrete beeswax. An older bee over 21 days can have a variety of jobs including forager, storer, or undertaker. Brood care is a task allocation given to younger bees. Queens are the only ones who reproduce in the colony, establishing the reproductive division of labor. Workers are responsible for feeding the larvae, constructing and cleaning the nest, foraging for food, and defending the nest.

Photo: Lisa Mason

Figure 17. The honey bee, a eusocial bee.

Photo: Jessica Louque, Smithers Viscient, Bugwood.org

Figure 18. A queen honey bee is larger than the worker bees.

Photo: Lisa Mason

Figure 19. Arathi Seshadri checking the frames in a new hive at CSU's Agricultural Research, Development and Education Center.

Photo: Tara Costanzo

Figure 20. A bee swarm on a juniper tree. Swarming is when a group of bees leave the current colony to start a new colony.

Primitively Eusocial Bees

Some bees such as bumble bees (*Bombus* spp.) have both eusocial and solitary characteristics and are known as primitively eusocial bees. Bumble bees live underground or in cavities and have a one-year life cycle like a solitary bee. Within the season, a colony will develop. A queen will find a place to nest and hibernate over the winter. When spring arrives, she will emerge, begin to forage, build a new nest, and lay eggs. The eggs will mostly be female worker bees. The queen will continue to lay eggs throughout the season. In late summer, a few new queens and male bumble bees will hatch and leave the colony. The new queens will mate with male bumble bees and then hibernate through the winter. Queen bumble bees are more aggressive and capable of living alone, unlike honey bee queens. Most primitively eusocial bees store food in the brood cell for the larva to feed on. Bumble bees are an exception and store food outside brood cells, a characteristic of eusocial bees.

Photo: MaLisa Spring

Figure 21. A bumble bee emerging from her nest.

Photo: MaLisa Spring

Figure 22. A commercial bumble bee nest.

What Do Bees Feed On?

All bees feed on pollen and nectar. Most of the bees in this field guide are polylectic, meaning they collect pollen and nectar from a variety of flower species. These bees are opportunistic but still may prefer certain flowers. A monolectic bee only feeds on a specific plant species. Monolectic bees have generally coevolved with a specific plant species meaning the plant and bee depend on each other for survival.

Tips for Identifying Bees

Identifying bees is a challenge. Hundreds of bee species exist, especially in the western United States, that scientists can only identify to the genus level because of the uncertainty with species identification. You do not want to assume or guess an identification. If you are not confident which type of bee it is, note if it is a honey bee, native bee, fly, wasp, or other pollinator.

Weather Conditions and Time of Year

Note the weather conditions because this will directly affect bee activity. Bees will not be active in windy, cold, or cloudy weather. Bees are the most active in the mornings which is why sampling will occur between 9am-11am. Check the weather temperature and forecast before observing bees. We will provide protocols on how to determine if cloud cover or wind will affect the sampling session.

Different species of bees will be more active in different parts of the year. Different plants also bloom at different times of the year.

Bee Characteristics

- **Four wings -** two pairs, sometimes difficult to see, hind wings are often small
- **Hair -** most have hairy bodies for carrying pollen
- **Eyes -** large, well-separated on top of head
- **Antennae -** long, segmented, and often bent
- **Corbiculae -** many bees have flattened plates used as pollen baskets on hind legs
- **Scopa -** Pollen-carrying hairs on hind legs or abdomen, often covered with pollen
- **Body Shape -** rounder bodies than wasps and flies
- **Size -** 2 to 25 mm (less than 1/8th inch to 1 inch) or more
- **Body Color -** Can be black, brown, orange, yellow, red, metallic blue or green, or copper-colored
- **Stripes -** Body color (exoskeleton) or hair colors (yellow, orange, white, black, or brown) can form stripes

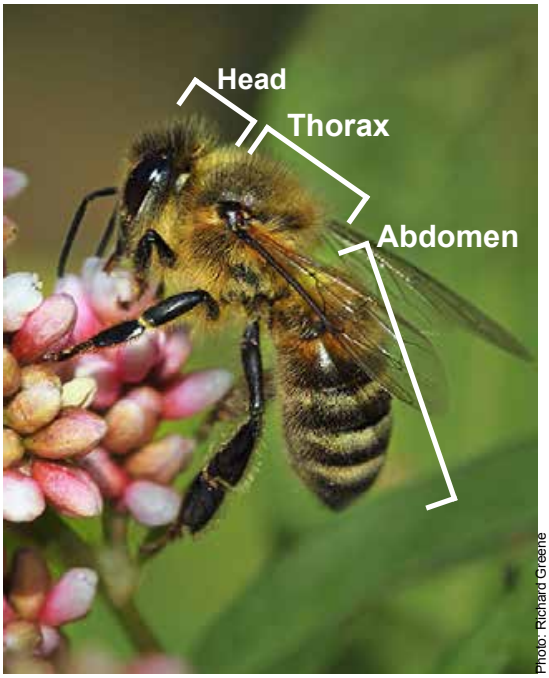


Figure 23. Important identification characteristics of a bee. Can you spot some of the major characteristics?

Figure 24. Note the four wings.

Figure 25. Hairs on the thorax of a bumble bee.

Figure 26. Note the bent antennae on a *Ceratina* sp.

Figure 27. A pollen basket on a bumble bee.

Figure 28. The flattened plate of a hind leg on a honey bee.

Figure 29. Note the large compound eye on the side of the honey bee's head.

Identification

Non-Bee Pollinators, Common Flower Visitors


Photo: Bob Parks

Figure 30. Ants. (Example: *Formica* sp.)


Photo: Lisa Mason

Figure 31. Beetles. (Example: Red or milkweed longhorn beetle)


Photo: Lisa Mason

Figure 32. Birds. (Example: Hummingbird)


Photo: Lisa Mason

Figure 33. Butterflies. (Example: Two-tailed swallowtail)


Photo: Micaela Truslove

Figure 34. Flies. (Example: Syrphid or flower flies)


Photo: Whitney Cranshaw, Colorado State University,

Figure 35. Moths. (Example: Army cutworm moth)


Photo: Lisa Mason

Figure 36. Wasps. (Example: European paper wasp)


Photo: Robert Schorr, Colorado Natural Heritage Program

Figure 37. Bats. (Example: Townsend's big-eared bat)

Flies Versus Bees

Flies can often be confused with bees because some look very similar and often mimic bees.

Common characteristics that differentiate flies from bees include:

- Two (one pair) of flying wings
- Short, thick antennae, usually three segments (bees usually have 10-11 segments)
- Large eyes near the front of their head
- Usually not hairy (there are exceptions)
- Flies can hover (most bees cannot)
- Flies do not carry pollen loads

Syrphidae - Flower, Syrphid, or Hover Flies

Photo: Micaela Truslove

Figure 38. Flower flies are often flower visitors. This group of flower flies are called "drone" flies, supposedly mimicking male honey bees known as drones.

Photo: Lisa Mason

Figure 40. A common flower fly that feeds on nectar, pollen, and honeydew secreted by aphids.

Photo: Lisa Mason

Figure 39. A flower fly that mimics a bumble bee. Note the short antennae.

Bombylidae - Bee Flies

Photo: Bob Parks

Figure 41. *Bombylius* sp. near the Cache la Poudre River.

Wasps Versus Bees

Bees can also be confused with wasps because some species of wasps look very similar to bees.

Common characteristics that differentiate wasps from bees include:

- Not distinctly hairy
- Two pairs (four wings), often longer than bees
- Many have a pinched abdomen known as a “wasp waist”
- Narrower bodies
- Often distinct black, yellow, or white color patterns on the exoskeleton
- Do not carry pollen loads

Pseudomasaris - Pollen or Masarid Wasp

Photo: Granite Ridge Nature Institute, Lynn & Gene Monroe

Figure 42. This wasp is a well-known pollinator of violet-colored penstemon or phacelia flowers.

Polistes dominula - European Paper Wasp

Photo: David Cappaert, Bugwood.org

Figure 43. Note the pinched abdomen known as a “wasp waist”. This wasp is the common paper wasp in the area.

Sceliphron caementarium - Black and Yellow Mud Dauber

Photo: Lisa Mason

Figure 44. Note the pinched abdomen known as a “wasp waist”.

Types of Bees


Photo: Lisa Mason

Figure 45. Honey bees.


Photo: Micaela Truslove

Figure 46. Bumble bees.


Photo: Susan Ellis, Bugwood.org

Figure 47. Green metallic sweat bees.


Photo: Richard Greene

Figure 48. Hairy belly bees.


Photo: Lisa Mason

Figure 49. Striped sweat bees.


Photo: MaLisa Spring

Figure 50. Tiny dark bees.

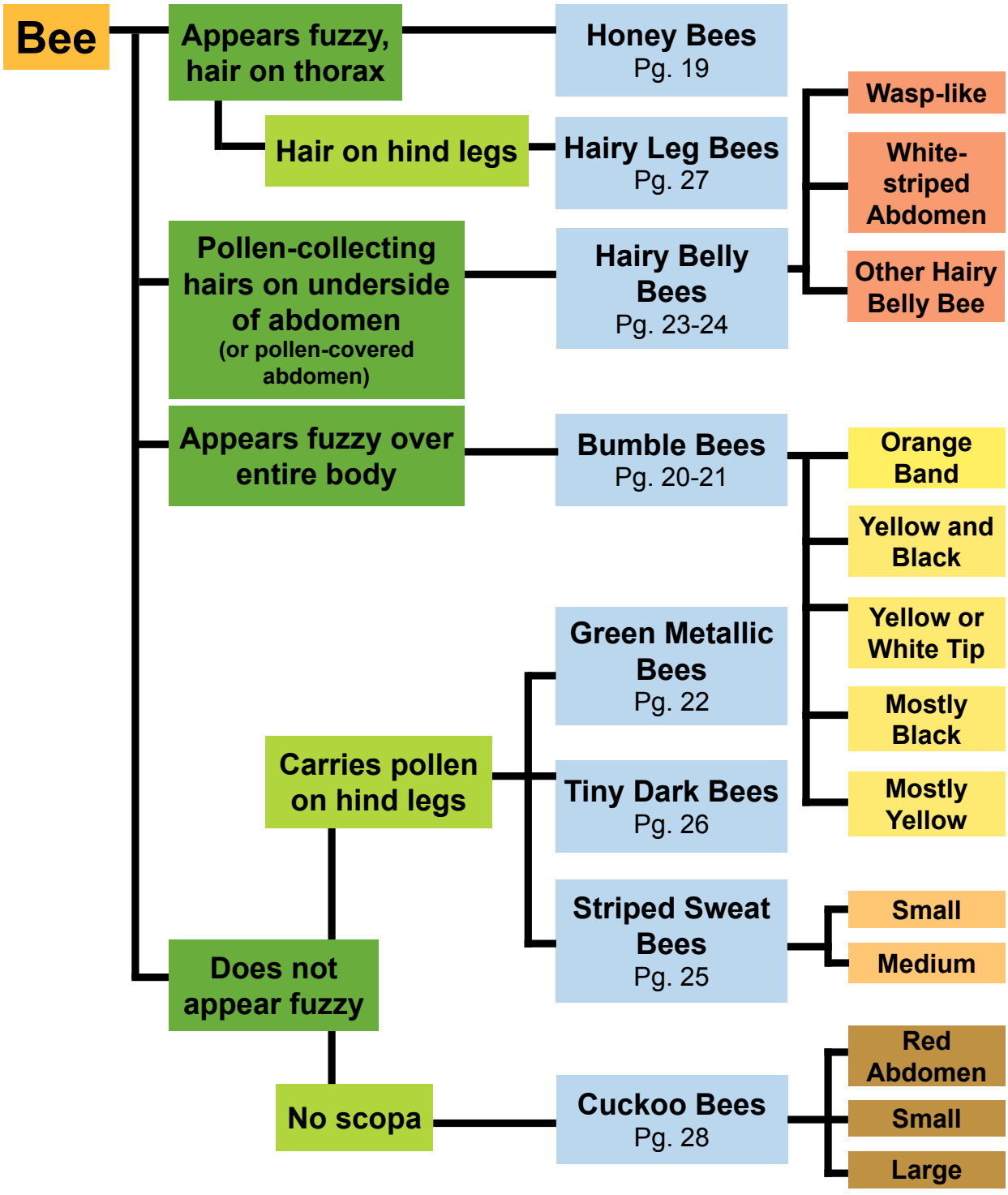

Photo: Lisa Mason

Figure 51. Hairy leg bees.


Photo: Whitney Cranshaw, Colorado State University, Bugwood.org

Figure 52. Cuckoo bees.

Key to Identifying Bees



Bee Groups and Scientific Classification

Bee Group	Bee Subgroup	Common Name	Scientific Name	Family
Honey bee	NA	Honey bee	*Apis mellifera*	Apidae
Hairy leg bee	NA	Digger bee Flower bee Long-horned bee Sunflower bee	*Anthophora* sp. *Diadasia* sp. *Melissodes* sp. *Svastra* sp.	Apidae Apidae Apidae Apidae
Hairy belly bee	Wasp-like	Wool carder bee Resin bee	*Anthidium* sp. *Megachile* sp.	Megachilidae Megachilidae
	White-striped	Leafcutter bee	*Megachile* sp.	Megachilidae
	Other hairy belly bees	Mason bee	*Megachile* sp. *Osmia* sp. *Hoplitis* sp.	Megachilidae Megachilidae Megachilidae
Bumble bee	Orange band	Hunt's bumble bee Central bumble bee	*Bombus huntii* *Bombus centralis*	Apidae Apidae
	Yellow and black	Brown belted bumble bee Morrison's bumble bee Nevada bumble bee	*Bombus griseocollis* *Bombus morrisoni* *Bombus nevadensis*	Apidae Apidae Apidae
	White or yellow tip	Western bumble bee	*Bombus occidentalis*	Apidae
	Mostly black	Cuckoo bumble bee	*Bombus insularis*	Apidae
	Mostly yellow	Golden northern bumble bee	*Bombus fervidus*	Apidae
Green metallic bee	NA	Sweat bee	*Agapostemon* sp. *Augochlorella* sp.	Halictidae Halictidae
Tiny dark bee	NA	Small carpenter bee Small carpenter bee Yellow-faced bee	*Ceratina neomexicanum* *Ceratina* sp. *Hylaeus* sp. *Lasioglossum* sp.	Apidae Apidae Colletidae Halictidae
Striped sweat bee	Small	Sweat bee Sweat bee, other	*Halictus* sp. *Lasioglossum* sp.	Halictidae Halictidae
	Medium	Sweat bee Sweat bee, other	*Halictus* sp. *Lasioglossum* sp.	Halictidae Halictidae
Cuckoo bee	Red abdomen	Cuckoo bee Cuckoo bee	*Nomada* sp. *Sphecodes* sp.	Apidae Halictidae
	Small	Cuckoo bee Cuckoo bee Cuckoo bee	*Epeolus* sp. *Nomada* sp. *Sphecodes* sp.	Apidae Apidae Halictidae
	Large	Cuckoo bee Cuckoo bee Cuckoo bee	*Epeolus* sp. *Nomada* sp. *Sphecodes* sp.	Apidae Apidae Halictidae

Note: This is not an inclusive list of all bees found in these categories or in Colorado. These are some of the more common bees observed.

Honey Bees

- Size: Medium to large
- Color: Orange-brown with black stripes on abdomen
- Legs: Enlarged, flattened plates used as pollen baskets on hind legs
- Carries moist pollen in clumps on hind legs
- Fuzzy thorax
- Flies methodically from flower to flower
- Makes a buzzing sound when flying
- Polylectic

Note: When monitoring, be sure to differentiate between honey bees and other native bees, even if you cannot identify the native bee to type.

Figure 53. A fuzzy thorax is the first characteristic to look for when using identification key.

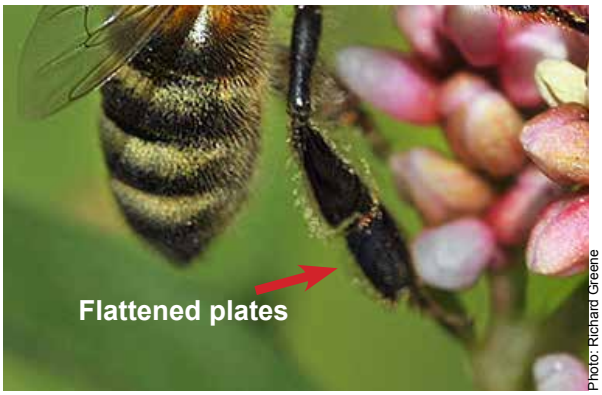


Figure 54. Large, flattened plates on the hind legs are used as pollen baskets.

Figure 55. Note the corbiculae, pollen baskets.

Honey Bee Color Variations

Figure 56. Note the darker shades on the honey bee's body.

Figure 57. Note the lighter color orange shade on the honey bee's body.

Bumble Bees

- Size: Medium to very large, often workers or specific species vary in size
- Color: black with yellow stripes (sometimes rust or gray stripes)
- Legs: Flattened plates on upper hind legs for carrying pollen called corbiculae
- Rounded body shape
- Entire body is fuzzy
- Makes a low buzzing sound when flying
- Parasitic bumble bees, known as cuckoo bumble bees (*Bombus* sp.), look like bumble bees but do not have corbiculae, are less hairy with harder bodies
- Polylectic

This key is for female bumble bees and only for the very common species along the Front Range in Larimer County. Variations in color exist within each species and between the different species, and these are general guidelines. Remember: If you cannot identify which bumble bee group your bee falls into, please note that as a bumble bee only. Feel free to write down other details in the "Additional Observations" section.

Orange Band Bumble Bees

- Orange band on abdomen
- Yellow thorax with black band
- Species include: *Bombus huntii* and *Bombus centralis*

Figure 58. *Bombus huntii,* a common bumble bee species.

Figure 59. *Bombus centralis*, Central bumble bee.

Yellow and Black Bumble Bees

- Black and yellow abdomens with variation within species and between species
- Thorax can be both black and yellow also with variation
- Species include: *Bombus nevadensis, Bombus morrisoni,* and *Bombus griseocollis*

Figure 60. *Bombus nevadensis.*

Figure 61. *Bombus griseocollis.*

Did You Know?

- Bumble bees "buzz pollinate" flowers which means they produce vibrations to shake the flower. The anther (male flower part holding the pollen) will then release the pollen. Tomatoes and blueberries are great examples of plants that require buzz pollination to properly cross-pollinate.

Bumble Bees

Mostly Black Bumble Bees

- Abdomen is mostly black, with some yellow hairs on the sides of abdomen
- Thorax can be black and/or yellow
- Species include: *Bombus insularis*

Figure 62. *Bombus insularis*, cuckoo bumble bee.

Mostly Yellow Bumble Bees

- Abdomen is mostly yellow with a black tip
- The thorax can be both black and yellow
- Species include: *Bombus fervidus*

Figure 63. *Bombus fervidus*, golden northern bumble bee.

White or Yellow Tip Bumble Bees

- Tip of abdomen can be white or yellow. The upper abdomen can be black or yellow
- Thorax can be black or yellow
- Species include: *Bombus occidentalis*

Figure 64. *Bombus occidentalis,* western bumble bee.

Did You Know?

- *Bombus insularis* is a cuckoo bee named after the cuckoo bird, because it lays eggs in another bumble bee's nest. The worker bumble bees will care for this parasitic bee's offspring.
- Cuckoo bees do not have pollen baskets like other bumble bees. They also appear less hairy than other bumble bees.

Green Metallic Bees

- Size: Medium
- Color: Metallic green thorax and head, females have a metallic green abdomen, and males have black and yellow stripes on abdomen
- Most carry pollen on hind legs
- Fast flying
- Polylectic

Note: Some hairy belly bees may also appear metallic green. Check where the bee is carrying pollen. Green metallic bees will carry pollen on their hind legs, while hairy belly bees carry pollen on the underside of their abdomen.

Compare hairy belly bees and green metallic bees. Can you spot where the bee is carrying pollen?

Shiny and Slender Body

Photo: Susan Ellis, Bugwood.org

Figure 65. Female *Agapostemon* sp.

Stripes on Abdomen

Photo: Richard Greene

Figure 66. Male *Agapostemon* sp. have black and yellow stripes on the abdomen and a green thorax.

Pollen on Hind Legs

Photo: Lisa Mason

Figure 67. Note the pollen on the legs of the *Agapostemon* sp.

Photo: Diane Wilson

Figure 68. *Augochlorella aurata.*

Hairy Belly Bees

- Includes leafcutter, mason, wool carder, and resin bees
- Size: Small to medium
- Color: Black with white/silvery hairs, white bands on abdomen
- Prominent hair on underside of abdomen, often yellowish in appearance from pollen
- Carries pollen on the underside of abdomen
- Polylectic

Note: Some hairy belly bees may appear metallic green. Check where the bee is carrying pollen. Green metallic bees will carry pollen on their hind legs, while hairy belly bees carry pollen on the underside of their abdomen. Compare hairy belly bees and green metallic bees. Can you spot where the bee is carrying pollen?

Did You Know?

- Leafcutter bees can be seen clipping portions of leaves on trees. They roll up the leaf and carry it back to their cavity nest. They use the leaf pieces to line and seal each egg chamber.

Figure 69. Leafcutter bees have cut pieces of leaf to take back to their nest.

White-striped Abdomen Bees

- Gray to black with thin white stripes on abdomen
- Hair easily seen on body, especially on abdomen
- Bottom of abdomen usually bright yellow with pollen
- Size is variable

Photo: Richard Greene

Figure 70. Note the white stripes on the black abdomen.

