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Developing A Pollinator Activity Guide For Pre K-6 Formal And Non-Formal Educators

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DEVELOPING A POLLINATOR ACTIVITY GUIDE FOR PREK-6 FORMAL AND NON-FORMAL EDUCATORS

by

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CHAPTER ONE

INTRODUCTION

Introduction

As a park ranger and naturalist, I am always looking for opportunities to provide and develop resources for other educators that encourage and foster a positive relationship with the outdoors. In this capstone I will focus on answering this question: *how can I develop a pollinator activity guide for preK-6 formal and non-formal educators?* This pollinator unit will include leveled lessons that are engaging and applicable for a wide audience and can be conducted in a groomed schoolyard or in a more traditional natural space. While this unit will mainly focus on bees and butterflies native to Minnesota, pollinators include any animal or insect that helps pollinate plants, which is the action of transferring pollen from the male to the female portions of plants. Plants need to be pollinated in order to create fruits and seeds, so these bees, wasps, ants, beetles, and butterflies are critical parts of our ecosystem. In this chapter I will cover the circumstances and personal background that led to my career trajectory and my passion for raising awareness for native pollinators.

My personal journey

I started getting outside at a young age, as my parents enjoyed being in natural landscapes and exploring new places and that didn't change once they had kids. The majority of my youngest memories involve water, whether it was sitting duff in a canoe on a river, trolling for fish in our tiny boat (shore fishing was boring!), getting a leech in between my toes after wading or splashing with our dog at a local beach. And while

adults facilitated all those experiences, as we got older, my younger brother and I were also given freedom on a more local scale.

With a mother that limited and prohibited television and video games, my brother and I were pushed to learn how to entertain ourselves outside independently in our neighborhood, which included many other kids in our age range. We were pretty lucky with the options in our vicinity and the materials at our disposal, which included a swing set in our backyard, the park behind our house, a small patch of forest, several giant trees bordering the church parking lot and our neighbor's backyards (they had pools and trampolines!). These different locations provided us with countless opportunities and many different games and situations that we could play out. Days ranged from collecting clay that we dug out from underneath the sand at the park to climbing the trees at the church to making snow forts using recycling bins as our building block molds. The options are endless when you put your heads together!

While imaginative play was encouraged near home, my connection to nature was ultimately initiated and fostered through my experiences at the local nature center. Our next-door neighbor, Dick Touvell, was the director of the Chippewa Nature Center (CNC) and he encouraged my parents to get us more involved out at the nature center. This relationship and stroke of fortune played a major role in my childhood, as my summers began to include day camp at the nature center and helping Dick open and close the nature center. I enjoyed tagging along with him, as this involved feeding the farm animals that call the nature center home, including chickens, sheep and pigs, with my favorite being the sow and piglets. Those moments will stick with me forever and I remember being so excited to be able to help in this capacity.

Summer camp programming at the CNC introduced me to playing in the mud, catching frogs in the wetlands and backpacking. Through the summer programming, I transitioned from their nature day camp programs to local overnights to weeklong programs in the Porcupine Mountains in Michigan and the Cranberry Wilderness Area in West Virginia. I loved the independence that these programs gave participants and they increased my appreciation and love for the peace of the outdoors. They gave me the confidence that I could do these activities on my own and these two trips gave me my first experiences truly away from civilization for any extended period. Prior to that, I had been car camping in rural areas throughout Michigan, but was never more than a short hike or paddle away from a car or road noise. As well, attending these camp programs inspired me to become one of the individuals that I had looked up to throughout my childhood, which culminated in becoming a volunteer Counselor in Training for two summers. This was my first true leadership role and it was rewarding to help other campers enjoy their programs and to be a role model.

Throughout this time period my family and I continued to travel, expanding my horizons. There are several trips that really stand out to me due to the sheer beauty that I still remember. While visiting the Yucatan peninsula in Mexico, I was blown away by the beauty and color of the coral reefs and the sheer willpower and ferocity of our tour guide that ensured that we got nowhere close to touching this natural resource that brings in eco tourists. While in southern Alaska, the tide pools, sea otters, whales, glaciers, black bears climbing trees and brown bears flipping rocks on the coastline mesmerized me. Kayaking the Painted Rocks National Lakeshore and eating lunch floating on Lake Superior was a once in a lifetime experience (but really, I will probably never take an inflatable kayak

onto that powerful lake again). Seeing the majestic blue Lake Michigan from atop the rolling Sleeping Bear Dunes was indescribable. All of these experiences have driven me to interpret the natural landscape and their ecosystem services, because I want to communicate the importance of protecting and living amongst not only these natural wonders, but also the important habitats in our neighborhoods and surrounding areas. Green spaces are more important than the average person gives them credit for.

My Professional Journey

Though, I had always enjoyed being outside, I also had always changing career aspirations, but the thought of being a naturalist was never a common thread. During high school that I found that I really enjoyed learning about biology in both the introduction class and the AP Biology course. I really liked completing the labs and learning about a variety of topics, including genetics. I went into college prepared to go into biology, with the goal to eventually conduct groundbreaking research and make a difference. Long story short, I found that the field of research was not a passion of mine. I enjoyed the inquiry and methodology process of the several projects that I worked on, along with collecting the actual data, but the process that preceded and followed these steps was unappealing. I didn't want to constantly have to be seeking grants and attempting to submit papers for a living.

So, then came the job search. I looked for positions (mostly unpaid or stipended) in applied conservation biology and stumbled upon outreach and education positions. On a whim I took a four-month internship at the Prairie Wetlands Learning Center in Fergus Falls, MN and stepped into my current career. I enjoy being outside and working with children, so youth-based public programming and environmental education turned out to

be a great fit – it was staring me in the face all those years. Through these types of programming you can provide participants with a positive outdoor experience and help them to explore and be more curious about the natural world that surrounds them.

Conducting environmental education in urban parks and schools in the Twin Cities area, I've witnessed the fear and panic that insects can bring out in people. An extreme example was the sheer terror that overcame a South Minneapolis 2nd grader after seeing butterflies and moths in ryker mounts. He panicked and ran across the room, putting plenty of space between himself and the glass frame. This was not an anticipated reaction, nor one that I'd experienced before, especially with a younger student. For young children, the fear is often due to the perceptions and reactions that are modeled by the adult figures in their life. Along those same lines, I've found that it's a lot easier to overcome the fear held by a child than the fear held by an adult, as the fear of a child is often based on what they are told, in contrast to a personal experience.

One way that I would work to overcome the negative perception was to bring insects out to urban parks, as the Minneapolis Parks and Recreation Board had hissing cockroaches (that don't fly) as education animals. I would gather up individuals that happened to be at the park to see the "mystery animal' that I brought with me. After an initial shock and modeling how to hold the cockroaches, I had individuals from all walks of life tentatively touch the insect, with some being brave enough to hold it in their hands. Through this process I was able to have a conversation about insects and talk about their dislikes and the benefits that insects provide. More often than not, kids would beg their adult to touch the cockroach, so you'd get them (slightly) on board as well. Overcoming these negative types of reactions are exactly why more outreach and education is needed

for pollinators, to dispel the anxiety and panic that can be felt when one finds themselves in a space with insects, which includes the majority of the summer months in Minnesota.

As a naturalist, I thought that I was fairly knowledgeable about pollinators as a whole. But as it happens with any niche topic, I hadn't even scratched the surface. At a conference in the fall of 2015 I learned that beetles (yes, beetles!) are the most numerous pollinators and that there are over 300 native bees to Minnesota, including many solitary species. I have used the different nuggets of knowledge gained since then to amaze visitors about the biology and sheer diversity of bees that are native to Minnesota. Besides the fact that they're inherently connected to human's food supply, fun facts can make bees more relatable and interesting to visitors, to people that might walk away a little less afraid of this particular flying insect.

During the summer of 2016 I would catch bees in the pollinator garden outside of the main visitor center at the Minnesota Valley National Wildlife Refuge and provide informal environmental education about these insects to intrigued visitors walking by. Humans have a hardwired curiosity and they were intrigued with what we were doing, but then were not always interested once they got their answer. They might have a look of revulsion take over their face or look flighty, ready to run away if a larger threat appeared. In most of these instances, I would talk to them about the variety of bumblebees in Minnesota and wow them with the 18 species that can be found. At that point they would be hooked and would start to maybe start looking closer at different distinguishing marks. It was really powerful to see this transformation, from fear to being in the vicinity of bees to being willing to hold the container and look closely. Providing safe experiences like this are critical to overcoming instinctual fears.