Photo: Richard Greene

Figure 71. Note the pollen on the underside of the abdomen.

Hairy Belly Bees

Wasp-like Bees

- Wide abdomen
- Wasp-like markings (black and yellow stripes, varied patterns)
- Hair on belly is harder to see
- Polylectic

Photo: Lisa Mason

Figure 72. Wool carder bee, *Anthidium manicatum*.

Photo: Lisa Mason

Figure 73. Resin bee, *Anthidium* sp.

Did You Know?

- Female *Anthidium* species will use their mandibles to take the "fuzz" off plants. They use it to line their nests.

Other Hairy Belly Bees

- Size variable
- Hair visible on abdomen

Photo: Diane Wilson

Figure 74. *Hoplitis* sp.

Photo: Diane Wilson

Figure 75. *Osmia* sp.

Striped Sweat Bees

- Size: Small to medium
- Narrow body shape
- Color: Usually black
- Stripes on abdomen may be white to dark gray
- Hair on hind legs can collect pollen
- Crawls to the base of flowers, be sure to look deep inside flowers
- Fast flier with jagged movements
- Common
- Polylectic


Photo: Joseph Berger, Bugwood.org

Figure 76. Note the pollen on the legs.

Pollen on Legs


Photo: Diane Wilson

Figure 77. *Halictus* sp.

Stripes on Abdomen


Photo: Diane Wilson

Figure 78. *Halictus* sp.

Small-sized


Photo: Lisa Mason

Figure 79. *Halictus* sp.

Medium-sized


Photo: Diane Wilson

Figure 80. *Halictus* sp.

Tiny Dark Bees

- Size: Tiny
- Narrow body shape
- Color: Black, sometimes looks metallic
- Can swarm flowers
- Some have white or yellow markings on face
- Hair on hind legs can collect pollen
- Crawls to the base of flowers, be sure to look deep inside flower
- Flies fast with jagged movements
- Polylectic


Photo: MaLisa Spring

Figure 81. *Lasioglossum* sp. inside a flower. At first glance it may look like another insect because it is so small, but note all the bee characteristics.

Yellow Markings on Face


Photo: MaLisa Spring

Figure 82. *Hylaeus* sp., yellow-faced bee.

Hairs on Hind Legs


Photo: MaLisa Spring

Figure 83. *Lasioglossum* sp.

Metallic Black


Photo: MaLisa Spring

Figure 84. *Ceratina* sp., small carpenter bee.


Photo: Diane Wilson

Figure 85. *Ceratina* sp., small carpenter bee.

Hairy Leg Bees

- Size: Medium to large
- Short, dense hair on thorax
- Pollen collection on the hair of legs, but the entire body will also be covered in pollen
- Fast flying, often will fly in a “figure 8” pattern
- Male bees have long antennae and striped body
- Polylectic


Photo: Richard Greene

Figure 86. A digger bee, *Anthophora urbana.*

Dense Hair


Photo: Diane Wilson

Figure 87. *Diadasia enavata.*

Pollen-collecting Hair on Legs


Photo: Diane Wilson

Figure 88. *Melissodes* sp., long-horned bee.

Color Variation


Photo: Diane Wilson

Figure 89. *Melissodes bimaculata.*

Pollen-covered Body


Photo: Diane Wilson

Figure 90. *Svastra obliqua.*

Cuckoo Bees

- Size: Variable from small to large
- Not very hairy
- Body Color: Black, white, red, or yellow
- May have wasp-like markings made from short, thick hairs
- Leg color: Red or black
- No pollen carrying structure
- Polylectic

Wasp-like Markings

Photo: Diane Wilson

Figure 91. *Nomada* sp.

Did You Know?

- Just as *Bombus insularis* is a cuckoo bee laying eggs in a bumble bee nest (pg. 21), other parasitic cuckoo bees mimic other types of bees to lay eggs in other bee nests.
- For example, *Coelioxys* sp. look similar to *Megachile* sp. (Hairy Belly Bees) and parasitize them.

Photo: Diane Wilson

Figure 92. Note the pointy abdomen on the *Coelioxys* sp.

Photo: Richard Greene

Figure 93. Note the hair on the *Megachile* sp.

Variations in Color

Photo: Whitney Cranshaw, Colorado State University, Bugwood.org

Figure 94. *Epeolus* sp.

Photo: Diane Wilson

Figure 95. *Nomada* sp.

Photo: Diane Wilson

Figure 96. *Holcopasites calliopsidis.*

Native Bee Watch - A Northern Colorado Citizen Science Project

Data Collection Sheet

Names of Participants: _____ **Transect Number** _____ **Date:** _____

Garden Location: _____

Instructions: Fill in your name and your partner's name, date and garden location at the top. Record the start time, end time, and circle the appropriate weather information. Fill in the table as you make observations. Be as specific as possible. Observe each plant for 2 minutes, and count and identify the bees. After the 2 minutes, record the plant species, number of plants and number of flowers. One person should track the timer for 2 minutes and record the observations. The other person should do the observing. Partners should take turns. Please record any additional observations at the end of the session. Return this data sheet to the researcher you are working with.

Start Time: _____ : _____ **End Time:** _____ : _____

Weather: (Circle one) 40s 50s 60s 70s 80s 90s 100s

Wind: (Circle one) Still Light Wind Windy Gusty **Sky:** (Circle one) Clear Partly Cloudy Mostly Cloudy Overcast

Name of Plant	# of Plants	# of Flowers	Honey Bee	Bumble Bee	Hairy Leg Bee	Green Metallic Bee	Striped Sweat Bee	Tiny Dark Bee	Hairy Belly Bee	Cuckoo Bee	Other

EXAMPLE

Native Bee Watch - A Northern Colorado Citizen Science Project

Data Collection Sheet

Names of Participants: LISA MASON

Date: 6/7/16

Garden Location: GARDENS AT SPRING CREEK

Instructions: Fill in your name and your partner's name, date and garden location at the top. Record the start time, end time, and circle the appropriate weather information. Fill in the table as you make observations. Be as specific as possible. Observe each plant for 2 minutes, and count and identify the bees. After the 2 minutes, record the plant species, number of plants and number of flowers. One person should track the timer for 2 minutes and record the observations. The other person should do the observing. Partners should take turns. Please record any additional observations at the end of the session. Return this data sheet to the researcher you are working with.

Start Time: 9 : 06 **End Time:** 10 : 52

Weather: 40s 50s 60s (70s) 80s 90s 100s

Wind: Still (Light Wind) Windy Gusty **Sky:** (Clear) Partly Cloudy Mostly Cloudy Overcast

Name of Plant	# of Plants	# of Flowers	Honey Bee	Bumble Bee	Hairy Leg Bee	Green Metallic Bee	Striped Sweat Bee	Tiny Dark Bee	Hairy Belly Bee	Cuckoo Bee	Other
CONEFLOWER, PURPLE	3	17	II	I	I	III	I				
PENSTEMON, PINK	5	29		IIII				I			
ENGLISH LAVENDER	1	500+	IIII IIII								
RABBITBRUSH	1	500+	IIII II	III							
CATMINT	2	~60	IIII	I					II		
COLUMBINE, YELLOW	2	11					II	I			
PENSTEMON, PINK	3	22	I	II							

References and Resources

References

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Colorado Resources

City of Fort Collins Natural Areas
www.fcgov.com/naturalareas/

City of Fort Collins Nature in the City
www.fcgov.com/natureinthecity/

Colorado State University
www.colostate.edu/

Colorado State University Flower Trial Gardens
http://www.flowertrials.colostate.edu/

Plant Select®
www.plantselect.org

The Gardens on Spring Creek
http://www.fcgov.com/gardens/

National Resources

The Pollinator Partnership
www.pollinator.org

The Xerces Society for Invertebrate Conservation
www.xerces.org

More Citizen Science Opportunities

Bug Guide
www.bugguide.net

Discover Life
www.discoverlife.org

iNaturalist
www.inaturalist.org

The Great Sunflower Project
www.greatsunflower.org



NativeBeeWatch.WordPress.com

APPENDIX B: COLORADO STATE UNIVERSITY EXTENSION FACT SHEET NO. 5.615 – ATTRACTING NATIVE BEES TO YOUR LANDSCAPE

Attracting Native Bees to Your Landscape informs the reader about native bees' biology, habitat requirements, and how to provide habitat for bees.

COLORADO STATE UNIVERSITY
EXTENSION

Attracting Native Bees to Your Landscape

Fact Sheet No. **5.615** Insect Series | Home and Garden

by H.S. Arathi, D. Davidson and L. Mason*

Of all the pollinators found in gardens, agricultural fields and natural areas, bees are the most common and efficient. There are over 20,000 bee species found throughout the world. Of the approximately 4,000 native species known to occur in the United States, 946 are found in Colorado. They vary greatly in size, shape and color (Fig. 1, 2). In fact, there is a good chance that you have seen a native bee, but didn't realize that it was a bee because they can look so different than the more familiar honey bee.

The well-known honey bee (Fig. 3) is native to Europe and was introduced into the US by European settlers in the 1600s. They have been a part of the American landscape ever since.

Figure 1: Bumble bee, *Bombus* sp. Photo by Micaela Truslove

*H.S. Arathi (Arathi Seshadri), Department of Soil and Crop Sciences, D. Davidson: CSU Extension, Boulder County, L. Mason: Bioagricultural Sciences and Pest Management Department, 12/2017.

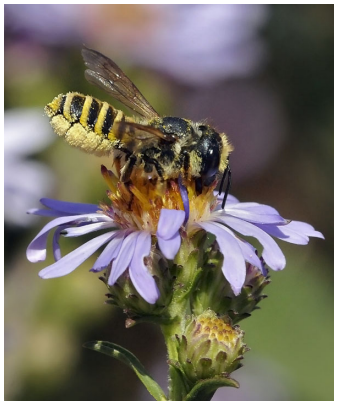

Figure 2: Leaf-cutting bee, *Megachile fidelis*. Photo by Richard Greene

While honey bees sting as a means of protecting their offspring and honey in their hive, it is important to note that most of the native species in Colorado are simply not inclined to sting or do not have enough venom for a painful sting, even if they try.

Habitat Needs for Native Bees

Just like humans and other animals, bees and other pollinators need food, water, shelter and space to support robust populations. Pollinator habitat is an area with a variety of flowering plants that provide food and nesting space (see Fact Sheet 5.616 for more information).

Figure 3: Honey bee, *Apis mellifera*. Photo by Lisa Mason

Quick Facts

- There are over 20,000 bees species found worldwide.
- There are 946 native bee species in Colorado.
- Most native bees are solitary and nest underground or in drying/dead plant stalks.
- Studies have shown that native plants are four times more attractive to native bees than introduced ornamentals.

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Figure 4: Bee emerging from soil. Photo by MaLisa Spring

Unlike honey bees that are social and live in large colonies, 90% of native bee species found around the world are solitary. Approximately 70% of these nest underground in the soil (Fig. 4), and about 30% nest inside hollow stems of plants and in tunnels left by other insects. When creating habitat for these solitary species it is important to take this into account. You can provide snags (dead wood) and areas of sunny, undisturbed, unmulched ground in your garden to allow for the native bees to create spaces for their nests. You should avoid using landscape fabric in the habitat area as it would impede the ability of ground-nesting bees to tunnel into the soil.

When considering shelter and vegetation for native bees, it is best to plant in layers, replicating nature. Begin by establishing a basic structure as the first layer with trees and shrubs. Then add perennials, grasses, and groundcovers as further layers within the landscape. Bees, of course, need water too. You can provide a shallow dish filled with pebbles and water to allow bees and other insects to get a drink (Fig. 5).

The pebbles allow for an easy landing and an easy exit. Be sure to drain and refill the dish every few days to avoid harboring mosquito larvae. Bees will also drink water from common landscape irrigation sources like drip systems and sprinkler heads. It is important to avoid spraying chemicals near any source of water such as bird baths or fountains, to avoid poisoning bees.

Figure 5: Bee watering dish.

Plant List for Foraging Bees

The list of plants for pollinator habitats will vary for different parts of Colorado as climatic conditions, soil quality, elevation and water availability are highly variable. It is important to have plants that bloom from early spring through summer and as late into the fall as possible to provide continual resources for pollinators. A Xerces Society study shows that native plants are four times more attractive to native bee species than introduced ornamentals which makes sense because they would have co-evolved together.

Here are some suitable native plants that are grouped based on the flowering season to get you started. Please see Fact Sheet 5.616 for a more complete list.

Early-Season

- Blue Flax – *Linum lewisii*
- Pasque flower – *Pulsatilla patens*

Mid-Season

- Asters (many options available, check with local nursery)
- Yarrow – *Achillea millefolium*
- Flowering trees including willows and black locust

Late-Season

- Rocky Mountain bee plant – *Cleome serrulata*
- Common sunflower – *Helianthus annuus*
- Goldenrod – *Solidago spp.*
- Late season flowering shrubs
- Rabbitbrush – *Chrysothamnus nauseosus*

Incorporating Nesting Habitat into Your Home Garden

Many people are familiar with the managed (or domesticated) honey bee and the large colonies they create. In a single honey bee hive there is one queen that does all the egg laying and tens of thousands of workers that are

Figure 6: Digger bee, *Anthophora sp*. Photo by Lisa Mason

building cells, cleaning the hive and foraging for pollen and nectar.

In the case of native bees (Fig. 6), each female builds her own nest. The female excavates nesting material (whether in a hollow stem or underground), makes a cell, gathers pollen and rolls it into a pollen ball, lays an egg on the pollen ball and then seals off the cell. She then builds another cell, gathers more pollen and lays an egg on the pollen ball and so on (Fig. 7). This building and egg laying begins in the spring and continues through the season. At the end of the season the female dies. The eggs she has laid hatch, the larvae feed on the pollen ball and overwinter as pupae. The adult emerges next spring and whole cycle repeats.

Nesting materials for native bee species include natural material such as dead wood, drying plant stems and exposed ground that is not mulched. Dead tree stumps can be left in the yard adding a landscape element while encouraging wood boring bees to nest. Avoid pruning perennials and cane fruits like raspberries during fall. Instead, leave dry stems behind providing stem nesting bees a location to overwinter and add winter interest for your garden. Prune stems back during late spring when adults have emerged from the stems. You can also recycle any extra sod into a 'bee bank' for ground nesting bees. Allow sod to sit upside down (dirt side up) in the sun. Once the grass is dead, bees will use the dried sod for nesting. Planting flowering plants on the top and along the sides of the sod bank will attract mining and digging bees that will nest in the sod and forage on the plants nearby.

Figure 7: Pollen ball (left), and a larva feeding on a pollen ball (right). Photo by MaLisa Spring

You can also create nesting materials. Nest boxes, untreated 4" x 4" or larger wood with holes of different sizes drilled into it, can also be set up. Several bee species will nest in these wooden boxes. Make sure holes are smooth and do not quite go all the way through the piece of wood. Place the nest boxes in an open, but protected spot that receives plenty of early morning sun which helps bees warm to flying temperatures (Fig. 8).

Figure 8: Nesting box.

Nest boxes can also be built as a group of bamboo canes of varying sizes tied together in a box. The hollow bamboo stems provide nesting holes for a wide range of native bee species. Clay bee homes are also common handmade nesting homes that mimic holes in the earth. With any of these options, you will be able to observe bees flying in and out of the holes and eventually sealing up the ends with mud, sand and small gravel or bits and pieces of leaves and grass.

Native bees are the unsung heroes of the pollination world. While there are numerous species of pollinators, because of their solitary nature, native bees can easily go unnoticed. Learning more about them and providing valuable habitat for them will help sustain these important pollinator species.

Reference

Creating Pollinator Habitat, Colorado State University Extension Fact Sheet #5.616.

APPENDIX C: COLORADO STATE UNIVERSITY EXTENSION FACT SHEET NO. 5.616 – CREATING POLLINATOR HABITAT

Creating Pollinator Habitat provides general information on pollination biology, habitat requirements for insect and bird visitors, how to create pollinator habitat, and a basic list of plants for pollinators.

Colorado State University
EXTENSION

Creating Pollinator Habitat

Fact Sheet No. **5.616** Insect Series | Home and Garden

by H.S. Arathi, D. Davidson and L. Mason*

Quick Facts

- Pollinator species include bees, beetles, flies, moths, butterflies, hummingbirds, and bats.
- More than 70% of the world's flowering plants rely on pollination which is essential for producing fruits and seeds.
- Just like humans and other animals, pollinators need food, water, shelter and space (collectively known as habitat) to support robust populations.
- Creating habitat is something that everyone can do to help support pollinators in their area.

Pollinators are animal species that provide pollination services to plants in natural/wild landscapes, cultivated gardens and agriculture settings around the globe. They have coevolved with plants and the relationship between plants and pollinators is very intricate; each relying on each other for survival. These important services help many plants complete their lifecycles, as well as ensuring food and shelter for humans and other animals for many generations. Pollinators visit flowers to collect nectar and pollen which provides nutrition for their offspring. More than 70% of flowering plants in the world rely on pollinators for fruit and seed production.

Figure 1a: Swallowtail butterfly. Photo by Lisa Mason

Figure 1b: Hummingbird. Photo by Lisa Mason

Flower Visitor or Pollinator?

Pollinators include bees, wasps, beetles, flies, moths, butterflies, hummingbirds, and bats (Fig. 1a, b and c). However, just because an insect or a bird is visiting a flower, it is not necessarily a pollinator (Fig. 2). Pollinators move between flowers of the same plant species in an orderly fashion, whereas flower visitors move haphazardly among flowers spending very little time within a flower. Even if it does happen that a flower visitor gathers pollen grains on its body, it will not necessarily move to the same flower species, therefore pollination would not occur.

How Pollination Happens

When a pollinator enters a flower, pollen grains from that flower stick to its body (Fig. 3). The pollinator then moves to another flower on the same plant or a different plant, but of the same species. This leads to the transfer of pollen from its body

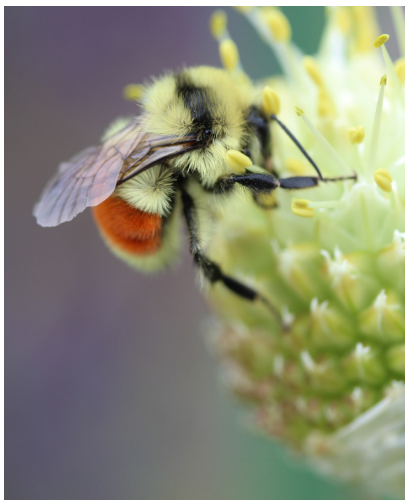

Figure 1c: Bumble bee. Photo by Lisa Mason

*H.S. Arathi (Arathi Seshadri), CSU, Department of Soil and Crop Sciences, D. Davidson: CSU Extension, Boulder County, L. Mason: CSU Bioagricultural Sciences and Pest Management Department, 1/2018.

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to the next flower resulting in cross-pollination. Pollination is essential for plant reproduction – production of fruits and seeds. It is important to note that not all plants rely on pollinators, some are wind pollinated such as most of our grains: wheat, rice, corn, barley, oats, etc.

What is Pollinator Habitat?

Just like humans and other animals, pollinators need food, water, shelter and space to support robust populations. Pollinator habitat is an area with a variety of flowering plants that provide food and nesting space. The habitat may be a natural setting such as a prairie or a meadow, or it could be manmade where a combination of flowering plants are cultivated specifically to provide nutrition and nesting space for pollinators. Manmade pollinator habitats can be found in a variety of settings, both large and small. Some gardens, such as botanical gardens, may be a collection of plants used for conservation and display purposes and in other cases, gardens may be places where new varieties of flowering plants are being evaluated; these, along with home gardens can serve as pollinator habitat. In most cases, when there are several flowering plants all in bloom, pollinators will be attracted to them (Fig. 4).

Figure 2: Masarid wasp. Photo by Lynn and Gene Monroe

Figure 3: Honey bee covered in pollen grains. Photo by Bruce Leander

If a habitat is intentionally planted to provide nutrition for pollinators, then it needs to contain a mixture of plant species so that bloom times range from early spring to late fall. This ensures that flowers will be available throughout the pollinator activity season. Home gardens, parks, community gardens, prairies and meadows can all provide pollen and nectar. These habitats can be refuges for pollinators foraging through lawns and farmlands that may not have the floral resources they need.

How to Create Pollinator Habitat

You can design a garden that is both beautiful for you and provides habitat (food, water and shelter) for pollinators. An important factor to consider when planning a habitat garden is what type of pollinator you are designing it for. Providing plants that bloom early in the season until late is important for all pollinators, but you should also consider what type of flowers and potential nesting sites to make the garden attractive to different species. For instance, bees prefer a broad range of plants, some of which may provide pollen only, while others provide pollen and nectar. Flower size also matters. Some natives bees are quite large and prefer size appropriate flowers, whereas smaller bees will be able to work smaller flowers more effectively. When planting for pollinators it is important to consider the structure of the flowers too. Different species may be more or less inclined to visit a bell shaped flower over a flat disk shaped flower and vice versa. Bees like to focus on flowers of similar structure and so grouping flowers of similar structure together while designing the landscape will work in sync with their preferences. It is best to plant in layers, replicating nature. Begin by establishing a basic structure with trees and shrubs. Then add perennials, grasses, and groundcovers as further layers within the landscape.

Plant list for forage

The list of plants for pollinator habitats will vary for different parts of Colorado as climatic conditions, soil quality, elevation and water availability are highly variable. Here are some suitable plants that are grouped based on the flowering season. Again, it is important to have plants that bloom from early spring through summer and as late into the fall as possible to provide continual resources for pollinators. This list may be updated periodically so check back before planting season and make sure plants you choose are appropriate to your area.