Lack of information and misinformation about “scary” critters is what gets us into trouble and it makes it really easy to dislike some insects, especially bees and wasps. Throughout the past two years, I have done an increased number of pollinator programs and have purposefully included large sections about bees. I’ve found that looking at bees up close, examining their intricate patterns and differences in a safe environment have increased participant’s admiration of these small insects. Seeing kid’s faces, most of which were always told that bees are dangerous, catching and holding a bee or wasp is worth it. Environmental education, including hands on activities, is one way to increase appreciation for an otherwise despised and feared animal.

We need native bees and other pollinators for a healthy future, as bees are one of the most effective types of pollinators and the majority of human’s food sources are tied to pollinators. Obvious examples include apples, tomatoes and strawberries and less intuitive examples include almonds, chocolate and coffee. Our daily lives would be severely impacted with the loss of these pollinators, which are adversely affected not only by herbicides and pesticides used around personal homes and in agricultural practices but by loss of habitat in general. Native bees and butterflies prefer native plants and flowers, which can be hard to find in today’s landscape. Awareness and simple stewardship activities can inspire individuals to make changes on a personal level in order to support insects that they might have tried to suppress in the past.

Summary

I’ve touched on how my relationship with the natural world was fostered throughout my childhood and how that led to my education and career choices in the fields of ecology, the environment and education. In the following chapters, I will

demonstrate the importance of introducing insects in a positive manner to students and why learning about pollinators is critical for future generations. I will provide more information about Minnesota's native pollinators and their benefits to society. As well, I will present research that outlines engaging learning strategies that will be translated and incorporated into lessons within the pollinator unit.

CHAPTER TWO

LITERATURE REVIEW

Introduction

My research question is *how can I develop a pollinator activity guide for preK-6 formal and non-formal educators?* The topics of inquiry that I will discuss in this chapter include the emergence and best practices for environmental education, the importance and plight of native pollinators and the ability to use education to increase awareness and change negative perceptions and attitudes.

Emergence of Environmental Education

The Belgrade Charter, a historic document that provided "a global framework for environmental education", defines the goal of environmental education as the development of:

> A world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones (UNESCO-UNEP, 1976, p. 2).

Though environmental education wasn't defined internationally until 1975 at the International Environmental Education Conference in Belgrade, the philosophy behind the practice has much earlier roots (Biedenweg, Monroe, & Wojcik, 2015, p. 10; UNESCO-UNEP, 1976, p. 1). Jean Jacques Rousseau (1712-1778) advocated for a more exploratory approach to learning centuries ago; mirroring the current philosophy, Rousseau proposed that the rote memorization of scientific facts was not as powerful as hands-on learning (Biedenweg, Monroe, & Wojcik, 2015, p. 10). As Wiggins and

McTighe point out in Understanding in Design, coverage-focused teaching is not effective and instructors are missing the mark (Wiggins & McTighe, 2005, p. 3). Though educators can "teach, test and hope for the best", experiential environmental education provides students with a deeper understanding (Wiggins & McTighe, 2005, p. 3).

Environmental Education Philosophy

While the philosophy can be lofty, at its core environmental education and outdoor education can be distilled into a much less complicated practice. In the 1950s, Rachel Carson provided parents with a simple framework that children need an adult to explore with them, someone to discover with them and keep alive their "sense of wonder" (Carson, 1956, p. 55). With no need to be an expert or have a repertoire of fancy materials, she made this an easy and accessible way for many adults to explore with children (Carson, 1956, p. 56). Carson also proposed that you don't need to be in a wild space to experience nature, instead you can take advantage of any trees in the area, watch the seasons change, experience and embrace weather events and take in the sky, whether that means looking at the clouds or marveling at the stars (Carson, 1956, p. 66). In essence, Carson suggests that we go back to basics and utilize sensory experience in many of our activities (Carson, 1956, p. 67). So often only the eyes and the mouth are utilized, as students and adults alike forget to listen to the exquisite sounds that surround them, to gently touch the plants and moss along their path or take in the scents of nature (Carson, 1956, p. 83-5).

This is supported by Eckman, Hudson, Granlund, Powers, Rust, and Schneider (2002, p. 10), as activities that engage the whole body are far more effective for younger children. They suggest that "if you want something to stick in the brain, it must first go

through the heart" (Eckman et al., 2002, p. 10). Educators need to appeal to multiple types of learners, instead of having students solely learn by closed questioning or traditional lecture methods. As Ekman et al. discusses, students have different strengths and respond better to certain methods, and any individual student will understand concepts more fully when the information is presented and reinforced in multiple ways (2002). This is echoed in several studies throughout the country. Lieberman and Hoody found that "a recent study of 40 schools across the nation indicates that using environment as an integrating context (EIC) in school curricula results in wide-ranging, positive effects on student learning" (as cited in Sobel, 2004, p. 36). Lieberman and Hoody also noted that:

> In [Dallas,] Texas, for instance, in the first year of the Hotchkiss EIC programs, teachers made 560 disciplinary referrals to the office. The next year, as program implementation expanded, the number dropped to 160. The following year, with the EIC curriculum fully established, Hotchkiss administrators reported only 50 disciplinary referrals. Both the principal and teachers attribute these decreases in behavioral problems to student's increased engagement in learning (as cited in Sobel, 2004, p. 37).

Incorporating environmental concepts into learning and using strategies that appeal to a wider audience can really make a difference in the motivation and engagement of students. When students are actively engaged, boredom is minimized, knowledge is engrained and connected to those experiences, and their improved behavior reflects their interest.

Carson discusses the relevance of identification, of parsing out and naming specific species to young children (1956, p. 94). She essentially asks the question, what is the value of a detailed species or sightings list in the long term? Carson proposes that the perceived importance and long term retention depends on how it is approached, suggesting that "it is more important to pave the way for the child to want to know than to put him on a diet of facts he is not ready to assimilate" (1956, p. 56). John Burroughs echoes this sentiment, stating, "knowledge without love will not stick. But if love comes first, knowledge is sure to follow" (in Sobel, 1996, p. 13). In contrast to activities focused on identification, Carson encourages exploration and loosely structured time outside, which will lead to discoveries and emotions that can then be tied to specific species and increased knowledge (1956, p. 56). If students care or their interest is piqued, they will be driven to investigate and will desire to learn more about the species in question.

In the same thread, Sobel encourages fostering empathy in young students, and only after that is established should educators introduce larger environmental topics (1996, p. 16). Environmental education was established to increase environmental literacy and to create advocates for conservation, but Sobel argues that if we place these burdens on students when they aren't mentally or developmentally prepared, they are susceptible to ecophobia, or a feeling of hopelessness about the future of the environment (1996, p. 1). As well, environmental problems are often global and abstract, and these two characteristics can lead to a less than complete understanding by students that are still concrete learners (Sobel, 1996, p. 7). One example that Sobel cited involved an eight year old who learned about ivory poaching in Africa and later created a protest sign that stated "SAVE THE ELEPHANTS. DON'T USE IVORY SOAP" (1996, p. 6-7). In her

mind, these two things were inherently connected, showing the disconnect that can easily occur if educators are not mindful about crafting their message appropriately and teaching using developmentally appropriate strategies and topics. Overall, Sobel recommends not introducing large environmental issues, or tragedies, before students reach fourth grade (1996, p. 33).

Sobel recommends a leveled and constructivist approach to environmental education, moving away from the practices of decades past (1996, p. 14). Based on the developmental stage of students, concepts should be approached differently and topics vary based on the age of the group. Students that are ages 4 to 7 should learn to empathize with animals and natural items that they come into contact with on a daily basis and ultimately create and foster a connection with the outdoors (Sobel, 1996, p. 16). Instead of learning about jaguars, they should be exploring the schoolyard in search of commonly found animals, one example being squirrels. Extensions to this simple activity include students coming up with questions about squirrels and investigating to find the answers, pretending to be squirrels, and learning about the characteristics of mammals as a whole. Other local and common animals to investigate include earthworms, beetles, spiders, chipmunks, turkeys and common feeder birds (nuthatches, chickadees, finches and woodpeckers).