Early-Season

- Nodding onion – *Allium cernuum*
- Serviceberry – *Amelanchier alnifolia*
- Winecups – *Callirhoe involucrata*
- Sulphur flower – *Eriogonum umbellatum*
- Wallflower – *Erysimum spp.*
- Prairie smoke – *Geum triflorum*
- Blue Flax – *Linum lewisii*
- Blue mist and firecracker penstemon – *Penstemon eatorii* and *P. virens*
- Pasque flower – *Pulsatilla patens*
- Flowering fruit trees including apples, cherries, peaches and plums
- Penstemons (many native and cultivar options, check with local nursery)
- Yarrow – *Achillea millefolium*

Figure 4: Pollinator habitat. Photo by Deryn Davidson

Mid-Season

- Lead Plant – *Amorpha canescens*
- Asters (many native and cultivar options, check with local nursery)
- Pearly everlasting – *Anaphalis margaritacea*
- Showy milkweed – *Asclepias speciosa*
- Harebells – *Campanula rotundifolia*
- Blanket flower – *Gaillardia aristata*
- Salvias (many native and cultivar options, check with local nursery)
- Flowering trees including willows, black locust, linden and honey locust

Late-Season

- Blue Giant Hyssop – *Agastache foeniculum*
- Rocky Mountain bee plant – *Cleome serrulata*
- Plains Coreopsis – *Coreopsis tinctoria*
- Common sunflower – *Helianthus annuus*
- Hairy False Goldenaster – *Heterotheca villosa*
- Goldenrod – *Solidago* spp.
- Rabbitbrush – *Chrysothamnus nauseosus*
- Chokecherry – *Prunus virginiana*
- Boulder raspberry – *Rubus deliciosus*

Location of the garden is extremely important. Most pollinators generally prefer sunny areas and large connected habitats are better than small patchy ones. Before planting, determine if you can connect your front yard and your backyard through the use of flowering plants and plan accordingly. It is important to have a variety of flowering species planted as groups/swaths in the landscape rather than as single plants. This allows the pollinators to work one area more thoroughly and efficiently, rather than having to move around a great deal to find plants of the same species.

Challenges for Pollinators

There are a variety of factors facing pollinators which interact with each other. Intensive agriculture with increased monocropping, several rotations in the year, indiscriminate and improper use of chemicals to reduce weeds and pests, and destruction of natural habitats are some of the most important factors. These, in combination, compromise the nutrition and health of our pollinators, leaving them to become vulnerable to many diseases and pests. Your efforts to create habitat for these important species can greatly contribute towards the ongoing efforts for the protection and conservation of all pollinators.

The important thing to remember is that any habitat is better than no habitat. If done correctly, creating a beautiful garden for yourself can have far reaching benefits that positively impact the greater ecosystem that surrounds you.

References

Attracting Native Bees to Your Landscape, Colorado State University Fact Sheet # 5.615

Websites for other plant options:

- The Xerces Society: (https://xerces.org/pollinator-conservation/plant-lists/)
- USDA NRCS: (https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/plantsanimals/pollinate/?cid=NRCS143_022326)
- NAPPC/Pollinator Partnership: (http://pollinator.org/guides)

APPENDIX D: NATIVE BEE WATCH NEWSLETTERS

E-newsletters were sent out approximately every other week during the summer season and monthly during the off-season to keep volunteers engaged in the program. Through a number of outreach presentations and events, more subscribers signed up for the newsletter for general information on pollinator conservation and did not enroll to participate in the citizen science program.

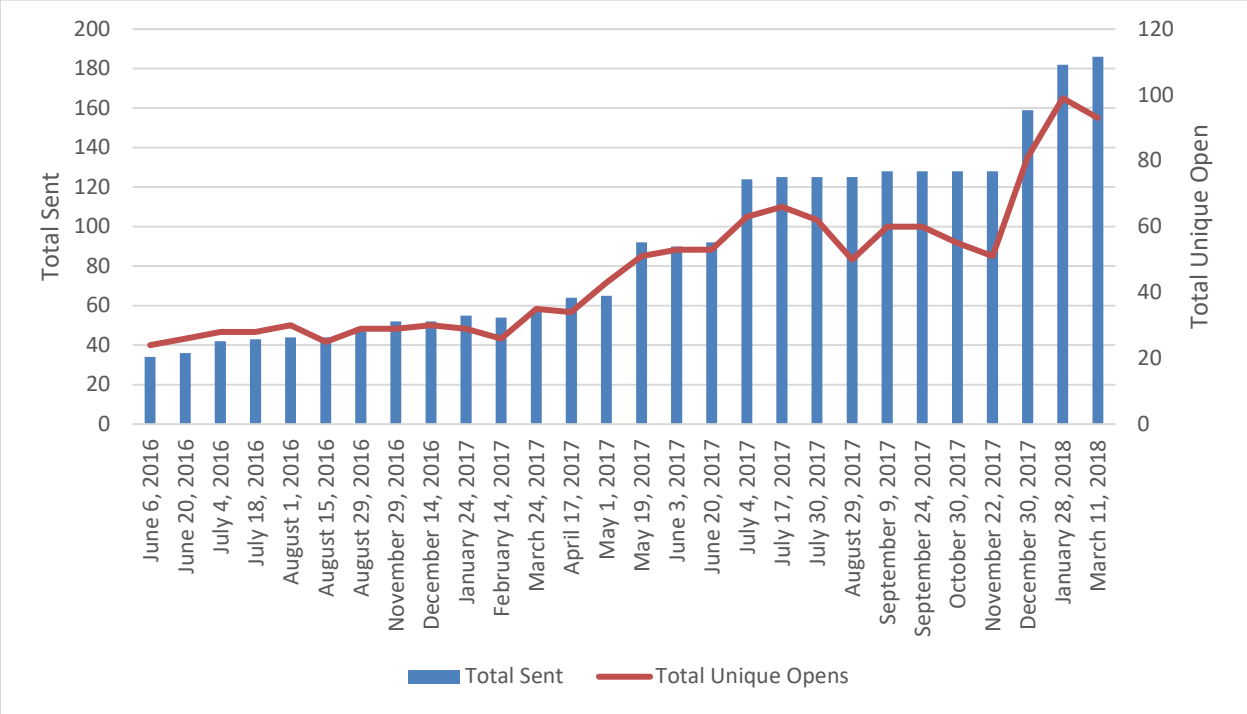


Figure D.1. Number of e-newsletters sent and number of unique opens over time.

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #1

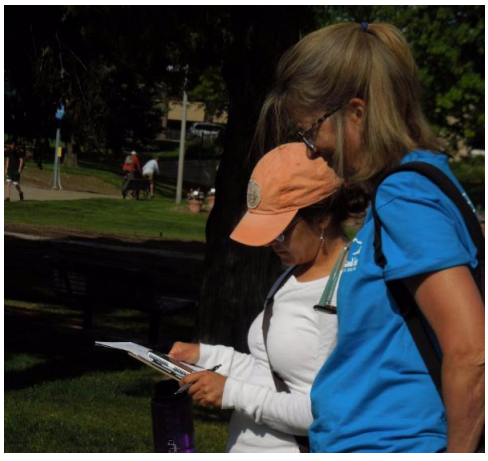
Welcome to the Native Bee Watch Newsletter! This biweekly newsletter will provide the current buzz on bee monitoring, tips for best practice observing, the Bee and Plant of the Week, and other fun, educational resources. Enjoy!

Visit our Website

Citizen Scientist Session
Tuesday, June 7th

We are looking forward to observing bees again this Tuesday from 9am-11am. Please remember to wear a sun hat and sunscreen, and to bring a water bottle to your observation site. It got pretty hot at our last session, and it's only going to get hotter! Do what you need to do to keep yourself cool!

Schedule



Gardens at Spring Creek
- Lauri
- Lori

Nix Farm
- Kate
- Lori

CSU Trial Gardens
- Rosmary
- Linda
- Barb

Project Updates

- We are starting to see more and more native bees! Keep your eyes out!
- Due to project logistics, we will be dropping the Fort Collins Utilities Garden from the Citizen Science Monitoring Sessions. If you signed up for the Utilities Garden, let me know your preferred garden to monitor instead (Gardens at Spring Creek, CSU Trial Gardens - Plant Select area, or Nix Farm Natural Area). If I don't hear from you, I will contact you about switching gardens. Thanks for your understanding!
- You will only be monitoring one garden during your two-hour session. Please arrive at the garden you originally signed up for.
- We encourage volunteers to monitor on their own! However, bee monitoring takes practice. There are also a lot of questions that come up. If you would like to monitor on your own, please attend at least two monitoring sessions with a researcher. That will give you experience and will improve your accuracy in collecting data.
- Saturday and Sunday monitoring dates are coming soon!

Syrphid Flies

During the monitoring session on May 26th, our team witnessed a large number of syrphid flies. It can be a little tricky to tell them apart from bees, but here are a few tips:

- Syrphid flies hover and move erratically instead of taking their time moving from flower to flower like bees.
- Flies also have short stubby antennae rather than long bent antennae.
- Check out this article to help you learn more about bee mimics!
- Bee Mimics

A syrphid fly at the CSU Trial Gardens.

A syrphid fly at the CSU Trial Gardens.

A honey bee at the Fort Collins Utilities Garden on Wood Street.

A metallic green sweat bee at the Gardens at Spring Creek.

Cool Science!

We received an e-mail from an enthusiastic Citizen Scientist this week, sharing a great article on bumblebees, so we thought we'd share it with everyone! We love receiving e-mails with questions, thoughts, or just to share the passion for pollinators! Please send us a note anytime!

Bumblebees' Electric Sense

Bee of the Week: Hairy Belly Bees

The famous Leafcutter bee, known in Latin as *Megachile spp. is* often overlooked because of its solitary nature but it is an important native pollinator in Colorado After their nest is made, the bees collect fragments of leaves to construct individual nest cells.

For more information, click here

Plant of the Week: Silver Blade Evening Primrose

The Silver Blade Evening Primrose is a hardy plant with a long flowering season that is perfectly suited to Northern Colorado and our native pollinators.

For more information, click here

A metallic green sweat bee spotted at the Gardens at Spring Creek on June 1st.

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #2

Welcome to the Native Bee Watch Newsletter! This biweekly newsletter will provide the current buzz on bee monitoring, tips for best practice observing, the Bee and Plant of the Week, and other fun, educational resources. Enjoy!

Visit our Website

Happy National Pollinator Week!

Nine years ago the U.S. Senate's unanimous approval and designation of a week in June as "National Pollinator Week" marked a necessary step toward addressing the urgent issue of declining pollinator populations. Pollinator Week has now grown into an international celebration of the valuable ecosystem services provided by bees, birds, butterflies, bats and beetles.
The Pollinator Partnership is proud to announce that June 20-26, 2016 has been designated National Pollinator Week by the U.S. Department of Agriculture and the U.S. Department of the Interior.

Citizen Scientist Session Wednesday, June 22nd

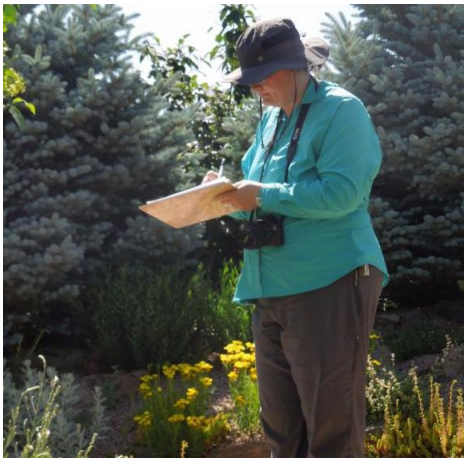
We are looking forward to observing bees again on Wednesday from 9am-11am. Please remember to wear a sun hat and sunscreen, and to bring a water bottle to your observation site. The temperatures are in the 80's and 90s this week!

Schedule

Gardens at Spring Creek
- Kate
- Carol
- Linda
- Carole
- Harry

Nix Farm
- Colleen
- Lori
- Barb
- Kate

CSU Trial Gardens
- Diana
- Shelly
- Lori
- Suzy



Remember: Send your pictures to lisa.mason@colostate.edu!

Join Us For Bee Monitoring on July 2 or 3rd!

Start off your 4th of July weekend by helping us monitor bees! Saturday, July 2nd, we will be at the Gardens at Spring Creek. Sunday, July 3rd, we will be at Nix Farm Natural Area. Both sessions are from 9-11 am.

Please email Lisa at lisa.mason@colostate.edu if you are interested in attending!

Photo of the Week - A Budding Young Scientist!

Clover, daughter of volunteer Lori, came with her mom and helped monitor in early June. They paired up with volunteer, Lauri and made a great team observing bees! With the help of mom, Clover wrote down all the bee sightings on the data sheet. Clover's younger brother, Ansel also helped run the 2-minute timer.

5 Easy Steps to Help Pollinators

Since it is National Pollinator Week.... It is a good time to talk about easy things we can all do to support pollinators. Here are 5 things you can do:

Pick the right plants

Plant native, flowering plants that are known to attract pollinators. Make sure to have flowering plants that will bloom all or most of the season. You can have a succession plan to ensure that pollinators will have food all season long. You can start small, and add new plants each year to make gardening more cost-effective and manageable.

Color is important

Bees can see in color and ultraviolet light. Yellow, white, violet, and blue are all good colors for flowers. Bees can't see the color red because it looks similar to the color green in their eyes.

Give them nesting spaces

Approximately 70% of bees are ground nesters. Patchy vegetation or places with open soil can provide nesting spaces. Avoid landscape fabric because bees can't dig through the fabric. Other bees are cavity nesters. You can provide human-made bee homes for them.

Provide water

Bees need to drink water. Place a small, shallow water source near pollinator-friendly plants. A bird bath or other dish works well. A water source may also attract other birds or wildlife. Be sure to change the water often to help avoid mosquitos.

Help spread the word

Educate your neighbors, friends, families, school and community groups about the importance of pollinators. Tell them about the bee monitoring you are doing this summer! The more of a buzz we can create, the better!

Plant of the Week: Denver Gold® by Plant Select®

The bright yellow flowers on the Denver Gold Columbine® (Aquilegia chrysantha) can be over 3-inches long. They can bloom from May to autumn. This perennial can tolerate dry, shady growing conditions, but thrives in the sun. They generally grow between 28-32 inches in height, and can be 16-18 inches wide. To encourage longer blooming throughout the season, you can remove the flowers that are done blooming. The Denver Gold® variety is actually longer lived than most other columbines. The plant is well-adapted to grow at higher elevations. You can find this variety at the CSU Trial Gardens. We have observed striped sweat bees on the flowers this summer. Have you seen any other bees on the Denver Gold®? *(Photo: Lisa Mason)*

For more information, click here

Bee of the Week: Cuckoo Bees

A cuckoo bee is a cleptoparasitic bee that may come from about 16 social bee lineages including *Bombus* and *Apidae*, as well as 31 solitary bees, mostly in *Apidae*, *Megachilidae*, and *Halictidae*. Collectively, cuckoo bees make up a large portion of the bee population.
Cleptoparasitism describes the cuckoo bird-like behavior of laying their brood in the nests of other bees. They tend to look similar to the bees they parasitize and when their young are hatched, they will be tended by the host bees. Sometimes the queen of the host species will be killed and replaced by a cuckoo bee queen.
Cuckoo bees can be distinguished from other bees by their thickened exoskeletons and reduced hair quantities. They are not typically pollinators and lack pollen sacs and other features that would typically help with the job. Have you seen cuckoo bees this summer? *(Photo: Diana Wilson)*

A striped sweat bee spotted at the CSU Trial Gardens on May 26th. Photo: Lisa Mason

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #3

Welcome to the Native Bee Watch Newsletter! This biweekly newsletter will provide the current buzz on bee monitoring, tips for best practice observing, the Bee and Plant of the Week, and other fun, educational resources. Enjoy!

Visit our Website

Citizen Scientist Session Wednesday, July 6th

We are looking forward to observing bees again this Wednesday from 9am-11am. Remember, it will be another toasty day in the sun! Bring water, a hat and sunscreen!

Schedule

Gardens at Spring Creek
- Diana
- Lori
- Colleen

Nix Farm
- Kate
- Linda
- Stephanie
- Shelly

CSU Trial Gardens
- Suzy
- Barb

We have 2 extra spots at the CSU Trial Gardens and 1 extra spot at the Gardens at Spring Creek. Email lisa.mason@colostate.edu if you would like attend.

Reminders

- Send your photos to Lisa.Mason@colostate.edu!
- If you have participated in at least 2 group bee monitoring sessions, you are welcome to monitor on your own! Ask Lisa if you have questions about getting started!

Volunteer Spotlight

Meet Citizen Scientist Linda -- The Bee Groupie

A Little About Linda...

Linda is "mostly" retired from Fine Print Imaging - a fine art and photography reproduction facility celebrating its 41st year of operation in Fort Collins. She and her husband Mark have dedicated their careers to helping independent photographers and artists succeed.

Why Does She Volunteer?

Over their many years of working with incredible images of the natural world, Linda and Mark have developed a serious commitment to conservation issues both local and global. It is this passion for protecting nature that drew Linda to the Nature in the City Initiative and subsequently to volunteer with the Native Bee Watch. She loves the idea of using "citizen scientists" to help gather data as well as the chance to learn about the life and times of native bees!

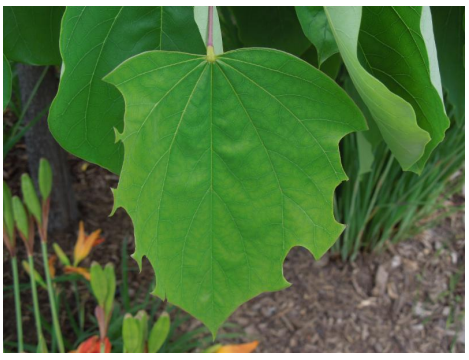
Underground Nest Sighting!

Volunteers at Nix Farm on June 22nd had an interesting experience. First, they couldn't access the gardens by the farm house because a family of raccoons broke into the building!

Then, while monitoring the garden around the main office building, a ranger showed them a nest of metallic green sweat bees! Native bee nests are hard to find. We watched about 5 bees fly in the nest, and 1 or 2 bees fly out of the nest. What a treat!

Guess Who Lives in Here?

Another native bee nest was spotted at the Gardens at Spring Creek on Saturday, July 2nd! The bee lives in a tiny cavity just under the stone stair. We weren't able to get a picture of the bee, but we saw the bee fly into the nest twice. Any guesses what type of bee lives here?



Here is a Hint...

The same type of bee that lives in the cavity in the picture above can also be seen on leaves like this Eastern Redbud tree at the Gardens at Spring Creek. Notice how parts of the leaf are missing. What was this bee doing?

Email your answers to Lisa! The answers will be in the next edition of the newsletter.

Bee of the Week: Green Metallic Sweat Bees

Family: *Halictidae*
Genus: *Agapostemon*
Sweat bees are very important pollinators as their large populations are second only to those in the *Apis* family (honey bees, etc). *Agapostemon* are generalists so they reach a large variety of flowers that may not be pollinated otherwise. These bees have short tongues, so they prefer flowers that are aren't too deep, and the nectar is easy to access.
Most species live a solitary life in underground nests. Some species live in large communes of 200+ females. In species that have a communal lifestyle, the females will share a common entrance hole. Once underground, each bee creates their own nest, and collects pollen and nectar which will be for the egg they will lay.
The females of *Agapostemon* can have solid green-blue metallic color over their entire body, or be similar to males with a striped abdomen and are quite fast fliers, while the males typically have a striped abdomen and fly a little more slowly to search for females.
Some great ways to cultivate space for these bees in your garden include:

1. Leave bare ground for them to nest. Plastic mulch, weed barrier, rocks, and even wood chips can disturb sweat bee nesting or prevent them from nesting in those areas.
2. Plant a large number and variety of pollinator-friendly plants.

For more information, click here

Plant of the Week: Little Trudy® Catmint by Plant Select®

Little Trudy® is a compact Catmint with silvery leaves and purple flowers that is perfect for xeric conditions (seasonal dry weather patterns) and attracting pollinators. The smell of catmint is pleasant for both humans and our feline friends. This perennial is low-growing and is great as a ground cover plant. We have seen sweat bees, honey bees and bumble bees on catmint so far this summer!

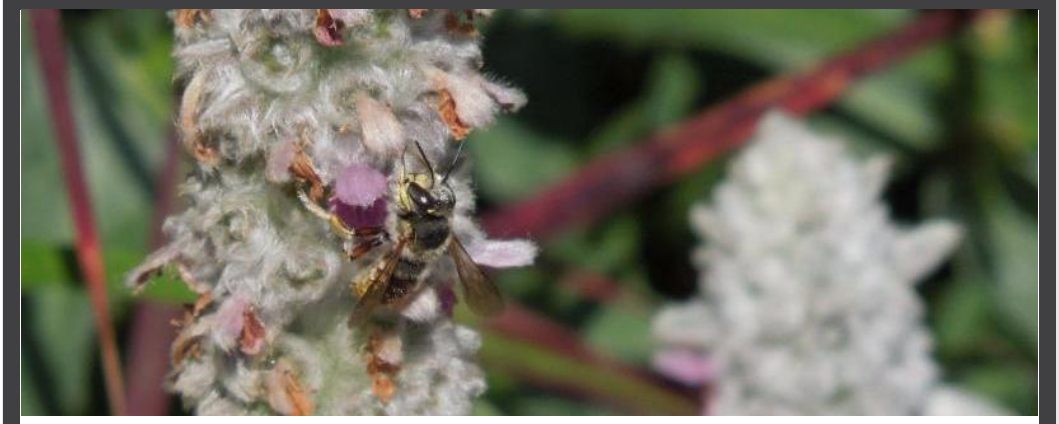
For more information, click here

Below: *A metallic green sweat bee at the Gardens at Spring Creek on July 2nd. Photo: Lisa Mason*

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado



Native Bee Watch Newsletter #4

Welcome to the Native Bee Watch Newsletter! This biweekly newsletter will provide the current buzz on bee monitoring, tips for best practice observing, the Bee and Plant of the Week, and other fun, educational resources. Enjoy!