Students that are age seven to eleven should expand that upon schoolyard explorations, investigating the surrounding neighborhoods of the school, the town as a whole, and continue up in geographic scope from there (Sobel, 1996, p. 23). This allows students to remain rooted in familiar, hands-on and concrete experiences while utilizing their observational skills in new territories. They expand their horizons and can compare

the new areas to closer areas that they know really well. These new experiences can provide food for learning, as they can write about these excursions, practicing sentence structure, they can investigate different natural characteristics, utilizing the scientific method, and they can measure and count different types of plants or animals, utilizing math in a more concrete way. Being in the Midwest, water is plentiful and this expansion is a great way to discuss watersheds with elementary students in a place-based way (Sobel, 1996, p. 26-27). Following streams and discovering where they flow into is a great activity for this developmental age, and it shows how watersheds are connected (Sobel, 1996, 26-32). This expansion allows for students to connect to and get to know a larger landscape, while still basing the instruction around inquiry, exploration and observation.

Students that are twelve and up can start getting involved in social action and local activism (Sobel, 1996, p. 33). Sobel proposes as students approach and move through adolescence, they crave a connection to society and are looking to get involved (1996, p. 33). He proposes that "managing school recycling programs, passing town ordinances, testifying at hearings, planning and going on school expeditions are all appropriate activities at this point (Sobel, 1996, p. 33). This is also the appropriate age to start introducing environmental problems into the curriculum, ideally including local problems that students can impact and see concrete positive changes (Sobel, 1996, p. 35).

The Importance of Place-based and Hands-on Lessons

It is important to think about how to effectively engage an audience, no matter the age. An effective curriculum unit is developmentally appropriate, inspires exploration and higher thinking and, ultimately, is engaging and hands-on. Sobel proposes that while

it is easier and tidier to teach environmental topics within the confines of a classroom, other techniques are more effective (1996, p. 6). No matter the age group, lessons that are place-based, or locally and seasonally appropriate, are ideal, as they are more concrete and experiential for students. Utilizing photos of captivating animals and writing reports on endangered or threatened fauna or flora in the classroom is very clean and satisfying and students aren't exposed to the elements. Students complete a project and clearly fulfil the objective at hand.

However, Sobel questions the overall validity and success of lessons of this vein, as younger students often struggle to understand faraway species and ecosystems. They lack the ability to observe them outside their window or to go on a hunt to find tracks and scat in the schoolyard. Instead of inundating students with foreign landscapes that don't compute, Sobel suggests that student's connect to the land that surrounds them (1996, p. 15). David Ellis and Molly Stoddard, Instructional Systems Specialists and environmental educators at the Prairie Wetlands Learning Center, agree with this notion, stating:

> We often overlook local resources in favor of traveling to distant and seemingly more glamorous locations. When children are given the opportunity to know their own place intimately, however, they acquire an expert base from which to make comparisons and contrasts with unfamiliar and different biomes they visit and places they steward throughout life. (U.S. Fish and Wildlife Service, 2017, p. 4).

These real-life experiences trump the beauty of dramatic landscapes and unusual habitats that, while jaw dropping and full of vibrant life, are less relatable to the average student. There is an advantage to walking amongst the local landscape that is lost when solely examining it through photos, videos and web content.

Along those same lines, Sobel suggests educators introduce activism at a local level (1996, p. 35). If students can work to effectively create change in their own community, it's much more powerful than sending a check to a national foundation that supports conservation hundreds or thousands of miles away. Rather than raising money to save the rainforest, educators can have their classrooms raise money to buy plants or seeds to create a pollinator garden that improves habitat in the schoolyard. As well, they can talk to students about local issues and have them write to the legislators in their districts or adopt a surrounding park or green spaces and pick up litter on a regular basis. There are still a wide variety of innovative ways to improve environmental issues, close at hand.

Part of combatting and preventing ecophobia in youth and adults is breaking down the bigger issues into manageable ways to create change. It can be overwhelming to fathom how one class or one family can impact climate change, the rise of invasive species, the decline of pollinators or the litter dotting the landscape. Educators have the chance to communicate and demonstrate how change can be made with steps and how students and families can create positive change in their own communities. An elementary school in Modesto, CA was able to successfully make change and decrease their litter around their school (Johnson, 2015). They used Litterati, a free citizen science app, to document all of the litter that they were picking up around the school. This example shows that activism is really powerful when it is driven by the students and that students can make a significant difference in their schools and communities through local and place-based advocacy.

The Importance of Pollinators

Pollinators are a large classification of animals that help pollinate plants, or transfer pollen from one flower to another of the same species, which leads to the production of fruit and a seed(s) (National Academy of Sciences, 2007, p. 13). This diverse group includes bees, wasps, beetles, ants, butterflies, moths, hummingbirds and bats. On a global scale, pollinators are linked to more than 180,000 flowering plants and without pollinators the life cycles of these plants would be impacted negatively (Mueller & Pickering, 2010). This creates a direct connection between the food that we eat and insects. In a world without pollinators, our diversity of food options is decimated. Awareness of pollinators is becoming increasingly important in an era where their habitat is decreasing and pesticides and herbicides are being used in higher frequencies and on large scale landscapes (National Academy of Sciences, 2007, p. 11). It is important to understand how these animals are entwined in our ecosystem, how their presence and roles are connected to humans and how their populations are at risk.

The National Academy of Sciences concluded that there are over 200,000 native species of pollinators in North America (2007, p. 13). Within that, there are 4,570 native species of bees in North America, with 3,600 species that can be found in the United States (National Academy of Sciences, 2007, p. 50). The exact number of bees that can be found in Minnesota is still unknown, as the last census in 1919 only documented 67 species (Minnesota Bee Atlas, 2017). The Minnesota Bee Atlas looking to complete that census and is a four year citizen science project that is looking to discover the number of unique bee species that currently exist in Minnesota, giving scientists, legislators and citizens a baseline for going forward (Minnesota Bee Atlas, 2017).

In this section, I will be discussing and focusing on the importance of wild pollinators, even though managed pollinators, such as honeybees, are better known and utilized in agricultural fields (National Academy of Sciences, 2007, p. 36). While honeybees are efficient foragers and heavily tied to modern agricultural practices with large expanses of monoculture crops, they are heavily managed by apiarists (National Academy of Sciences, 2007, p. 40). Due to this management, the degradation and loss of adequate habitat does not affect the honeybees to the same extent as wild pollinators (National Academy of Sciences, 2007, p. 40). As well, the National Academy of Sciences report shows evidence that native pollinators are more efficient pollinators when you look at individual flowering species and examine the efficacy of a native pollinator versus a non-native honeybee (2007, p. 36).

Only 1.4%, or 50 species, of bees found in the United States are bumblebees, which leaves more than 3500 other species of bees that contribute to pollination of flowers and crops (Gardner, n.d., p. 1; National Academy of Sciences, 2007, p. 50). While scientists anecdotally know that bumblebees and other pollinator species are at risk, the lack of historical data and long-term monitoring projects increases the difficulty of proving population declines over time (National Academy of Sciences, 2007, p. 44). Without a baseline, researchers and scientists don't have anything to compare current data with, creating a large problem. Like it was previously mentioned, the Minnesota Bee Lab is in the process of establishing that baseline, as it is completing a census of native bees found within the state (Minnesota Bee Atlas, 2017).

The majority of documented bee species are solitary species, meaning that they do not belong to a colony and don't share work (National Academy of Sciences, 2007, p.

38). Every female is responsible for creating, maintaining and raising their own nest and offspring (National Academy of Sciences, 2007, p. 38). The majority of solitary bees (60-70%) make their nests by "digging a tunnel in the ground", with the other 30-40% utilizing holes in woods or hollow plant stems for their nests (Gardner, n.d., p. 3). This is important to note, as solitary species of both bees and wasps have much milder stings and display much less aggression, as they have less at stake (Gardner, n.d., p. 3). Eusocial, or colony-based species of wasps and bees have a whole colony at stake, which is linked to higher aggression (Gardner, n.d., p. 3). This alone can help reduce fears of bees, as people understand that not all wild bees and pollinators are looking to sting or attack them.