Visit our Website

Citizen Scientist Session Wednesday, July 19th

We are looking forward to observing bees again this Tuesday from 9am-11am.

Gardens at Spring Creek
- Lauri
- Shelly
- Barb

Nix Farm Natural Area
- Lori
- Carol
- Colleen

CSU Trial Gardens
- Carole
- Harry

Extra Open Slots for Bee Monitoring! Can you Help?

Thursday, August 4th
- 1 opening at Nix Farm
- 1 opening at the Gardens at Spring Creek

Wednesday, August 17th
- 3 openings at the Gardens at Spring Creek

- 2 openings at the CSU Trial Gardens
- 1 opening at Nix Farm Natural Area

Email lisa.mason@colostate.edu if you can attend!

Reminders

- Send your photos to Lisa.Mason@colostate.edu!
- If you have participated in at least 2 group bee monitoring sessions, you are welcome to monitor on your own! Ask Lisa if you have questions about getting started!

Volunteer Spotlight

Meet Citizen Scientist Rosemary -- The Bee Enthusiast

A Little About Rosemary

I have degrees in biology and biotechnology. Years ago I worked in various toxicology labs, including insect toxicology where I learned to rear crop insects and houseflies for testing. Raising houseflies is not as easy as you might think! More recently, I became involved in statistical software and worked in technical support and software testing. Now, I am a database specialist at the CSU Veterinary School.

Why Do You Enjoy Volunteering?

For me, volunteering is a way to meet new people, learn new skills, and do something that benefits our communities. I especially love volunteer experiences that involve nature and being outdoors, be it one of the wonderful citizen science projects here in Fort Collins or picking up trash along the Poudre River. It's a way of making a contribution and having fun doing it.

What is Your Favorite Bee?

I have always been fascinated with carpenter bees. It is amazing how such small creatures can make those perfectly round

holes in wood! Seems like a lot of hard work to me.

What is the Coolest Thing You Have Seen This Summer?

Well, that is a tough question. The interaction of the two insect species, the assassin bug and the bee, at the Gardens on Spring Creek during a recent bee count event, was really very cool, although fatal for the bee (see photo below).

Cool Sightings at the Gardens!

Besides the awesome bees, what else have you observed this summer?

Life is so busy and hectic! It is incredible what happens when you slow down and take in the scenery around you. I have thoroughly enjoyed not only bee observations, but other interesting critters and sites in the gardens.

We have quite a diverse range of awesome bees this summer! Even though we are only recording bees, we have seen some other awesome things that we may not have noticed had we not stopped to observe and notice our surroundings. Each monitoring session brings something new! A new bee, a new insect, a habitat observation, new wildlife, new species interactions…

A honey bee and a milkweed longhorn beetle spotted at the Gardens at Spring Creek on July 7th.

A predatory assassin bug feeding on a honey bee at the Gardens at Spring Creek.

A hummingbird spotted at the CSU Trial Gardens on July 13th.

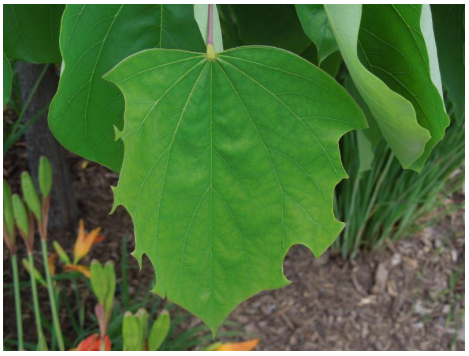
A checkered white butterfly at the Gardens at Spring Creek on July 7th.

A grasshopper camouflaged among the paprika yarrow at the Gardens at Spring Creek on July 7th.

A sand wasp (Bembix genus) at the Gardens at Spring Creek. These wasps have been spotted numerous times the past couple of weeks. These solitary wasps make their nests in sandy soils. They are predators of flies, but adults will also feed on nectar.

Answer: Guess Who Lives in Here?

In the last newsletter, I asked who lives in this cavity nest (left photo) and who is responsible for the the sections of missing leaf of the eastern redbud tree at the Gardens at Spring Creek (right photo).
Volunteer, Lori Nixon answered correctly right away: **A leaf cutter bee, in the family Megachilidae.** This family of bees falls in the **Hairy Belly Bee group**. Keep your eyes out! Both of these pictures were taken on along the monitoring path at the gardens!



Quiz Question: What is this insect?

I took this photo at the Gardens at Spring Creek. This insect loved the cone flowers! Take a close look....

Email your answer to lisa.mason@colostate.edu! The answer will be in the next newsletter.

Bee of the Week: Bumble bees

Family: Apidae
Genus: *Bombus*
There are over 2 dozen species of bumble bees native to Colorado, four of which have orange markings on their abdomen. Like the honey bee, they are a social creature and live together in colonies, unlike honey bees, however, only the queen bumble bees will overwinter, giving rise to a new colony each year.
Bumble bees are very important pollinators for a couple of reasons. First, they do quite well in extremely cold climates, acting as primary pollinators of Colorado's subalpine region. As well, they perform "buzz pollination" also known as *sonication*. This occurs when a bee rapidly contracts their flight muscles, powerfully forcing the pollen out of the flower's anther. About 8% of flowers are *porcidal*, hidden inside a tube-like anther, and require sonication for cross pollination. Some examples of these flowers include tomatoes, peppers, cactus, blueberry and kiwi. Chances are that if you have been to a greenhouse that is growing tomatoes or peppers, you have seen a commercial colony of bumble bees pollinating the crop.

Photo: Tabitha Covey

Photo: Lisa Mason

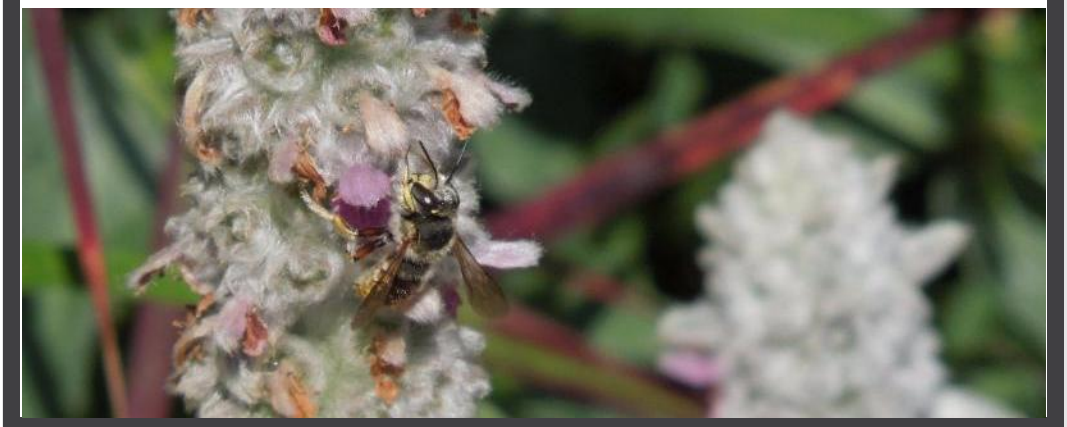
Plant of the Week: Grand Mesa Beardtongue

The Grand Mesa beardtongue from Plant Select® is a hardy Colorado penstemon variety that prefers full-to-partial sun, flowers from April to June, and is likely to attract a variety of pollinators to its beautiful blue blooms. A drought tolerant xeric plant that has been bred for Colorado's unique climate, the Grand Mesa beardtongue is a delightful addition to any local garden.

For more information, click here.

Photo: Plant Select

Below: A hairy belly bee at the Gardens at Spring Creek on July 14th. Photo: Lisa Mason



Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

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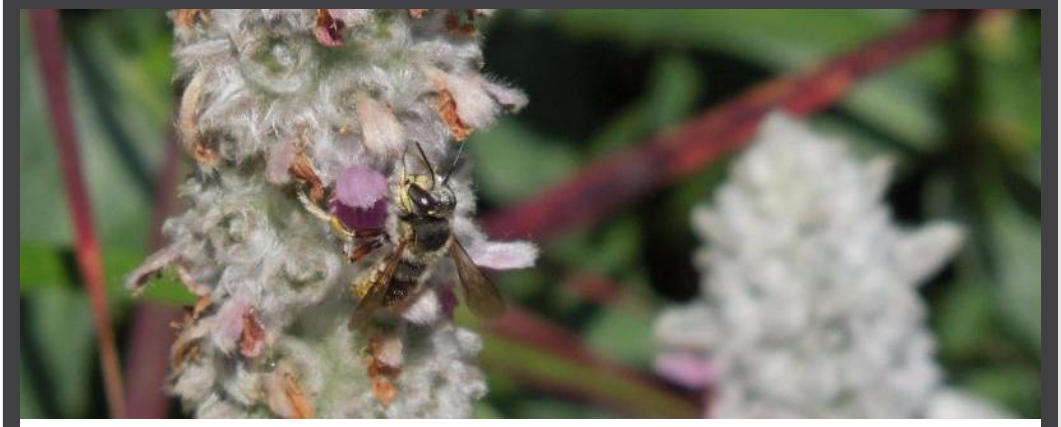
A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado



Native Bee Watch Newsletter #5

Welcome to the Native Bee Watch Newsletter! This biweekly newsletter will provide the current buzz on bee monitoring, tips for best practice observing, the Bee and Plant of the Week, and other fun, educational resources. Enjoy!

Visit our Website

Citizen Scientist Session Thursday, August 4th

We are looking forward to observing bees again this Tuesday from 9am-11am.

Gardens at Spring Creek
- Lauri
- Lori
- Linda

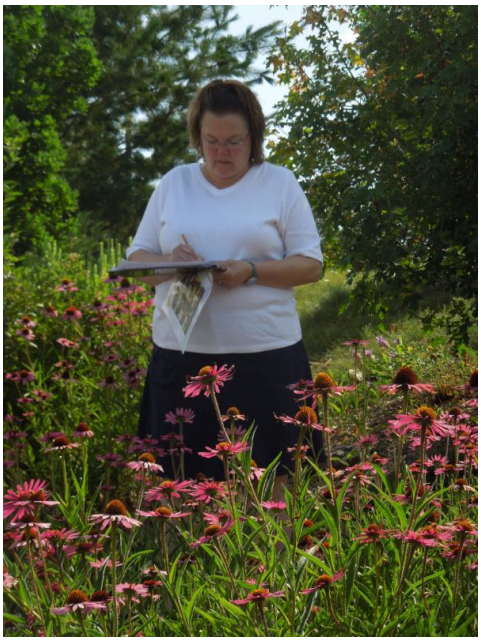
Nix Farm Natural Area
- Diana
- Carol
- Kate

CSU Trial Gardens
- Carole
- Harry
- Shelly
- Micaela

Extra Open Slots for Bee Monitoring! Can you Help?

Wednesday, August 17th
- 3 openings at the Gardens at Spring Creek
- 2 openings at the CSU Trial Gardens
- 1 opening at Nix Farm Natural Area

Email lisa.mason@colostate.edu if you can attend!



Reminders

- Stay tuned for the date of our End-of-Season Celebration in late August or early September!
- After you have participated in at least 2 group bee monitoring sessions, you are welcome to monitor on your own! Ask Lisa if you have questions about getting started!

More Cool Sightings at the Gardens!

If you seen awesome bees or other critters, send your photos in!

This wasp attacked a grasshopper while I was monitoring bees at the cone flowers at the Gardens at Spring Creek!

This dragonfly in the family of common skimmers (*Libellulidae* spp.) was sighted at the Gardens at Spring Creek on July 19th.

Quiz Answer: What is this insect?

This insect is actually a fly that is a bee mimic. It looks like a bumble bee, but if you look closely, it has all the key fly characteristics:

1.) Antennae are short and stubby (bees have longer antennae)

2.) One pair of wings (bees have two)

3.) Eyes are more on the front of the head, and a little larger than bees (bee eyes are on the sides of their head)

Notice the Bumble Bees (*Bombus* spp.) Characteristics...

Note the bright orange corbicula (pollen basket)!

Bee of the Week: Carpenter bees

Family: *Apidae*
Genus: *Xylocopa*

Carpenter bees are well known because of their wood nesting behavior and often large bumble bee-like appearance. They range in size from small to large, and from black/shiny to yellow/fuzzy. Carpenter bees can often be an unwelcomed guest nesting in the wood structures of houses. As with any undesired pest, the key is making the your home unappealing, while offering the bees an alternate habitat in areas where they are welcome.
Carpenter bees, as their name suggests, are attracted to wood. Coating all wood surfaces with polyurethane or oil based paints will make them unattractive to bees. If you have bees nesting in your wood structures, caulking and filling their holes before painting over is a

solution.
Another possible solution is placing untreated wood structures in your garden to provide an alternate nesting site. Male carpenter bees are stingless, and generally, these bees are non-aggressive. They pollinate orchard fruits and vegetable crops like tomato and eggplant. Creating habitat for them can be a huge asset for your garden! *(Photo Credit: Viette, from Viette's Garden Blog)*

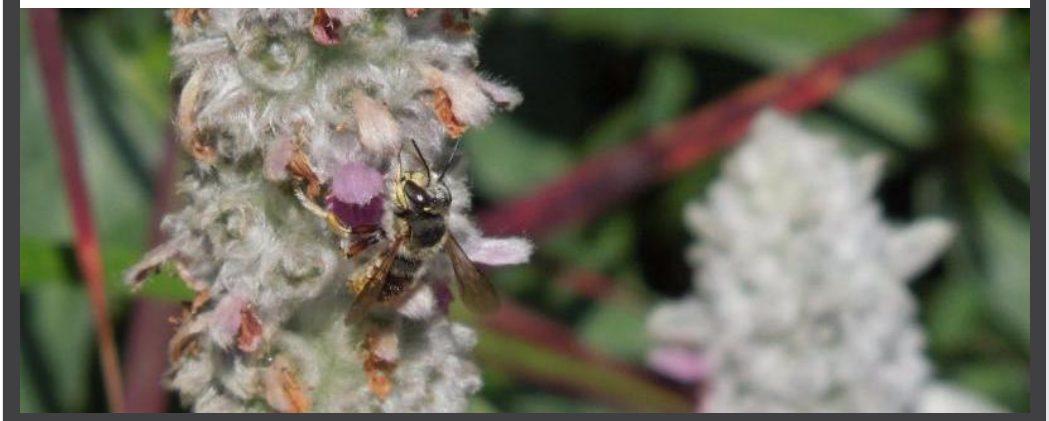
Plant of the Week: Ruby Voodoo Rose

Finding a great rose that will grow well in Colorado can be tough. Most roses are well adapted to sandy soils, moist conditions, and warmer climates, but the Ruby Voodoo was hybridized with Colorado's xeric conditions and clay soils in mind. Not only is Ruby Voodoo perfect for Colorado's climate, but also for rose lovers. As well as being great for pollinators, this flower boasts a high petal count of around 40, and a lovely rose fragrance. (Swartzendruber, Plant Select®)

For more information, click here.

Photo: Plant Select®

Below: A hairy belly bee at the Gardens at Spring Creek on July 14th. Photo: Lisa Mason



Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #6

Welcome to the Native Bee Watch Newsletter! This biweekly newsletter will provide the current buzz on bee monitoring, tips for best practice observing, the Bee and Plant of the Week, and other fun, educational resources. Enjoy!

Visit our Website

Citizen Scientist Session Wednesday, August 17th

We are looking forward to observing bees again this Wednesday from 9am-11am.

Gardens at Spring Creek
- Diana

Nix Farm Natural Area
- Lori
- Stephanie

CSU Trial Gardens
- Kate
- Suzy

End-of-Season Celebration!

Mark your calendar for Wednesday, September 7th, 6-8pm for a volunteer appreciation event at Nix Farm Natural Area (the same place we held

the training). In collaboration with Nature in the City, we will talk about the season successes! Special guest speaker, Jamie Weiss from Audubon Rockies, will talk about how to apply your new knowledge to your own backyards! Dinner and refreshments will be provided.

Look Closely!

At first glance, this insect could look like a bee or a wasp. If you look at the key characteristics, this insect is a syrphid fly! Note there is only one pair of wings, very small antennae, and it is not hairy like most bees. This syrphid fly was spotted on moon carrot, a Plant Select species at the CSU Trial Gardens (see below for the Plant of the Week).

Bee of the Week: Mining Bees

Also called digger bees
Family: *Apidae*
Subfamily: *Andrenidae*

Mining bees are solitary bees that nest underground. The female miner bee creates a chamber at the end of a tunnel for her offspring. The tunnel is coated in a waxy material and filled through the summer season with pollen, a provision for her overwintering offspring. The life cycle of a mining bee is one year, and both female and male offspring are fertile. Mining bees need bare ground for nesting. You can create space for them in your garden by leaving uncovered bare soil. *Photo Credit: Jackie at BugGuide.net*

Plant of the Week: Moon Carrot

Moon carrot (*Sesli gummiferum*) is a great plant for xeriscape gardens, in addition to attracting pollinators! It is a biennial plant, so it takes two years to complete its life cycle. During the second year of growth, the plant produces 5-inch umbels of pale pink to white flowers. The stems and leaves are silvery gray/blue. Moon carrot is easy to grow and can tolerate full sun to partial shade. The moon carrot plants at the CSU Trial Gardens attracted a high diversity and abundance of bees this summer!

For more information, click here.

Photo: Lisa Mason

Below: A bumble bee at the Gardens at Spring Creek on July 19th. Photo: Lisa Mason

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #7

Welcome to the Native Bee Watch Newsletter! This biweekly newsletter will provide the current buzz on bee monitoring, tips for best practice observing, the Bee and Plant of the Week, and other fun, educational resources. Enjoy!

Visit our Website

Join us for the Volunteer Appreciation and End-of-Season Celebration!

We are looking forward to Wednesday, September 7th, 6-8pm for the volunteer appreciation event at Nix Farm Natural Area (the same place we held the training). In collaboration with Nature in the City, we will talk about the season' successes! Special guest speaker, Jamie Weiss from Audubon Rockies, will talk about how to apply your new knowledge to your own backyards! Dinner and refreshments will be provided.

Please RSVP to the event here! See you there!

Help us Monitor Bees this Fall!

The bees are still active and we are still

monitoring! We have citizen science monitoring dates through mid-October. If you have participated in at least two sessions, please email Lisa to sign up!

The following dates/times are available:

Gardens at Spring Creek

- Wednesday, Sept. 14th

CSU Trial Gardens

- Thursday, Sept. 15th
- Week of Sept. 26th (day of your choosing)
- Sunday, Oct. 16th

Nix Farm

- Thursday, Sept. 15th
- Thursday, Sept. 29th
- Wednesday, Oct. 12th

All times are 9-11 am.

We will continue to monitor through mid-October or until the first snow storm arrives, whichever comes first!

Since school is back in session, there may not be a researcher onsite when you are monitoring. We will get you data sheets and clipboards. You can also text or call Lisa with questions. Send a picture if you need help identifying a bee!

In both photos, a bee in the hairy belly bee group rests on catmint at the Gardens at Spring Creek on September 1st. Photos: Lisa

What Happens to the Bees with the Changing Seasons?

We are noticing cooler temperatures in the morning and darkness earlier in the evenings. The bees are starting to notice the changing seasons, too. It is an interesting time to watch the changing seasons in nature, and the bees are no exception!

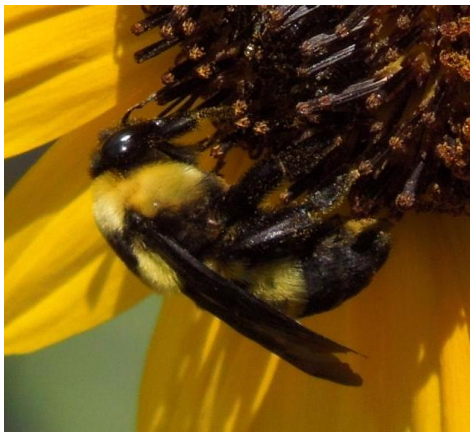
Some general trends you may start to notice:

- **Solitary bees:** We will start observing fewer native/solitary bees. The female bees have collected and created a ball of pollen/nectar called "bee bread". She has laid an egg on the bee bread. The larva will hatch, feed on the pollen and overwinter as a pupa. The pupa will transform to an adult bee, and the cycle will repeat next summer.
- **Honey bees:** You may have already noticed the honey bees are out in full force right now! Honey bees are preparing for winter by collecting as much pollen and nectar as they can to last them until warmer days arrive and flowers start to bloom.
- **Bumble bees:** There is a lot of bumble bee activity right now! New queen bumble

bees are emerging. New male bumble bees are also emerging. They will mate, and afterwards, the new queen bumble bee will forage for food. She is feeding on pollen and nectar to last her the entire winter hibernation! The new queen bumble bees are the only bumble bees that will survive the winter. She will hibernate underground until the following spring when she will find a new nest site, lay eggs, and the cycle will begin again.