Wild pollinators are often misunderstood and their critical role is undervalued. From a purely economic standpoint, Losey and Vaughan recommend that wild insects be evaluated for the monetary value of their ecosystem services, conservatively estimating that native pollinators contribute to $3.07 billion of fruit and vegetable production a year in the United States (2006, p. 316). This contribution can be examined further in Table 2, as Losey and Vaughan show how this number was reached by examining the crops produced in the United States, their average annual value, each individual crop's "dependence on insect pollination", the proportion of wild pollinators that visit that species and summing those values (206, p. 317). As well, Losey and Vaughan argue that while this number is subjective and hard to measure, their estimate is less than the true economic value, as they don't take into account peripheral benefits (2006, p. 316). These include the crops enhanced by pollination that don't require it, with two examples being an increase in tomato size when pollinated by insects, even though they are wind

pollinated, and the native bee interactions with honeybees that can increase the latter's efficiency (Losey and Vaughan, 2006, p. 316).

In addition to pollination, Losey and Vaughan estimate that insects provide over $57 billion a year in ecosystem services for inhabitants in the US, enhancing cattle farming, pest control and recreation on top of food production (2006, p. 312). Losey and Vaughan propose that by framing it through an economic and financial lens, more individuals are apt to consider conservation efforts; if pollinators decline, the benefits to individuals, communities and agriculture decrease as well (2006, p. 311).

Threats facing Pollinators

Pollinators are facing a variety of threats and declines on a nation-wide scale, and this trend is noted in the *Status of Pollinators in North America*. They state, "although many native bumblebee species in the United States were once common, entomologists and naturalists have been noting declines and regional absences of some species within the past decade (National Academy of Sciences, 2007, p. 43). While the variety of potential threats is not well researched as they affect wild pollinator populations, there are several different theories for this decline.

One potential threat to wild pollinators is the increase in pesticide application in agriculture and residential communities, though this threat has not been widely studied in the literature (National Academy of Sciences, 2007, p. 80). They state, "the negative impact of pesticides on managed honey bee colonies suggests that feral bee populations could be similarly affected by pesticides, but there are no studies on the latter subject to the committee's knowledge" (National Academy of Sciences, 2007, p. 80). The majority of studies on managed pollinators, including the honey bee and several species of bumble

bees, focused on the interactions and tolerances of these insects to pesticides that they encountered and their effects on foraging and pollinating (National Academy of Sciences, 2007, p. 86). Another aspect to consider is the decline of potential shelter available to wild bees with increased or expanded pesticide use. With the majority of solitary wild bees nesting in the ground or in hollow stems of plants, these species need pesticide-free areas in order to complete their life cycles (Winfree, 2008). While the effects of pesticides on wild pollinator populations hasn't been widely researched, the implications of these chemical applications can potentially have wide reaching effects on these critical animals.

Habitat loss and degradation are also proposed causes for the decline of wild pollinators. Insect pollinators require adequate nesting, sheltering and foraging areas where they can nest and find nectar and pollen (National Academy of Sciences, 2007, p. 93). Large scale landscape changes, increases in monocultures and the fragmentation of habitat impacts and decreases this habitat quality and availability. By breaking up habitat, some species suffer from the lack of access to resources and "it makes it more difficult for pollinators to maintain metapopulation structures, decreasing the availability of corridors and source populations for recolonization" (National Academy of Sciences, 2007, p. 93).