What have you bee activity have you been observing? Carol and I monitored the Gardens at Spring Creek last Thursday, and we only saw one native/solitary bee. We saw many honey bees and some bumble bees. At the CSU Foothills Campus, there is a field of sunflowers. In the last few days, I have seen more solitary/native bees and bumble bees than honey bees on the sunflowers.I also saw many queen bumble bees!

Sources: Bumblebee Conservation Trust and The Xerces Society



A queen bumble bee spotted in foothills on August 31st. Photo: Lisa

A hairy leg bee also spotted at the foothills on August 31st. Photo: Lisa

Missed a Newsletter or the a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com. You can also look back at newsletters here:

Newsletter #6 - August 16
Newsletter #5 - August 1
Newsletter #4 - July 18
Newsletter #3 - July 5
Newsletter #2 - June 21
Newsletter #1 - June 6

For the winter months, newsletters will come out once per month. Starting in late spring, you will receive biweekly newsletters again. Happy reading!

Below: A hairy leg bee spotted on a sunflower at the Colorado State University Foothills Campus on August 31st. . Photo: Lisa Mason

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A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #8

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

We hope everyone had a nice Thanksgiving holiday. There are so many things to be grateful for including the meals we ate over the holiday. While enjoying dinner with family, I started to wonder how much of the food on the table we could thank pollinators for. After a little research, I wanted to share this list of common holiday menu items and who pollinates them:

- Almonds - Honey bees
- Apples - Honey bees, blue mason orchid bees
- Cardamom - Honey bees, solitary bees
- Chocolate - Bees, flies
- Coffee - Stingless bees, other bees, flies
- Cranberries - 40+ bee species
- Dairy - Dairy cows eat alfalfa pollinated by leaf cutter and honey bees
- Nutmeg - Honey bees, birds
- Peppermint - Bees, flies
- Pumpkin - Squash and gourd bees, bumble bees
- Sugar cane - Bees, thrips
- Vanilla - Bees

Source: The Pollinator Partnership

A leaf cutter bee on a sunflower in the Fort Collins foothills. Photo: Lisa Mason

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Make Bee Homes for Holiday Gifts this Season

Need a unique gift for family and friends this holiday season? Consider making bee homes! About 30% of native bees are cavity nesters, which means they live in small holes and tunnels in trees, buildings and other crevices.

It can be a very simple craft project. Click here for a tutorial. The Xerces Society also has information on making bee homes.

If you are not feeling crafty, you can always purchase a bee home as well.

It is a great educational opportunity for kids and adults to watch native bees nest within viewing distance. Female leafcutter bees will carry pieces of leaves into their nest to build a chamber for each egg they lay.

Leafcutter bees and other native cavity nesters are not aggressive, if you place the bee house near your home.

Bee homes don't need to complex. A block of wood with a variety of hole sizes up to 10mm will work. Photos: GardenCollege.com

Bee homes can also be a functional and artistic part of your backyard. Photo: ConcreteWheels.com

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Bees and Pollinators Buzzing in the News!

Seven species of yellow-faced bees in Hawaii are now listed on the endangered species list. This is the first time bees have been listed as endangered and represents a big step towards protecting these native bees.

Rusty patched bumble bee proposed to be listed on the endangered species list. Did you enjoy cranberry sauce and apple pie over Thanksgiving? The rusty patched bumble bee is an important pollinator for cranberries, apples and other crops. Their native range includes the northeastern United States from Minnesota to Maine. This is another important step for bee conservation.

Scientists discover an underwater pollinator. A species of Caribbean seagrass can be pollinated by zooplankton and bottom-dwelling invertebrates. Until this discovery, it was thought that pollination in the ocean wasn't necessary, because the ocean currents and tides move pollen to marine plants.

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com. Previous newsletters are also here:

Newsletter #7 - September 5
Newsletter #6 - August 16
Newsletter #5 - August 1
Newsletter #4 - July 18

Newsletter #3 - July 5
Newsletter #2 - June 21
Newsletter #1 - June 6

Below: A bumble bee spotted on a sunflower at the Colorado State University Foothills Campus in September. Photo: Lisa Mason

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A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #9

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Happy Holidays from Native Bee Watch!

Looking Forward to 2017

What a year! 2016 was the first year for Native Bee Watch and it was a very successful first season. All the data has been entered, and we are now processing and analyzing it. Thanks to your monitoring efforts, here are numbers at a glance:

- 4 months of monitoring
- 22 volunteers
- 60 monitoring sessions (34 included citizen scientists)
- Over 3,700 bees observed
- 1,630 lines of data in the spreadsheet

Preliminary results will be available later in the spring. Thank you for all your hard work throughout the past summer!

A Ghost in the Making: Rusty-Patched Bumble Bee

In the November newsletter,

there was a link about how the U.S. Fish and Wildlife service has proposed the Rusty-patched Bumble Bee should be listed on the Endangered Species List.

Citizen scientist and self-proclaimed "bee groupie" Linda shared the following video. Her friend, Clay is the producer and writer.

Summary:

Everyone has heard about bee declines, but with so much attention focused on domesticated honeybees, someone has to speak up for the 4,000 species of native bees in North America. Natural history photographer Clay Bolt is on a multi-year quest to tell the stories of our native bees, and one elusive species – the Rusty-patched Bumble Bee – has become his white whale.

Traveling from state to state in search of the Rusty-patched, he meets the scientists and conservationists working tirelessly to preserve it. Clay's journey finally brings him to Wisconsin, where he comes face to face with his quarry and discovers an answer to the question that has been nagging him: why save a species?

This is a lovely 20-minute video to share with your family and friends. Check out RustyPatched.com.

Buzzing Information on Bees

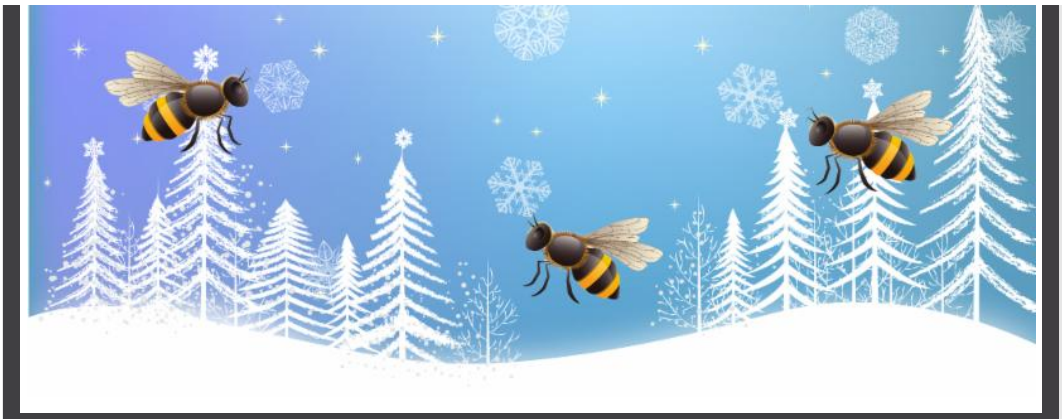
6 Scientists, 1,000 Miles, 1 Prize: The Arctic Bumblebee. Think Colorado is chilly? Can you imagine being a ground-nesting bumble bee living in the Arctic?

City Bees Are Actually More Diverse Than Country Bees. A study in the U.K. finds that bee diversity is higher in urban areas than in farmland and nature preserves.

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com. Previous newsletters are also here:

Newsletter #8 - November 29
Newsletter #7 - September 5
Newsletter #6 - August 16
Newsletter #5 - August 1
Newsletter #4 - July 18
Newsletter #3 - July 5
Newsletter #2 - June 21
Newsletter #1 - June 6



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A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #10

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Happy New Year from Native Bee Watch!

The Beauty of Pollination

Got the winter blues? Here is a reminder that spring is coming and pollinators will soon be out and about! This is a beautiful TED Talk by Louie Schwartzberg. He is a filmmaker with a passion for pollinators. If you enjoy this video, I recommend watching Disney Nature's Wings of Life, currently available on Netflix.

This orchid bee pokes his head through the petals of a bucket orchid revealing himself to the bright sunlight of Santa Rita, Panama.

The Rusty-Patched Bumble Bee is Protected!

The U.S. Fish and Wildlife Service released their final rule on listing the rusty-patched bumble bee (*Bombus affinis)*—and they will

be protecting it under the Endangered Species Act! Check out more information at The Xerces Society. You can also view the U.S. Fish and Wildlife Service final rule in the Federal Register.

Buzzing Information on Bees

Scientists Consider Potential of Honey Bee Brood as Food Source. Have you ever thought of honey bee brood as a tasty snack? You could be part of the the 2 billion people around the world that eat insects, a practice called entomophagy. Insects are high in protein and other nutrients, honey bee brood included.

Alzheimer's Cure: Honeybee Brains And Memories Give Clue For Dementia Treatment. From the article: "Honey bees can form complex memories through processes much like those happening in human brains. But, the honeybee brain is simpler and they have a smaller genome. This makes them an ideal model for investigating how the different processes needed for long-term memories happen."

Native Plant Events Coming Up

Interested in adding more native plants to your garden this year? Check out this upcoming webinar!

Native Plants for Every Landscape Situation - March 16th, 12-1pm, taught by Irene Shonle, CSU native plant expert

A full list of events by CSU Extension's Native Plant Master Program is here.

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com. Previous newsletters are also here:

Newsletter #9 - December 14
Newsletter #8 - November 29
Newsletter #7 - September 5
Newsletter #6 - August 16
Newsletter #5 - August 1
Newsletter #4 - July 18
Newsletter #3 - July 5
Newsletter #2 - June 21
Newsletter #1 - June 6

Two bees in the Megachilidae family (leaf cutter and mason bees) at the Gardens at Spring Creek.

Photo: Lisa Mason

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A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #11

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Happy Valentine's Day from Native Bee Watch!

The Tale of the Yucca Plant and Yucca Moth

The yucca moth (*Tegeticula* spp.) and the yucca plant (*Yucca* spp.) cannot survive without the other. This symbiotic relationship has coevolved over millions of years.

Yucca moths nest underground near yucca plants. They stay in cocoons for up to three years. The moths emerge from their cocoons at the same time the yucca plant blooms.

In addition, the female moth will intentionally collect pollen from one yucca plant and place it on the stigma of another yucca plant. (The stigma is the female part of a flower that collects the pollen to develop into fruit or seeds.) Most insects

will not intentionally pollinate; the pollen sticks to their bodies and transfers to the next plant.

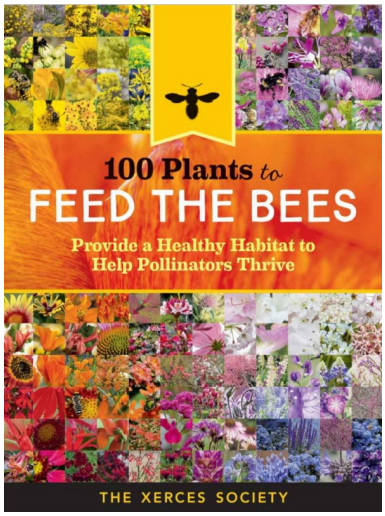
After pollinating the yucca plant, the female moth will lay an egg in the ovary of the yucca flower. The egg hatches and the larvae feed on the growing seeds. They don't consume all the seeds so that the plant will still have seeds to reproduce. The female moth also releases a pheromone so that other moths know that this yucca is taken and can't hold more eggs.

We thought a symbiotic pollinator relationship was the perfect highlight for our February newsletter!

Source: Yuccas, Yucca Moths, and Coevolution: A Review and The Yucca and its Moth
Photo: Betsy Betros, BugGuide.net

Book Review: *100 Plants to Feed the Bees*

The Xerces Society published a new book in December called 100 Plants to Feed the Bees. For each of the 100 plants, the book covers the plant's native range, growing requirements, plant uses and notable flower visitors. It is an easy-to-use field guide for a beginner researching plants to attract pollinators. Each plant has icons for the common pollinators, which can include honey bees, native bees, hummingbirds, butterflies, and moths. The range covers the United States and Canada, so not all of the plants in the book are native to Colorado. This book is a great resource for assembling pollinator plant ideas.



Buzzing Information on Bees

This Drone Can Do the Work of Honeybees
Researchers in Japan have developed a drone to pollinate flowers. They used horse hair to mimic hairs on bee bodies. The horse hair in combination of a gel adhesive was attached to a drone to pollinate.

Dead Bees Washing Up on Naples Beach
Last week, bees started washing up on the beach. Scientists are unsure why.

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com. Previous newsletters are also here:

- Newsletter #10 - January 24, 2017
- Newsletter #9 - December 14, 2016
- Newsletter #8 - November 29, 2016
- Newsletter #7 - September 5, 2016
- Newsletter #6 - August 16, 2016
- Newsletter #5 - August 1, 2016
- Newsletter #4 - July 18, 2016
- Newsletter #3 - July 5, 2016
- Newsletter #2 - June 2, 2016
- Newsletter #1 - June 6, 2016

A green metallic sweat bee (Agapostemon sp.) on a purple coneflower at the Gardens at Spring Creek, July 2016. Photo: Lisa Mason

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Native Bee Watch Newsletter #11

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Visit our Website

The Rusty Patched Bumble Bee is Officially Protected!

The Rusty Patched Bumble Bee is the first bee in the continental United States to become an endangered species.

Announced on the first day of spring, March 21, 2017, the Rusty Patched Bumble Bee is now protected under the Endangered Species Act. In their press release, The Xereces Society wrote: "This historic moment comes as a result of a listing petition filed by the Xerces Society for Invertebrate Conservation. Steps can now be taken to work toward the recovery of this species, which previously was common from Minnesota to the Atlantic." (Read more)

Source: The Xerces Society
Photo: Clay Bolt

Bee Educated Before Planting Just Any Wildflower Seeds

Many of you saw the announcement from General Mills (Honey Nut Cheerios) that it has given away 1.5 billion wildflower seeds across the country.

Some of you may have requested wildflower seeds. While it is great they are raising awareness for bees and encouraging people to create pollinator habitat, they are sending out seeds that may contain invasive species in some areas. Different plants are native to different regions and grow differently depending on the climate, soil, etc. It is best to do research on what is native and grows well in your area. Be sure to avoid invasive species!

What is the difference between non-native and invasive?

An invasive species is a non-native species that has been found to cause economic, environmental, or human harm. Here is a list of what NOT to plant in Colorado.

A non-native plant is a species that was introduced, but does not cause harm. Many common perennials are non-native to Colorado and readily available.

How do you know what to plant? Native plants are a great place to start because they are adapted to grow well in Colorado and many of them attract pollinators. The Xerces Society has a list of websites and resources specifically for Colorado and the Rocky Mountain Region.

Happy spring planting!

Photo: Micaela Truslove

Buzzing Information on Bees

Bees learn new tricks from one another
Bumble bees were taught to do a task with a sugar reward. They improved on that task after watching other bumble bees complete the same task. This study shows that bees may have more cognitive abilities than we originally thought.

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com. Previous newsletters are also here:

- Newsletter #11 - February 14, 2017
- Newsletter #10 - January 24, 2017
- Newsletter #9 - December 14, 2016
- Newsletter #8 - November 29, 2016
- Newsletter #7 - September 5, 2016
- Newsletter #6 - August 16, 2016
- Newsletter #5 - August 1, 2016
- Newsletter #4 - July 18, 2016
- Newsletter #3 - July 5, 2016
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- Newsletter #1 - June 6, 2016

Photo: Micaela Truslove

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A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #13

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Visit our Website

Help Us Monitor Bees!

Interested in being a citizen scientist? Want to know more about bees in your community? Sign up to monitor bees this summer! Applications are available here. First-time visitors will need to create an account through the City of Fort Collins volunteer program. This is the same application to also monitor birds and butterflies with the City of Fort Collins Nature in the City program if you are interested.

Applications are due by May 1st!

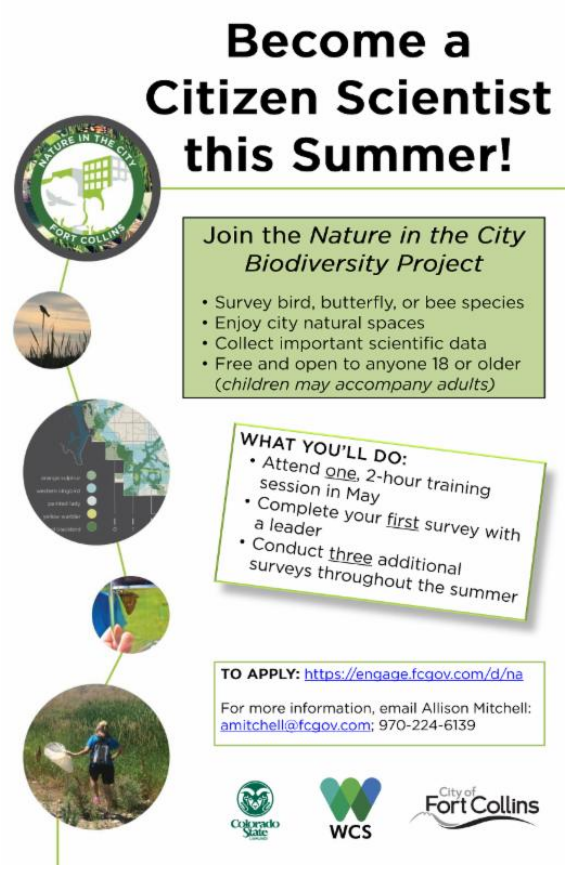
To monitor bees this summer, you are required to:

- Attend ONE of two training sessions on Saturday, May

20th from 9-11am OR Thursday, May 25th from 6-8pm. Both sessions are at Nix Farm Natural Area at 1745 Hoffman Mill Rd, Fort Collins.

- Commit to monitoring bees four times throughout the summer (June - September). Each monitoring sessions will be two hours from 9-11am.

Please forward this email on to anyone who might be interested in learning more about bees! Email Lisa if you have any questions at Lisa.Mason@ColoState.edu. Looking forward to another great season of bee monitoring!



Citizen science volunteer monitoring bees at the Gardens at Spring Creek last summer. Photos: Lisa Mason

Buzzing Information on Bees

What's the buzz? Over 1 million bees worth €15,000 stolen in Austria. Thieves stole more than one million bees from beehives in the small Austrian town.

MSU study: Montana has more bumble bee species than any other state. A new study shows 28 species of *Bombus* have been documented in Montana.

A girl and her bees. A young Girl Scout implements a project to install leaf cutter bee nests in her hometown.

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com. Previous newsletters are also here:

- Newsletter #12 - March 24, 2017
- Newsletter #11 - February 14, 2017
- Newsletter #10 - January 24, 2017
- Newsletter #9 - December 14, 2016
- Newsletter #8 - November 29, 2016
- Newsletter #7 - September 5, 2016
- Newsletter #6 - August 16, 2016
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- Newsletter #1 - June 6, 2016

Photo: MaLisa Spring

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Last Day to Sign up for Bee Monitoring!

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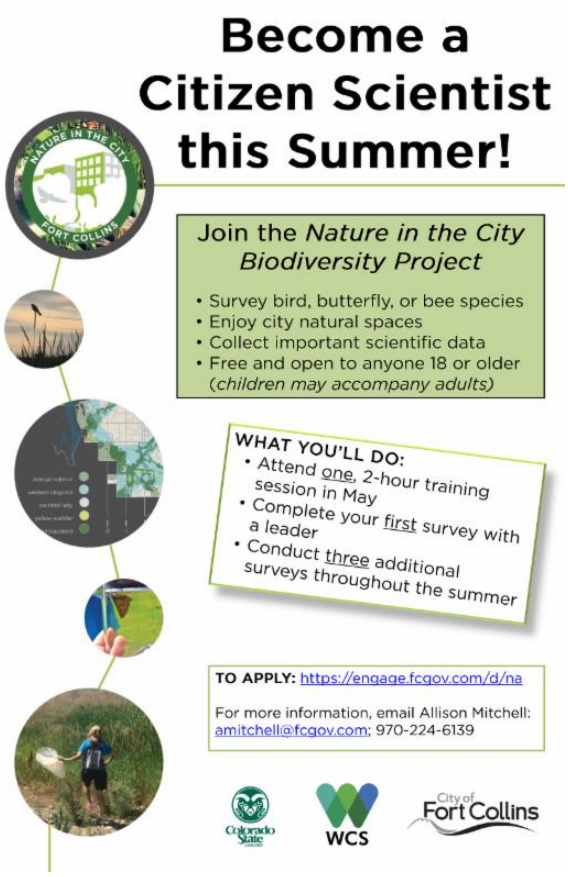

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A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #14

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

About Native Bee Watch

We have new bee-enthusiasts on the Native Bee Watch Newsletter, so I wanted to introduce myself.

My name is Lisa Mason and I am a graduate student at Colorado State University. I am pursuing my Master's Degree in entomology (the study of insects). I am passionate about pollinator conservation and thus started my research project -- Native Bee Watch.

Native Bee Watch is a research and citizen science program that monitors bees. Currently, we are monitoring in Fort Collins, but we may expand in the future. The goal with monitoring is to determine how urban areas are impacting bee populations. In the future, we hope to make recommendations to homeowners and city planners on how to create bee biodiversity hotspots in urban areas.

This project is part of CSU's Pollination Biology Lab. You will meet many of the lab members this summer if you are bee monitoring. To learn more about our lab, visit the Pollination Biology Lab website.

I am so excited for everyone that signed up to monitor bees this summer! We are going to have a fun, educational summer.

The bees are already out! I stopped by the Gardens at Spring Creek this morning, and saw two *Halictus* sp. or striped sweat bees, four bumble bees with orange stripes (most likely *Bombus huntii* or *Bombus centralis*), and many honey bees!

We have about 30 volunteers participating in bee monitoring this summer. The training will be a valuable tool to help get you out in the field. (Details below).

Please let me know if you have any questions. I look forward to seeing you soon!

Lisa

Photo (above right): *Agapostemon* sp., Susan Ellis, Bugwood.org

Bee Monitoring Training

If you signed up to monitor bees this summer, here is a reminder about training:

****NOTE THE LOCATION CHANGE****

Saturday, May 20th from 9-11am at the Lory Student Center, rooms 304-306

OR

Thursday, May 25th from 6-8pm at the Lory Student Center, rooms 304-306

Thanks to the those that have RSVP'ed. If you haven't RSVP'ed, please email me as soon as possible.

The Lory Student Center is located at 1101 Center Ave Mall, Fort Collins, CO 80521. Here is a map. You can park on the north side in the engineering parking lot or west of Morgan Library in the library parking lot.

Volunteers studying bee specimens. Photo: Victoria Halligan

Dr. Arathi Seshadri showing the parts of a flower to volunteers. Photo: Lisa Mason

Buzzing Information on Bees

I-76 designated as new 'Colorado Pollinator Highway'. The new designation of I-76 from Denver to Nebraska is a way to raise awareness and educate people about how important pollinators are to the state. Here is the full House Joint Resolution 17-1029.

Why Honeybees Are Good at Grooming (It's All in the Hair). A one-minute video from the New York Times with great footage about honey grooming. You can see why bees are the most efficient pollinators!

Noise pollution from gas compressors changes abundance of insects, spiders. It would be interesting to know how noise pollution affects ground-nesting bees.

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com. Previous newsletters are also here:

- Newsletter #13 - April 17, 2017
- Newsletter #12 - March 24, 2017
- Newsletter #11 - February 14, 2017
- Newsletter #10 - January 24, 2017
- Newsletter #9 - December 14, 2016
- Newsletter #8 - November 29, 2016
- Newsletter #7 - September 5, 2016
- Newsletter #6 - August 16, 2016
- Newsletter #5 - August 1, 2016
- Newsletter #4 - July 18, 2016
- Newsletter #3 - July 5, 2016
- Newsletter #2 - June 2, 2016
- Newsletter #1 - June 6, 2016

Diadasia enavata on a coneflower. Photo: Diane Wilson

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #15

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Bee WILD for Pollinators!

Join us to celebrate pollinators at this free, educational event at Wolverine Farm Letterpress and Publick House on June 14th from 6-8 pm.

You will learn about:

- Honey bee health and nutrition
- How to create pollinator habitats in your own backyard

- Bee identification basics
- How to make bee homes
- Native plants and more!

Wolverine Farm Letterpress and Publick House is a non-profit that helps to host and organize community events and projects. They graciously donated the space for us to hold this event. You can support them by purchasing drinks and snacks at the event.

Bring your friends and family!

Bee Monitoring Schedule - Week of June 4th

Wednesday, June 7th - Gardens at Spring Creek

- Diana D.
- Julia M.
- OPEN SLOT
- OPEN SLOT

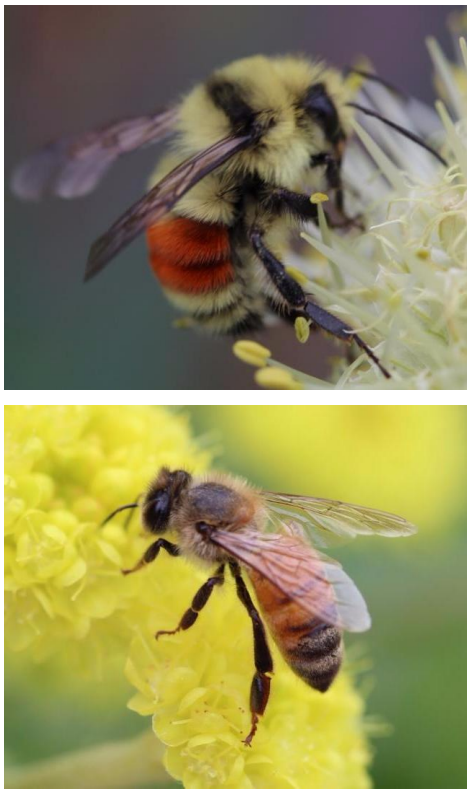
Thursday, June 8th - Trial Gardens

- Julia M.
- Sunny H.
- OPEN SLOT
- OPEN SLOT

Friday, June 9th - Nix Farm

- Kandice D.
- Suzy D.
- OPEN SLOT
- OPEN SLOT

We need more volunteers to monitor next week! Email Lisa if you are available at Lisa.Mason@colostate.edu



A bumble bee (top) and a honey bee (bottom) at the Gardens at Spring Creek on May 29, 2017. Photos: Lisa Mason

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More Citizen Science Sessions Available!

Need to sign up for monitoring sessions? There are more sessions available than there were at the training.

Click here to look at the calendar.

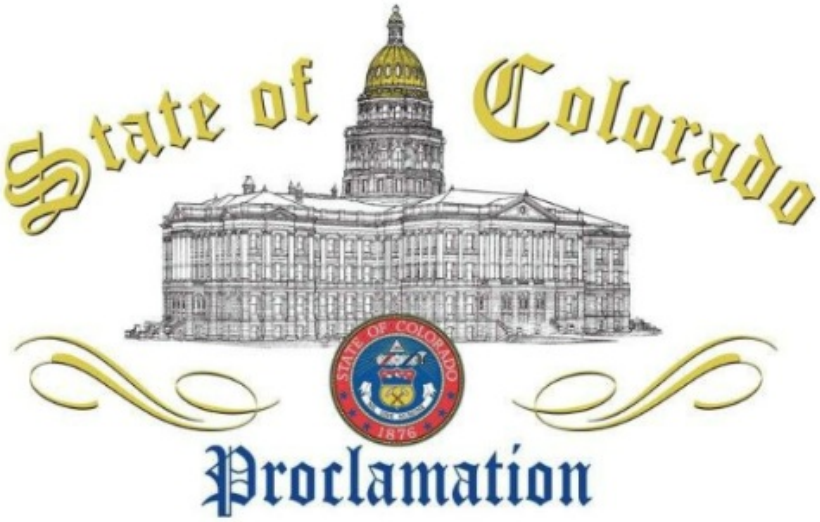
Please email Lisa with the dates you would like to monitor.

If you monitored bees last summer, you can add additional monitoring sessions to the calendar. Just let Lisa know the day and the garden.

Buzzing Information on Bees

Bees and butterflies continue to add political buzz, as Colorado governor gives them a June

commemoration. June is Pollinator Month in Colorado! How will you celebrate pollinators?



Proclamation

WHEREAS, pollinators, such as bees, butterflies, and birds, are vital to our ecosystem health and are essential in producing much of our food supply; and

WHEREAS, native pollinators, as well as honeybees and beekeepers, provide pollination services across our state, supporting our agriculture, which provide millions of dollars in services to our economy; and

WHEREAS, pollinators provide significant ecosystem benefits that are essential to maintaining the diversity of our native flowering plants; and

WHEREAS, Colorado has high diversity of native bees which in partnership with honey bees and beekeepers are highly efficient pollinators of our flowers, vegetables, and fruits; and

WHEREAS, pollinator populations are in decline and require an "all hands on deck" approach to providing a healthy, diverse habitat in our state, and raising public awareness is key to protecting pollinators; and

WHEREAS, Coloradans are encouraging conservation measures that promote the protection and maintenance of pollinator habitat;

Therefore, I, John W. Hickenlooper, Governor of the entire State of Colorado, do hereby proclaim, forever after, June 2017, as

POLLINATOR MONTH

in the State of Colorado.

GIVEN under my hand and the Executive Seal of the State of Colorado, this first day of June, 2017

John W. Hickenlooper
Governor

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com. Previous newsletters are also here:

- Newsletter #14 - May 19, 2017
- Newsletter #13 - April 17, 2017
- Newsletter #12 - March 24, 2017
- Newsletter #11 - February 14, 2017
- Newsletter #10 - January 24, 2017
- Newsletter #9 - December 14, 2016
- Newsletter #8 - November 29, 2016
- Newsletter #7 - September 5, 2016
- Newsletter #6 - August 16, 2016
- Newsletter #5 - August 1, 2016
- Newsletter #4 - July 18, 2016
- Newsletter #3 - July 5, 2016
- Newsletter #2 - June 2, 2016
- Newsletter #1 - June 6, 2016

A bee in the "Tiny Dark Bee" category at the CSU Trial Gardens on June 2, 2017. Photo: Lisa Mason

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #16

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Bee WILD for Pollinators!

Thank you all for coming out to Wolverine Farm Letterpress and Publick House on June 14th to learn about bees and pollinators! We hope you learned new information and will be an advocate for pollinators! Happy Colorado Pollinator Month!

Bee Monitoring Schedule - Week of June 4th

Thursday, June 22nd - Gardens at Spring Creek

- Diana D.
- Rosemary L.
- Ellen H.
- Jud H.

Friday, June 23rd - Trial Gardens

- Lori N.
- Ashley C.
- Meg G.
- OPEN SLOT FOR VOLUNTEER

Saturday, June 24th - Nix Farm

- Susan H.
- Kevin B.
- Cassie M.
- Kathy K.

Saturday, June 24th - Gardens at Spring Creek

- Rosemary L. (Citizen Science Leader)
- Sara White

We have one space left for a volunteer to sign up on Friday! Email Lisa if you are available at Lisa.Mason@colostate.edu

A striped sweat bee (top) at Nix Farm and volunteers monitoring at Nix Farm (bottom). Photos: Lisa Mason

More Citizen Science Sessions Available!

Need to sign up for monitoring sessions? Click here to look at the calendar.

Please email Lisa with the dates you would like to monitor.

If you monitored bees last summer, you can add additional monitoring sessions to the calendar. Just let Lisa know the day and the garden.

Bee of the Week - Squash Bees

Family - Apidae

Genus - *Peponapis* sp.

Peponapis sp. are referred to as squash bees because they're commonly found foraging for pollen and nectar in the flowers of squash plants. They can be spotted very early in the morning collecting right as the squash plants flower, often before daylight. They use their sense of smell to find flowers in the near-dark. By midmorning the squash flowers will have wilted and the females will go back to their nests. If you peel open a wilted squash flower you may find several male *Peponapis* sp. nested at the flowers base! *Peponapis* sp. are solitary bees but typically groups will cluster around their host squash plants and nest in the ground nearby.

Photo: *Peponapis pruinosa* in a squash plant. Credit: Tabby

Plant of the Week - Silver Fountain Butterfly Bush

Scientific name: *Buddleia alternifolia 'Argentea'*

The Silver Fountain butterfly bush is a very popular beautiful large shrub that blooms around mid-spring with lavender to violet flowers. When the blooms have wilted the plant still remains attractive because of its grey-green silver foliage. The silver fountain can reach heights of 12 to 15 feet and their width can be between 10 to 12 feet! Plant Select® recommends to not cut back all the way in the spring like other butterfly bushes but, instead to prune for shape and the size needed to fit your space. These lovely shrubs attract bees, butterflies, lady beetles, and moths. Some nectar feeding birds like orioles and bushtits forage on the flowers during the growing season too.

Click here for more information. Photo: Plant Select®

Missed a Newsletter or a Native Bee Watch Update?

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Previous newsletters are also here:

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- Newsletter #4 - July 18, 2016
- Newsletter #3 - July 5, 2016
- Newsletter #2 - June 2, 2016
- Newsletter #1 - June 6, 2016

A striped sweat bee at the Gardens on Spring Creek on June 7th. Photo: Lisa Mason

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com **Contact: Lisa Mason at** Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

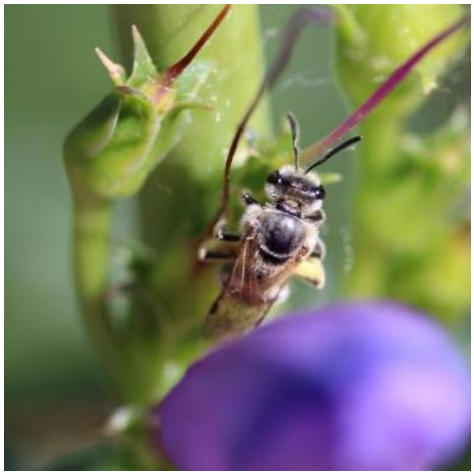
Native Bee Watch Newsletter #17

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Happy Independence Day! Have a safe, fun-filled holiday!

Bee Monitoring Schedule - Week of July 3rd



Wednesday, July 5th - Gardens at Spring Creek

- Kathy K.
- Ann D.
- Meg G.
- OPEN SPOT FOR VOLUNTEER

Thursday, July 6th - Trial Gardens

- Carole H.
- Harry R.
- Rebecca E.
- OPEN SPOT FOR VOLUNTEER

Friday, July 7th - Nix Farm

- Suzy D.
- Nicole D.
- OPEN SPOT FOR VOLUNTEER

- OPEN SPOT FOR VOLUNTEER

Saturday, July 8th - Gardens at Spring Creek

- Rosemary L. (Citizen Science Leader)
- Sunny H.

We have extra spaces left for a volunteer to sign up this week! Email Lisa if you are available at Lisa.Mason@colostate.edu

A striped sweat bee (top) at the Gardens on Spring Creek and Citizen Science Volunteer Nancy D. monitoring at Nix Farm (bottom). Photos: Lisa Mason

---

More Citizen Science Sessions Available!

Need to sign up for monitoring sessions? Click here to look at the calendar.

Please email Lisa with the dates you would like to monitor.

If you monitored bees last summer, you can add additional monitoring sessions to the calendar. Just let Lisa know the day and the garden.

Bee of the Week - Lithurgopsis sp. (i.e. cactus-foraging bees)

Family - Megachilidae

Genus - *Lithurgopsis* sp.

Cactus bees or *Lithurgopsis* sp. are specialists that only forage on cactus flowers. This is a symbiotic plant-pollinator relationship. Certain species of cacti close their anthers (the male reproductive part of the flower that produces the pollen) around the bee similar to fingers closing into a fist. *Lithurgopsis* bees can push through the anthers to collect pollen. Most other bees cannot do this! All *Lithurgopsis* sp. will bore into wood for their nests and make their own holes rather than finding preexisting holes. They will typically nest in rotting stumps or branches but can be found in door frames.

Source: The Bees in Your Backyard
Photo: *Lithurgopsis* sp. in a cactus plant in Mesa, Arizona. Credit: Lisa Mason

Plant of the Week - Colorado desert blue star

Scientific name: *Amsonia jonesii*

The Colorado desert blue star is native to Western America and thrives in ordinary gardens and unwatered xeriscape. The flowers are star shaped and beautiful sapphire blue.They will bloom from April to early summer at maturity reaching a height of 10 to 14 inches. Experts from Plant Select® recommend to start with a larger size plant if possible since this plant grows slowly. Click here for more information.

Source and photo: Plant Select®

What's the Buzz? Pollinators in the News

Do You Know Your Bees? There are over 4,000 bees in North America. Check out some neat photos of bees from The Weather Channel!

Report: Milkweed losses may not fully explain monarch butterfly declines. New research shows there may be other reasons for the decline.

Missed a Newsletter or a Native Bee Watch Update?

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Previous newsletters are also here:

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- Newsletter #15 - June 3, 2017
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- Newsletter #5 - August 1, 2016
- Newsletter #4 - July 18, 2016
- Newsletter #3 - July 5, 2016
- Newsletter #2 - June 2, 2016
- Newsletter #1 - June 6, 2016

Photo: Micaela Truslove

A striped sweat bee at the Gardens on Spring Creek on June 13th. Photo: Lisa Mason

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #18

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Quiz: What Kind of Bees?

(Left photo) Citizen scientists, Kathy and Lori, were bee monitoring at Nix Farm and captured this photo of a bee on a sunflower.

(Right photo) Citizen scientists, Kandice and Cassie, captured this photo at the Trial Gardens.

Quiz questions: To which category does these bees belong to?

Submit your answer here.

The answers will be provided in the next newsletter. Great photos! All volunteers can email photos to Lisa.Mason@Colostate.edu!

Bee Monitoring Schedule -

Week of July 17th

Four open slots available for volunteers this week! See below.

Wednesday, July 19th - Gardens at Spring Creek

- Carole H.
- Harry R.
- Nicole D.
- Aja M.

Friday, July 21st - Nix Farm

- Diana D.
- Greta D.
- OPEN SPOT FOR VOLUNTEER
- OPEN SPOT FOR VOLUNTEER

Saturday, July 22nd - Trial Gardens

- Suzy D.
- Jianjing Y.
- Sara W.
- Cassie M.

Additional Citizen Science Leader Sessions

Tuesday, July 18th - Nix Farm

- Lori N. (Citizen Science Leader)
- OPEN SPOT FOR VOLUNTEER

Thursday, July 20th - Nix Farm

- Lori N. (Citizen Science Leader)
- OPEN SPOT FOR VOLUNTEER

We have extra spaces left for a volunteer to sign up this week! Email Lisa if you are available at Lisa.Mason@colostate.edu

Volunteers (top) at the Gardens on Spring Creek and an *Anthidium* sp. of bee that falls into the hairy belly bee group (bottom). Photos: Lisa Mason

More Citizen Science Sessions Available!

Need to sign up for monitoring sessions? Click here to look at the calendar.

Please email Lisa with the dates you would like to monitor.

If you monitored bees last summer, you can add additional monitoring sessions to the calendar. Just let Lisa know the day and the garden.

Bee of the Week - Carpenter Bees

Family - Apidae

Genus - *Xylocopa sp.*

Although this bee does not occur in Colorado, the carpenter bee is an

interesting bee to learn about! They are large, dark-colored bees that often nest in wood where they chew huge holes to make nests for their young. Around the world, 500 species are known but only 10 species are found in the United States and Canada. They're generalists meaning they will forage on a variety of flowers but, like many generalist bees, they will consistently visit the same type of flowers in succession. Their nests, called galleries, are typically in dead wood or plant stems like reeds or bamboo. They are often considered a nuisance in other parts of the country because they nest in the wood of houses and infrastructure.

Source: The Bees in Your Backyard
Photo: Donna K. Race, BugGuide.Net

Plant of the Week - Remembrance® Columbine

Scientific name: *Aquilegia 'Swan Violet & White'*

TheRemembrance® Columbine is a hybrid derived from the Colorado state flower. Thepetals and spurs are a beautiful violet-blue color. The name honors the memoryof the students and teachers of Columbine High School. Proceeds from purchasingthis flower from Plant Select® will benefit organizations that promote diversityand tolerance in schools. Experts at Plant Select® recommend removing the spentflowers (already pollinated) in late June to encourage longer blooming. Foliagewill often decline in mid-summer so cutting it back to the ground will allow itto regrow for fall. The plant usually grows 18-24 inches tall, needs partialsun and a moderate amount of water. Click here for more information.

Source and photo: Plant Select®

What's the Buzz? Pollinators in the News

Unlocking the Secrets Behind the Hummingbird's Frenzy. Hummingbirds are important pollinators! Learn more about some recent research on how hummingbirds do what they do.

Goal! Bees can learn ball skills from watching each other, study finds. Bees are better at problem solving than previously thought!

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on

the website
at nativebeewatch.wordpress.com.

Previous newsletters are also here:

- Newsletter #17 - July 4, 2017
- Newsletter #16 - June 20, 2017
- Newsletter #15 - June 3, 2017
- Newsletter #14 - May 19, 2017
- Newsletter #13 - April 17, 2017
- Newsletter #12 - March 24, 2017
- Newsletter #11 - February 14, 2017
- Newsletter #10 - January 24, 2017
- Newsletter #9 - December 14, 2016
- Newsletter #8 - November 29, 2016
- Newsletter #7 - September 5, 2016
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- Newsletter #5 - August 1, 2016
- Newsletter #4 - July 18, 2016
- Newsletter #3 - July 5, 2016
- Newsletter #2 - June 2, 2016
- Newsletter #1 - June 6, 2016

Photo: Micaela Truslove

A hairy leg bee at the Gardens on Spring Creek in early July, 2017. Photo: Lisa Mason

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #19

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Quiz Answers: What Kind of Bees?

The hairy leg bee group has a a lot of variation in colors, size, antennae, and hairiness between hairy leg bees. Note the thick, pollen collecting hairs on the hind legs of both bees.

Thank you for sending photos! Keep them coming!

This bee belongs in the hairy leg bee group! It belongs to the genus *Diadasia*.
Photo: Kathy Keck and Lori Nixon

This bee also belongs in the hairy leg bee group! The bee belongs to the genus *Melissodes. It is most likely Melissodes bimaculatus.* Photo: Kandice Dixon and Cassie Mattson

****Citizen Scientists Needed August and September!****

There are MANY open spots in August and September. Please look at your calendar and sign up!

Click here to look at the calendar.

Please email Lisa with the dates you would like to monitor.

If you monitored bees last summer, you can add additional monitoring sessions to the calendar. Just let Lisa know the day and the garden.

Bee Monitoring Schedule - Week of July 31st

Two open slots available for volunteers this week! See below.

Thursday, August 3rd - Gardens at Spring Creek

- Greta D.
- Kathy K.
- Meg G.
- Rebecca E.

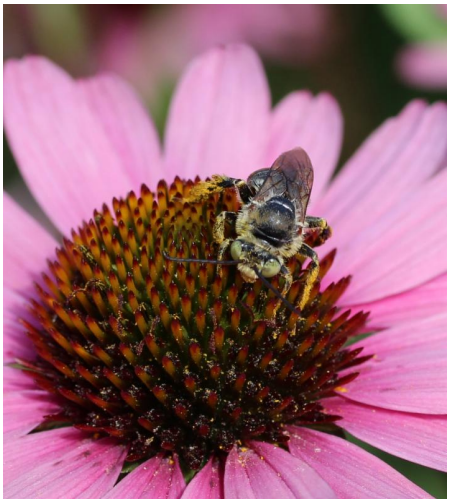
Friday, August 4th - Nix Farm

- Lori N.
- Kathy K.
- OPEN SPOT FOR VOLUNTEER
- OPEN SPOT FOR VOLUNTEER

Saturday, August 5th - Trial Gardens

- Sara W.
- Jianjing Y.
- Kevin B.
- Susan H.

We have extra spaces left for a volunteer to sign up this week! Email Lisa if you are available at Lisa.Mason@colostate.edu



Volunteers (top) at the Gardens on Spring Creek and a bee in the hairy leg bee group (bottom) also at the Gardens on Spring Creek. Photos: Lisa Mason

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Volunteer Spotlight: Meet Kathy!

Kathy is a new volunteer this summer and she has already monitored 6 times! If you have monitored with Kathy, you know there will be great conversation and laughs. Here is a little more about Kathy:

What is your background?

I was in the hospitality industry in the mountains for 30 years. We moved to Fort Collins a couple years ago.

Why do you enjoy volunteering?

It's so great to be able meet so many people with similar interests and follow my passion for learning all about the natural world. So many thanks to CSU, Fort Collins Natural Areas and all the entities that provide all the opportunities to those of us who lack the formal training in these areas but are willing to let us get involved.

What is your favorite bee?

Bumbles are the cutest but honey bees have some great lessons to teach us.

What is the coolest thing you have seen so far this summer?

Lisa and her team's enthusiasm and willingness to share their knowledge! And of course all of the bees and how they all coexist...what amazing, beautiful creatures.

Bee of the Week - *Calliopsis* Bees

Family - Andrenidae

Genus - *Calliopsis sp.*

Calliopsis sp. are part of the Andrenidae family of bees called mining bees. They are called mining bees because they nest underground. Their underground nests are waterproof from a substance that is secreted by the female bee. *Calliopsis* bees use the same substance to waterproof the bee bread (the pollen and nectar ball for the growing larva).

Calliopsis sp. can be found buzzing around in the summer and fall in dry areas of North and South America. The majority of species are found in Mexico. There are 11 species that have been documented in Colorado.

They are not generalists bees, meaning they only pollinate specific plant species. Some species of *Calliopsis* only forage on one specific genus of flowering plants. Others will forage on on a few genera of flowering plants.

Calliopsis sp. have a unique adaptation called bet-hedging that allows them to survive in drought areas. If the area has experienced very little moisture, there may not be enough foraging resources for the bees. Some of the bees will actually wait another year or more to emerge, when drought conditions have subsided and there is more of a guarantee for floral resources.

They have vibrant yellow bands going across their abdomen, but they are hard to identify based on observation only. You would need a microscope to get an accurate identification.

Source: The Bees in Your Backyard, The Bees of Colorado
Photo: Hartmut Wisch, BugGuide.Net

Plant of the Week - Winecups

Scientific name: *Callirhoe involucrata*

Winecups are a native Colorado plant seen throughout Fort Collins. They flourish in xeriscape gardens and are indigenous to a variety of landscapes including dry meadows, along rocky banks of water, and prairies. This ground cover plant enjoys the full-sun and is drought tolerant. It will bloom wine-colored red flowers from late spring to early summer. The experts at Plant Select® recommend using less water and pinching back to help the plant stay more compact and not spread out as much. They're able to self-seed quickly so removing any seedlings while they're young will help keep the plant contained. Click here for more information.

Source and photo: Plant Select®

What's the Buzz? Pollinators in the News

Monarch butterfly, Western honeybee star on new stamps highlighting pollinator protection. When you buy stamps, pick the Protect Pollinators collection!

NPR: No Offense, American Bees, But Your Sperm Isn't Cutting It. Researchers at Washington State University hope a deeper gene pool will give a new generation of honeybees much-needed genetic traits.

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com.

Previous newsletters are also here:

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- Newsletter #4 - July 18, 2016
- Newsletter #3 - July 5, 2016
- Newsletter #2 - June 2, 2016
- Newsletter #1 - June 6, 2016

Photo: Micaela Truslove

A striped sweat bee on Lindheimer's beeblossom at the Gardens on Spring Creek in late July, 2017. Photo: Lisa Mason

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

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A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #20

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Bee Monitoring Schedule - Week of August 27th

Open spots for volunteers! Please sign up!

Wednesday, August 30th - Gardens at Spring Creek

- Nicole D.
- Kathy K.
- OPEN SPOT FOR VOLUNTEER
- OPEN SPOT FOR VOLUNTEER

Thursday, August 31st - Trial Gardens

- Megan M.
- Kathy K.
- OPEN SPOT FOR VOLUNTEER
- OPEN SPOT FOR VOLUNTEER
-

Friday, September 1st - Nix Farm

- Suzy D.
- Patrick H.
- OPEN SPOT FOR VOLUNTEER
- OPEN SPOT FOR VOLUNTEER

Email Lisa if you are available at Lisa.Mason@colostate.edu

Volunteers monitoring at the Trial Photos: Lisa Mason

Volunteer Spotlight: Meet Kandice!

Kandice is monitoring bees for a second summer! She is full of energy and always eager to learn more. Here is a little more about Kandice:

What is your background?

I am originally from Massachusetts and came to Colorado to go to school, and 20 years later, I am still here and still in school! I have a degree in Animal Science from CSU and spent time working in the dairy world and then doing a wide array of biomedical and toxicology research. But recently I switched gears and am a phlebotomist for UCHealth and studying to become a Medical Laboratory Technician, so I can work in a hospital lab.

Why do you enjoy volunteering?

Why not spend a couple hours outside, enjoying the sun, looking at cool bugs, and beautiful flowers? Who wouldn't want to do that? When Lisa first told me about her project, I thought it sounded awesome and of course I wanted to help. The bee project has been a lot of fun and I've learned a bunch! I love the premise behind the citizen science project and feel it is a GREAT asset to the community.

What is your favorite bee?

Orange banded bumble bee!! Love them!!

What is the coolest thing you have seen so far this summer?

At the CSU Trial Garden we saw the largest hairy leg bee I had ever seen! All black with it's scopa full of pollen. It was super cool to see flying around! But every time I go out, there's something different: hummingbirds, beetles, or grasshoppers. It's always fun.

Bee of the Week - European wool carder bee

Family - Megachilidae

Scientific Name- *Anthidium manicatum*

One characteristic that bees in the Megachilidae family (leafcutter, resin and mason bees) share is the special pollen-collecting hairs on the underside of their abdomen known as the scopa. When monitoring, we know this group as the hairy belly bee group. European wool carder bees are no exception. They have been frequent visitors this summer at all three gardens we are monitoring. This non-native bee scrapes the fine hairs off plants and uses them to line their cavity nest. Lamb's ear is a great example of a plant they use. Wool carder bees are polylectic and will forage on a variety of plant species.

Source: The Bees in Your Backyard
Photo: Micaela Truslove

Plant of the Week - Cashmere sage

Scientific name: *Phlomis cashmeriana*

This durable and large perennial flower is native to Kashmir and the Western Himalayas. The flowers bloom early in summer with beautiful lavender-pink blossoms that are arranged in tight whorls on thin stems. The plant can grow up to heights around 3' feet and widths around 18" inches across. Many bees, especially bumble bees have been spotted foraging on these beautiful flowers at the Trial Gardens! The experts at Plant Select® recommend using this plant to border traditional gardens due to its large size. Click here for more information.
Source and photo: Plant Select®

What's the Buzz? Pollinators in the News

An Alfalfa Leafcutting Bee's First Meal is a Big Deal. Nutrition during the leafcutter bee's larval stage determines whether the bee's life cycle continues that summer, or if the bee overwinters and emerges the following summer.

Missed a Newsletter or a Native Bee Watch Update?

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Photo: Micaela Truslove

A striped sweat bee on blue mist spirea flowers at the Gardens on Spring Creek in late July, 2017. Photo: Lisa Mason

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #21

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Bee Monitoring Schedule - Week of September 10th

Open spots for volunteers! Please sign up!

Wednesday, September 13th - Gardens at Spring Creek

- Nicole D.
- Megan M.
- OPEN SPOT FOR VOLUNTEER
- OPEN SPOT FOR VOLUNTEER

Thursday, September 14th - Trial Gardens

- OPEN SPOT FOR VOLUNTEER
- OPEN SPOT FOR VOLUNTEER
- OPEN SPOT FOR VOLUNTEER
- OPEN SPOT FOR VOLUNTEER
-

Friday, September 15th - Nix Farm

- Suzy D.
- Megan M.
- OPEN SPOT FOR VOLUNTEER
- OPEN SPOT FOR VOLUNTEER

Email Lisa if you are available at Lisa.Mason@colostate.edu

(Top) Nicole and Kathy monitoring at the Gardens on Spring Creek. (Bottom) Aja and Suzy monitoring at Nix Farm. Photos: Lisa Mason

Kathy Wins Award for Most Bee Monitoring Sessions

Thank you to everyone who joined us at the Volunteer Appreciation Dinner. We had a great time sharing stories and talking about all the accomplishments from this summer.

Kathy was awarded a certificate for completing the most bee monitoring sessions this summer! She volunteered 12 times! That is about 24 hours of bee monitoring time. Congratulations, Kathy! We appreciate all your time and hard work!

Kathy (left) and Nicole (right) showing her certificate at the Gardens on Spring Creek. Photo: Lisa Mason

Interesting Summer Sightings

Monarch butterfly (*Danaus plexippus*).

Spreadwing damselfly (Lestidae family).

Sand wasp (*Bembix* sp.).

Photos by Lisa Mason at the Gardens on Spring Creek.

Woodland skipper (*Ochlodes sylvanoides*).

Bee of the Week
- *Hylaeus* bees

Family - Colletidae

Scientific Name- *Hylaeus* spp.

Hylaeus spp. are known as yellow-faced bees because of the yellow marks on their face and legs. There are 700 species of *Hylaeus* in the world, and 16 of those species are found in Colorado.

Hylaeus spp. are unique because they don't have any pollen-collecting hairs like most bees. At first glance, they almost look like wasps. Unlike other bees, the females feed on pollen and nectar and then regurgitate it at the nest site for the future young. They are solitary bees nesting in holes already created by other insects or inside twigs. Most of the species are found in forest ecosystems but are also found in urban areas.

Besides the rusty patched bumble bee, the only other bees listed on the endangered species list are seven species of *Hylaeus* only found in Hawaii. They were listed under the Endangered Species Act in 2016. Hawaii has over 60 *Hylaeus* species, but these seven species have small habitat ranges. With habitat loss, climate change, and a small habitat range, researchers believe other *Hylaeus* species have already gone extinct.

Source: The Bees in Your Backyard and The Bees of Colorado.
Photo: MaLisa Spring

Plant of the Week - Baby Blue rabbitbrush

Scientific name: *Chrysothamnus (Ericameria) nauseosus var. nauseosus*

Rabbitbrush (*Chrysothamnus* spp.) can easily be spotted this time of year and is a favorite of bees and butterflies since it provides food late in the season. A native Colorado plant, rabbitbrush has beautiful fall flowers that can continue blooming through November. This dwarf form of rabbitbrush is commonly found along the Front Range. It is a dense plant with silvery-blue leaves and bright yellow flowers. Rabbitbrush is drought, wind, and cold tolerant. If you plant Baby Blue rabbitbrush in your garden, it is recommended that you water it the first year until the plant is established. Do not water the plant after that. For more information, click here.
Source and photo: Plant Select®

What's the Buzz? Pollinators in the News

'Bee' informed: public interest exceeds understanding in bee conservation, says biologist. "A challenge with lack of knowledge about bees is you can't protect what you're now aware of," says Joseph Wilson, Utah State University. "We could be losing species or causing decline and not even know it."

No Flowers? No Problem. UF Study Shows Bees Have Other Ways of Finding Sugar. This research study shows that native bees can feed on honeydew, a sugary nectar produced by plant-feeding insects.

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Photo: Micaela Truslove

A green metallic sweat bee on spotted joe-pye weed at Nix Farm in September, 2017. Photo: Lisa Mason

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A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #22

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Bee Monitoring is Complete for 2017!

Last week was the final week for bee monitoring. Thank you all for your help collecting data! We hope you had an educational and fun summer! See you next summer!

Painted Lady Butterfly Migration in Colorado

Have you noticed all the painted lady butterflies recently? Painted ladies always migrate south this time of year. However, this year there are more than usual! Learn more about this year's migration here.

Painted lady butterflies are a fascinating species. They are one of the most widespread butterfly species in the world. They live on all continents except Antarctica and Australia. In Europe, painted ladies will migrate 9,000 miles over the course of about 6 generations. To learn more about painted lady butterflies, click here.

A painted lady butterfly on penstemon flowers at Nix Farm. Photo: Lisa Mason

Newsletter Correction: Monarch vs. Viceroy Butterflies

In the last newsletter, under the Interesting Summer Sightings, there was a picture of a butterfly labeled as a monarch. That was incorrect! The butterfly (pictured below), is actually a viceroy butterfly (*Limenitis archippus)*.

Why do these two butterflies look so much alike?

Monarch butterflies feed and host on milkweed plants (Asclepiadaceae family). Milkweed plants have a substance called cardenolides that make them toxic and taste badly to animals that prey on monarch caterpillars and butterflies. Predators associate the bright colors of monarch with the toxicity and poor taste. For a long time, it was thought that the viceroy butterfly mimicked the monarch butterfly to take advantage of this defense strategy. More recent research shows that the viceroy butterfly also tastes bad and can be toxic to predators. They mimic each other to warn predators to stay away.

While both species are in the caterpillar stage, they avoid predators too. Monarch caterpillars warn predators through their bright colors. Viceroy caterpillars look like bird feces and camouflage with their hosts (cottonwoods and willows).

How to identify a monarch versus a viceroy

Viceroy butterflies are a little smaller than monarchs. Also, there is a black circular line crossing the veins of the hindwing that is not present on a monarch butterfly. Curious to learn more? Test your knowledge here.

Viceroy butterfly (*Limenitis archippus)*. Photo: Lisa Mason

Monarch butterfly (*Danaus plexippus*). Photo: Kim Phillips, BugGuide.net

Viceroy caterpillar. Photo: Michelle Thibodeau, BugGuide.net

Monarch caterpillar. Photo: Lisa Mason

Bee of the Week - Green Metallic Sweat Bees

Family - Halictidae

Scientific Name- *Agapostemon spp.*

These medium sized bees are known for their noticeable bright green or blue coloration. They are found in the Western Hemisphere only but can be found at a variety of elevations, some at sea level and others above 10,000 ft. There are nine species in Colorado. They nest in the ground on hillsides, vertical banks, or on even-ground. The entrance to their nests are surrounded by a mound of dirt with a tunnel leading down to the nest. Although most nest individually, there are some species that nest communally. Females of those species still build their own individual nests for their own larvae and do not interact with others in the communal nest site. These bees don't have a floral preference but are commonly seen on plants in the sunflower family.

Source: The Bees in Your Backyard and The Bees of Colorado.
Photos: Lisa Mason

Plant of the Week - Cape-forget-me-not, Summer-forget-me-not

Scientific name: *Anchusa capensis*

A South African native, the Cape-forget-me-not, Summer-forget-me-not is a beautiful evergreen which produces vibrant blue flowers. This perennial grows to be about 12-16 inches tall, and produces flowers from May to October. Honey bees are frequently seen on the unmistakable dark blue flower with a white center. Plant Select recommends planting summer forget-me-nots in the center of flower garden as they like a bit of shade.
For more information, click here.
Source and photo: Plant Select®

What's the Buzz? Pollinators in the News

With Smart Planning, Coffee and Bees Can Survive Climate Change. In a new study, a Smithsonian scientist says coffee-growers have options.

The Secret Ingredient That Stops Honeybees From Becoming Queens. Researchers know that the honey bee larvae that feed on royal jelly, a substance secreted by nurse bees, will become a queen. New research shows that it is a combination of royal jelly and microRNA found in plants.

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Photo: Micaela Truslove

A painted lady butterfly (*Vanessa cardui) at the Gardens on Spring Creek.* Photo: Lisa Mason

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

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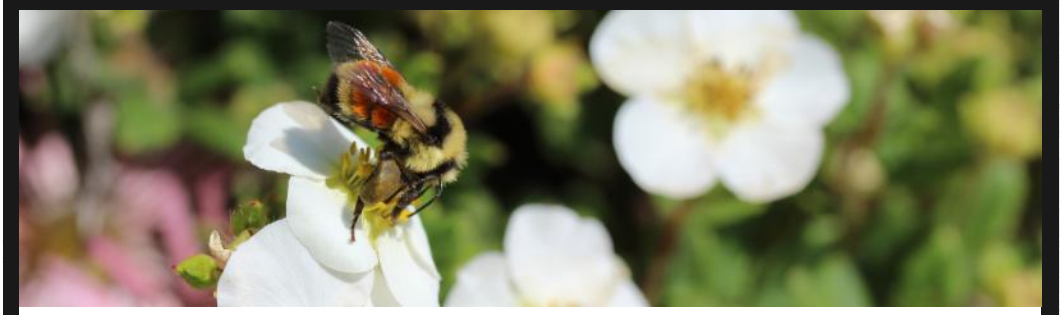

Native Bee Watch Newsletter #23

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

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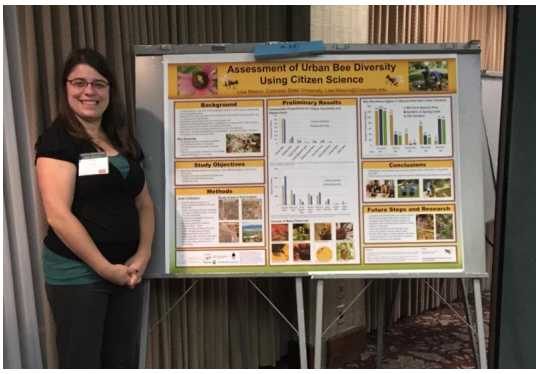
Protecting Pollinators in Urban Landscapes



This month I attended the Protecting Pollinators in Urban Landscapes conference in Traverse City, Michigan. This conference had sessions on research, management, outreach and advocacy on pollinators, especially native bees. I wanted to share some of the major take home messages that really stood out to me.

- We still need to increase conservation efforts for native bees and not only the honey bee.
- To protect bee diversity, we need to think about human diversity. Bee conservation needs to be inclusive and we need to get our messages out to people from all walks of life.
- Clean-cut, green-grass backyard lawns are like concrete for bees. We can create pollinator habitat and still have an aesthetically pleasing backyards. How do we get this message out?
- Everyone can make a difference in pollinator conservation! Even the smallest pollinator-friendly garden will help provide food, shelter and water for individual bees and other pollinators.

I presented a poster at the at the conference on the Native Bee Watch research project. I thoroughly enjoy talking about the research and the efforts of the citizen scientists that help make this project succeed! It was well-received and I talked to people that are curious about getting citizen scientists involved in their projects.

Thank you to all the citizen scientists involved in this project and for all of you being stewards for pollinators!

Why You Shouldn't Rake

the Leaves

Did you know that pollinators and other invertebrates rely on leaf material for winter cover?

Queen bumble bees in the soil and rely on leaves as an extra layer of protection. Many butterfly species make chrysalis in dead leaves that are camouflaged. The leave litter provides protection from predators. Many other invertebrates rely on leave litter for survival.

Leaf litter also has the same benefits as adding shredded mulch. It also can add nutrients to the soil.

Read more on Leave the Leaves! from the Xerces Society.

Personnel Update

Victoria Halligan will not be working with the CSU Pollination Biology lab anymore. Thank you, Victoria for your help in the field this summer and good luck in your future endeavors!

Bee of the Week - Striped Sweat Bees

Family - Halictidae

Scientific Name- Halictus spp.

Sweat bees received their name because they are often attracted to human sweat. Striped sweat bees are a widespread member of the sweat bee family, Halictidae and are one of the most abundant types of bees behind the honey bee. *Halictus* bees are ground nesters. Most are considered primitively eusocial, which means they have characteristics of both eusocial (i.e. honey bees) and solitary bees. Many species have been known to form colonies of several hundred bees. The color of *Halictus* bees varies. Some species in this genus have a distinctive metallic sheen ranging from gold to bright green. A white and black striped abdomen is common. They are polylectic meaning they will forage on a variety of plants. There are seven species found in Colorado.

Sources:

- Bees of the World 2nd edition
- Bees of Northwestern America
- The Bees in Your Backyard
- The Bees of Colorado

Photos: Lisa Mason

Plant of the Week -

Chocolate flower

Scientific name: *Berlandiera lyrata*

This perennial wildflower is native to the Southwest in North America and grows best in dry to xeric environments. These plants flower continuously with their yellow flowers from June until it frosts. They are good for pollination and typically grow between 12-20 inches both tall and wide. To grow them yourself, they do best with good drainage and soils that are not too high in organic materials. If you cut them back in July, it helps them bloom longer and avoids sprawling. Probably the coolest thing about them, is that they actually smell like chocolate in the mornings! For more information, click here.
Source and photo: Plant Select®

What's the Buzz? Pollinators in the News

Can You Pick the Bees Out of This Insect Lineup? Citizen Scientists - this should be easy! Test your knowledge on this New York Times quiz.

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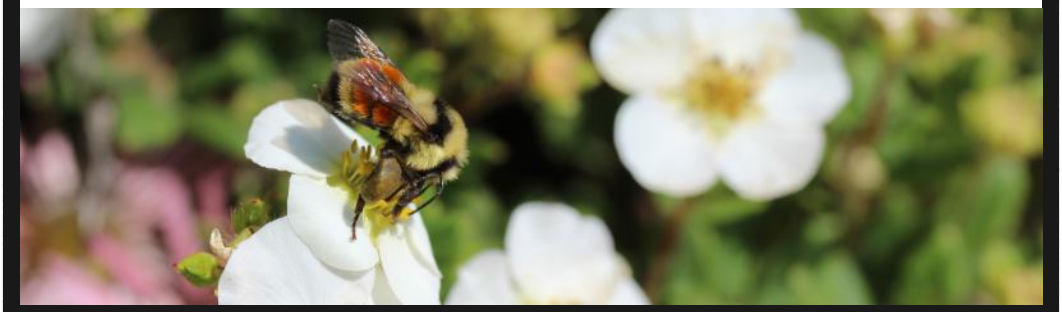
Photo: Micaela Truslove

A bumble bee, *Bombus huntii* at the Gardens on Spring Creek. Photo: Lisa Mason



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Native Bee Watch Newsletter #24

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Bee Thankful for Pollinators

There are so many things to be grateful for this holiday season including the meals we eat. Have you ever wondered how much of the food on the table we can thank pollinators for? Here is a list of common holiday menu items and who pollinates them:

- Almonds - Honey bees

- Apples - Honey bees, blue mason orchard bees
- Cardamom - Honey bees, solitary bees
- Chocolate - Bees, flies
- Coffee - Stingless bees, other bees, flies
- Cranberries - 40+ bee species
- Dairy - Dairy cows eat alfalfa pollinated by leaf cutter and honey bees
- Nutmeg - Honey bees, birds
- Peppermint - Bees, flies
- Pumpkin - Squash and gourd bees, bumble bees
- Sugar cane - Bees, thrips
- Vanilla - Bees

Source: The Pollinator Partnership
Photo: Lisa Mason

Bee of the Week - Hunt's Bumble Bee

Family - Apidae

Scientific Name- *Bombus huntii*

Hunt's bumble bee is a medium-tongued species that is medium-to-large, hairy, and native to North America. They live in high desert shrub habitats, prairies, and meadows and are common in urban areas. Hunt's bumble bee was the most commonly observed bumble bee by citizen scientists and researchers this past summer. They are generalist feeders, and they nest underground. Bumble bees in general are eusocial, which means they have a queen bee and worker bees. They also don't make honey, since they start new colonies each year. They use the nectar and pollen collected to feed their developing young. Bumble bees stay active in colder weather more than most bees and can carry more pollen, so they are more efficient pollinators. They are estimated to do eight times the amount of work that honey bees can do!

Source: The Bees in Your Backyard
Photo: Lisa Mason

Plant of the Week - RED ROCKS® penstemon

Scientific name: *Penstemon x mexicali 'P008S'*

RED ROCKS® penstemon is a perennial flower native to North America. It flowers from June to August and has bright pink flowers with dark green, narrow leaves. It grows 14-18 inches tall and 12-14 inches wide. Clay, loam or sandy soils are where this plant grows best, and it does not need a lot of water. If you want to grow these yourself, it helps to aerate the soil surrounding

these plants, but they are relatively easy and manageable to grow on your own! This plant is also deer-resistant. The hybrid plant was created by cross-breeding Mexican and American wild penstemons. This plant is great for pollinators! Honey bees and bumble bees are frequent visitors. For more information, click here.
Source and photo: Plant Select®

What's the Buzz? Pollinators in the News

The biggest collection of spiders in Colorado is built on citizen science. This may not be pollinator-related, but the Colorado Spider Survey is very impressive with over 38,000 specimens--the largest spider collection in Colorado.

Tiny bees play big part in secret sex lives of trees. New research shows how tiny bees are carrying pollen long distances. Pollen carried long distances can promote genetic diversity in trees, which is an essential component for plants to adapt with challenges such as disease and climate change.

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Photo: Micaela Truslove

- Newsletter #2 - June 2, 2016
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A bee in the hairy leg bee group on a sunflower at Nix Farm. Photo: Lisa Mason

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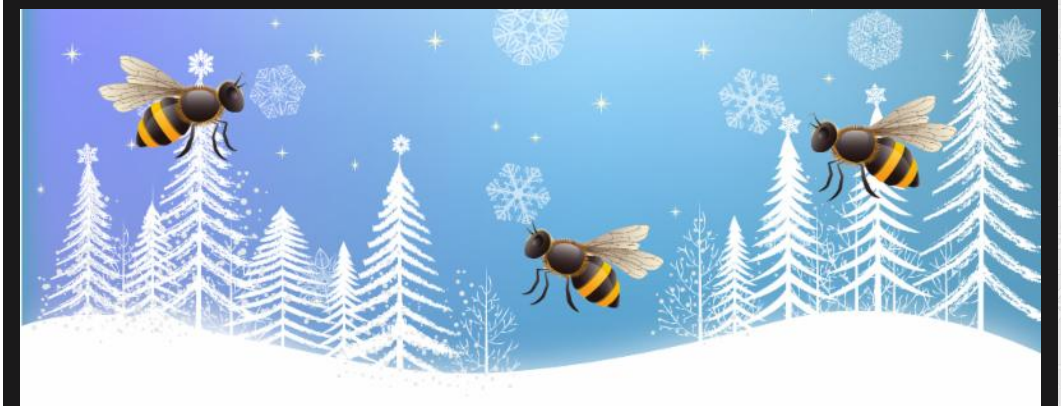

Native Bee Watch Newsletter #25

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Cheers to Pollinating Bats for Providing Tequila and So Much More!

Century plants (*Agave* sp.) are important for humans. Fibers used for textiles and paper can be obtained from agave leaves, which are an important export in some local

Mexican economies. The juice from *Agave tequilana* is used for tequila and exported worldwide.

We can thank long-nosed bats (*Leptonycteris* spp.) for pollinating century plants. With a long tongue and muzzle, the long-nosed bat is well-adapted to feeding on the nectar and pollen in agave flowers. Plants specifically pollinated by bats open their flowers at night and usually have a strong scent. While the bat is feeding on the pollen and nectar, pollen grains become stuck in the bat's fur and are transferred to other plants as the bat forages for food.

In fact, they are considered mutualists because century plants and long-nosed bats have co-evolved to benefit each other. The pollinator-plant relationship between the long-nosed bat and the century plant is so specialized that research shows one may not be able to survive without the other. If the plant population declines without the bats, then other pollinator populations, such as bees, moths, birds, and lizards, will decline, too.

The majority of agave plants are now human-planted crops instead of occurring in the wild. Humans planting agave for tequila production creates two major issues: 1) they are cutting the stalks before they have a chance to reproduce, and 2) they are planting genetic clones of agave plants, so the plants do not have to reproduce naturally. These problems are significant for the bats because they eliminate flower production but also increase the risk for plant diseases.

As with many bat species and other pollinators, the long-nosed bats are declining due to habitat destruction. Long-nosed bats are migratory and need a constant supply of food along the migratory corridor. Two of the bat species are already on the Endangered Species List.

Conservation of the wild agave is critical for the survival on the plant and the long-nosed bats. Currently, conservation programs are encouraging agave growers to help protect the bats and the genetics of the agave plant. For instance, the Tequila Interchange Project recommends allowing 5% of the cultivated agave plants to flower. While 5% doesn't sound like much, this percentage can make a significant difference for the bats.

Let's toast to long-nosed bats and the importance of plant-pollinator relationships!

Sources: Bat Conservation International, NPR, and The Tequila Interchange Project
Photo: Merlin Tuttle/Merlin Tuttle's Bat Conservation
Video: A three-minute Smithsonian YouTube video on pollinating bats

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What's the Buzz? Pollinators in the News

Investigators point to fungicides as one reason for bumble bee declines. Interactions between fungicides and insecticides are impacting bumble bee populations.

Bee-mimicking clearwing moth buzzes back to life after 130 years. The last known museum specimen was collected in 1887. Unlike most moths, the Oriental blue clearwing moth is active during the day and exhibits other bee-like behaviors. Since the moth looks like a bee with hairs on its body, predators avoid attacking the moth because they think it may sting like a bee.

The buzz around Denver: Broncos host to 100,000 honey bees. The Broncos added honey

bee hives on the headquarters property in Englewood, Colorado.

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Photo: Micaela Truslove

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An Interesting Read on the Future of Invertebrates

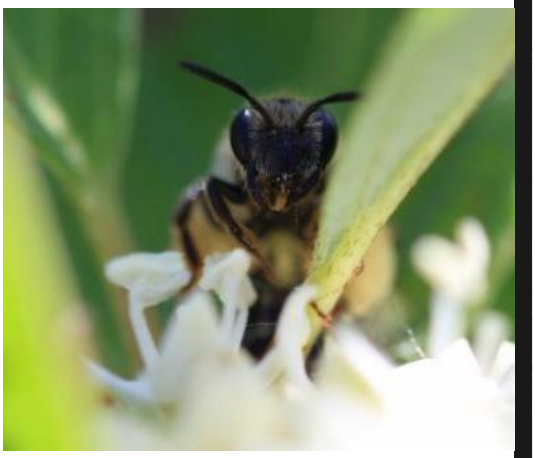
The article, **'A different dimension of loss': inside the great insect die-off** is a worthwhile read. While it does not paint an optimistic picture for the future of invertebrates and our planet, knowing the importance of diversity on our planet is a positive first step towards a brighter future.

Here are some excerpts:

"About 2 million species of plants, animals and fungi are known to science thus far. No one knows how many are left to discover. Some put it at around 2 million, others at more than 100 million. The true scope of the world's biodiversity is one of the biggest and most intractable problems in the sciences."

"But even as thousands of new species are being discovered every year, thousands more seem to be disappearing, swept away in an ecological catastrophe that has come to be known as the sixth extinction. There have been five such disasters in the past. The most famous (and recent) is the end-Cretaceous extinction, the one that killed off the dinosaurs 66m years ago. The most destructive was the Permian, the one that cleared the way for the dinosaurs 190m years before that."

"Everywhere, invertebrates are threatened by climate change, competition from invasive species and habitat loss. Insect abundance seems to be declining precipitously, even in places where their habitats have not suffered notable



A native bee at the Gardens on Spring Creek in summer, 2017. Photo: Lisa Mason

new losses. A troubling new report from Germany has shown a 75% plunge in insect populations since 1989, suggesting that they may be even more imperiled than any previous studies suggested... Entomologists across the world have watched this decline with growing concern."

"While we still don't have a clear idea of what's happening to insects at the species level, we are in the midst of a crisis at the population level. Put simply, even if many kinds of insects are holding on, their overall numbers are falling drastically. The alarming new data from Germany, which was based on tracking the number of flying insects captured at a number of sites over 35 years, is one warning sign among many. According to estimates made by Claire Régnier of the French Natural History Museum in Paris, in the past four centuries, as many of 130,000 species of known invertebrates may have already disappeared."

A monarch butterfly caterpillar at Maxwell Natural Area, 2017. Photo: Lisa Mason

A sand wasp (*Bembix* sp.) at the Gardens on Spring Creek, 2017. Photo: Lisa Mason

Insect Diversity in Our Own Backyards

Thinking about the sheer number of insects on our plant can be hard to comprehend. Millions of insect species have been identified, and potentially millions more have yet to be discovered. Insect biodiversity is everywhere, even in our own backyards! The smallest patch of habitat can make a significant difference for many insects.

This video shows how many insects can be found on one plant. Retired entomologist David Cappaert took pictures and video of all the insects that visited one mountain mint (*Pycnanthemum virginianum)* plant over a one-week period.

Guess how many insect species he counted?

Photo and video: David Cappaert

Bee of the Week - Hoplitis spp.

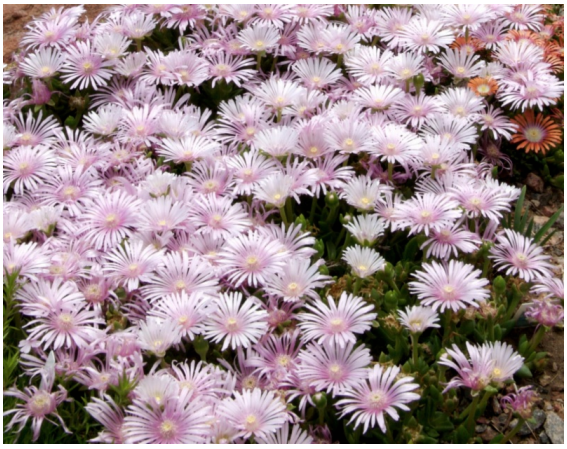
Family - Megachilidae

Scientific Name - *Hoplitis* spp.

Most of these bees prefer cool mountains and boreal habitats compared to the deserts many other bees prefer. They can be found throughout the northern hemisphere and dietary preferences range drastically from extreme specialists that only visit one type of plant to extreme generalists that will visit almost any. In Colorado, there are 8 species of *Hoplitis* bees. All species of *Hoplitis* are solitary. Their nesting habitats vary, and many will nest in the same area as others or where they were born. Some will even build on top or next to their mother's nests.

Sources: Bees in Your Backyard and The Bees of Colorado
Photo: Diane Wilson

Plant of the Week - Lavender Ice ice plant



Scientific Name - *Delosperma 'Psfave'*

The Lavender ice ice plant is a perennial, early summer flowering plant. As its name implies, the flowers are lavender, but they're also iridescent and have a dark center. This plant prefers well drained soil and sunny areas to grow. It doesn't need a lot of water and grows better in gravel than in mulch. As a ground cover plant, it grows 14-18 inches wide and only 1-2 inches tall. This plant is not native to North America, but it was introduced in 2009. If you want this plant in your own garden, it grows well with *Penstemon*, *Agastache* genera, and other plants in the *Delosperma* genus. For more information, click here.

Source and photo: Plant Select®

What's the Buzz? Pollinators in the News

Nobody Knows Why These Bees Built a Spiral Nest. The Australian stingless bee Tetragonula carbonaria is not your average pollinator. For starters, out of about 20,000 known bee species in the world, T. carbonaria is one of only 500 without stingers.

WSU Researchers Develop Pesticide Protection for Bees. Researchers develop a carbon micro-particle that can be fed to honey bees to remove pesticides from their digestive system.

Honeybees Help Farmers, But They Don't Help The Environment. A commentary published in Science this month discusses the importance of broadening our conservation focus from the honey bee to all the native bees (over 20,000 in the world) and other pollinators.

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com.

Previous newsletters are also here:

- Native Bee Watch #25 - December 30, 2017
- Newsletter #24 - November 22, 2017
- Newsletter #23 - October 29, 2017
- Newsletter #22 - September 25, 2017
- Newsletter #21 - September 9, 2017
- Newsletter #20 - August 29, 2017
- Newsletter #19 - July 30, 2017
- Newsletter #18 - July 16, 2017
- Newsletter #17 - July 4, 2017
- Newsletter #16 - June 20, 2017
- Newsletter #15 - June 3, 2017
- Newsletter #14 - May 19, 2017
- Newsletter #13 - April 17, 2017
- Newsletter #12 - March 24, 2017
- Newsletter #11 - February 14, 2017
- Newsletter #10 - January 24, 2017
- Newsletter #9 - December 14, 2016
- Newsletter #8 - November 29, 2016
- Newsletter #7 - September 5, 2016
- Newsletter #6 - August 16, 2016
- Newsletter #5 - August 1, 2016
- Newsletter #4 - July 18, 2016
- Newsletter #3 - July 5, 2016
- Newsletter #2 - June 2, 2016
- Newsletter #1 - June 6, 2016

Photo: Micaela Truslove

A *Halictus* sp., or Striped Sweat Bee on a Denver columbine at the CSU Trial Gardens in 2016. Photo: Lisa Mason

Native Bee Watch: A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu

A Citizen Science Project Exploring Bee Biodiversity in Northern Colorado

Native Bee Watch Newsletter #27

Welcome to the Native Bee Watch Newsletter! This newsletter provides the current buzz on bee monitoring, tips for best practice observing, and other fun, educational resources. Enjoy!

Visit our Website

Colorado State University Extension Fact Sheets on Pollinators!

Check out two newly released CSU Fact Sheets on pollinators:

- Fact Sheet No. 5.615 - Attracting Native Bees to Your Landscape
- Fact Sheet No. 5.616 - Creating Pollinator Habitat

These two fact sheets are great resources for anyone looking to learn more about pollinators and creating habitat in their backyards.

Colorado State University
EXTENSION

Creating Pollinator Habitat

Fact Sheet No. 5.616 | Insect Series | Home and Garden

by H.S. Arathi, D. Davidson and L. Mason*

Pollinators are animal species that provide pollination services to plants in natural/wild landscapes, cultivated gardens and agriculture settings around the globe. They have coevolved with plants and the relationship between plants and pollinators is very intricate; each relying on each other for survival. These important services help many plants complete their lifecycles, as well as ensuring food and shelter for humans and other animals for many generations. Pollinators visit flowers to collect nectar and pollen which provides nutrition for their offspring. More than 70% of flowering plants in the world rely on pollinators for fruit and seed production.

Figure 1a: Swallowtail butterfly. Photo by Lisa Mason

Figure 1b: Hummingbird. Photo by Lisa Mason

Flower Visitor or Pollinator?

Pollinators include bees, wasps, beetles, flies, moths, butterflies, hummingbirds, and bats (Fig. 1a, b and c). However, just because an insect or a bird is visiting a flower, it is not necessarily a pollinator (Fig. 2). Pollinators move between flowers of the same plant species in an orderly fashion, whereas flower visitors move haphazardly among flowers spending very little time within a flower. Even if it does happen that a flower visitor gathers pollen grains on its body, it will not necessarily move to the same flower species, therefore pollination would not occur.

How Pollination Happens

When a pollinator enters a flower, pollen grains from that flower stick to its body (Fig. 3). The pollinator then moves to another flower on the same plant or a different plant, but of the same species. This leads to the transfer of pollen from its body

Figure 1c: Bumble bee. Photo by Lisa Mason

*H.S. Arathi (Arathi Seshadri), CSU, Department of Soil and Crop Sciences, D. Davidson: CSU Extension, Boulder County, L. Mason: CSU Bioagricultural Sciences and Pest Management Department, 1/2018.

Quick Facts

- Pollinator species include bees, beetles, flies, moths, butterflies, hummingbirds, and bats.
- More than 70% of the world's flowering plants rely on pollination which is essential for producing fruits and seeds.
- Just like humans and other animals, pollinators need food, water, shelter and space (collectively known as habitat) to support robust populations.
- Creating habitat is something that everyone can do to help support pollinators in their area.

extension.colostate.edu

Bee of the Week - *Heriades* spp.

Family - Megachilidae

Scientific Name - *Heriades* spp.

Heriades spp. bees are found throughout most of the world. Only three species are found east of the Rocky Mountains, and another 25 species are found in North and Central America. They are small, black, and commonly have woolly patches of hair on their abdomens, which is how they got their name; '*Heriades'* means wool. These bees are generalists, so they visit a wide variety of flowers. They nest in other insects' holes, especially beetles, but some species are also known to use pine cones as a nest. *Heriades* spp. are difficult to distinguish from *Hoplitis* spp. (see last month's newsletter, Bee of The Week). Each genus has microscopic characteristics that differentiate the two.

Sources: Bees in Your Backyard
Photo: H. Go, BugGuide.net

Plant of the Week - SPANISH PEAKS® foxglove

Scientific Name - *Digitalis thapsi*

Spanish Peaks foxglove was introduced to North America in 1999. As the name implies, it's from Spain originally. It has pink flowers that bloom in early summer and furry leaves. The plant is a perennial that does best in dry, sunny climates. Spanish Peaks foxglove prefers clay, loam, or sandy soils and is deer-resistant. The plant grows to be 12-18 inches tall and 10-12 inches wide. A variety of native bees are frequent visitors. For more information, click here.

Source and photo: Plant Select®

What's the Buzz? Pollinators in the News

California Bumblebee Decline Linked to Feral Honeybees. Research shows that honey bees will outcompete bumble bees and native bees for resources.

How Urban Heat Affects Bee Populations. A new from North Carolina State University concludes that the urban heat island effect may contribute to bee diversity in urban areas.

Elephants Are Very Scared of Bees. That Could Save Their Lives. How the elephants' fear of bees is being used as a tactic for elephant conservation.

Missed a Newsletter or a Native Bee Watch Update?

All newsletters and updates are available on the website at nativebeewatch.wordpress.com.

Previous newsletters are also here:

- Native Bee Watch #26 - January 28, 2018
- Native Bee Watch #25 - December 30, 2017
- Newsletter #24 - November 22, 2017
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Photo: Micaela Truslove

Note the pollen-collecting hairs on the legs of this bee on a sunflower at Nix Farm, 2016. Photo: Lisa Mason

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Website: nativebeewatch.wordpress.com Contact: Lisa Mason at Lisa.Mason@ColoState.edu