Climate change was another threat to wild pollinators that is still unfolding (National Academy of Sciences, 2007, p. 100). With the forecasted increases in temperature and shifts in precipitation, the growth and flowering of plants can be greatly affected phenologically and geographically (National Academy of Sciences, 2007, p. 100-102). When flowers bloom earlier or later in the season or their range changes

latitude, pollinators can be greatly affected by the asynchrony or the absence of that species in their native habitat. The *Status of Pollinators in North America* even goes so far as to say that it could "cause local extinctions" of pollinators when that delicate relationship between plants and pollinators is disrupted (National Academy of Sciences, 2007, p. 100). As well, this potential seasonal asynchrony could be devastating to the subset of pollinators that are migratory, including the monarch butterfly and hummingbirds (National Academy of Sciences, 2007, p. 102). These species depend on plant species to be flowering along their migratory path or corridor during their spring and fall migrations. These annual trips are energetically exhausting to these species and if they aren't able to refuel along their route, the survival of these pollinators could be in question. As well, the plants that depend on those pollinators will suffer the absence of these species when they bloom before or after the animals migrate through their particular area (National Academy of Sciences, 2007, p. 102)

There are many threats facing pollinators in this modern world. Some of the threats facing pollinators can be mitigated and there are ways for communities to come together and improve and increase habitat for native pollinators that contribute incredible ecosystem services.

Increasing Awareness through Education

"When humans have a relationship with the outside world, they care about it" (U.S. Fish and Wildlife Service, 2017, p. 1). The general public does not always view pollinators favorably, even though their role is very important and connected to the daily lives of humans. It is important to understand how we can overcome these perceptions, increase awareness and allow humans to live alongside these insects peacefully. Through

increased knowledge and hands-on experience individuals can come to tolerate and maybe even appreciate the work and lives of these small animals. By examining them closer, they can look at the details and unique aspects of different species, versus immediately writing them off as a nuisance.

This concept and connection can be hard to quantify as increasing awareness and changing attitudes and perceptions can be difficult to objectively measure. Several studies show subtle shifts in attitude, and acknowledged the difficulties in scientifically measuring these feelings or that there was only a weak relationship (Looy & Wood, 2006, p. 47; Prokop, Tolarovicova, Camerik & Peterkova, 2009, p. 1682). Nonetheless, these increases in awareness are valuable, as "participants felt that the presentation (or similar presentations) did make a difference, even if that difference did not show up as a statistically significant changes" (Looy & Wood, 2006, p. 47).

While the ultimate goal is for education to increase awareness and also change attitudes, the change in attitude can be harder to prove. Prokop, Fancovicova and Kubiatko argue that when an animal presents a threat that attitude can be harder to change through an increase in knowledge (as cited in Prokop, Tolarovicova, Camerik, & Peterkova, 2009, p. 1682). In this case, a bee or wasp presents a perceived threat, as many people have experiences with bee stings or have heard of others that have been stung by bees. And for some, one bee sting can create a life-threatening situation. Prokop, Tolarovicova, Camerik, & Peterkova found that there was a statistically significant change in attitude about spiders as a result of increased awareness for Slovakian high school students, but only a weak relationship for South African high school students (2009, 1682). Spiders pose a larger threat to South Africans, so they propose that could

be one reason for the difference in attitude shifts between these two populations of subjects (Prokop et al., 2009, p. 1682). One thing that they do note is that "elimination of myths and enhancement of knowledge resulted in more positive attitudes, especially in Western cultures". This is important to keep in mind, as many myths can be propagated and spread in communities without any factual basis. When there is a lack of experience with certain animals, fear is easily cultivated.

McDonald and Dominguez also advocate for debunking those misconceptions, saying, "as children develop misconceptions about animals they believe are dangerous, they also adopt attitudes that are difficult to change" (2012, p. 73). They also comment that it is hard to teach about invertebrates and animals because their students lack first-hand experience with them and have negative perceptions and biases regarding them (McDonald & Dominguez, 2012, p. 73). They suggest that allowing students to investigate, observe and form hypotheses about an animal in question in order to start breaking down those myths and misconceptions (McDonald & Dominguez, 2012, p. 73). Their experiential lessons allowed students to make real-world investigations of spiders, an animal that is widely feared, and this provided students with an opportunity to make their own observations about these invertebrates. They watched them move, where they were hunting or making webs and looked at them more closely than they may have in the past (McDonald & Dominguez, 2012, p. 75). This type of activity could be extended and utilized to look at wild pollinators more closely, including beetles, bees and wasps. Insects can also elicit the same creepy-crawly feeling as spiders, but after close examination they can appear more interesting and less frightening.

Educators from Boulder Journey School in Colorado had similar findings after their young early childhood students investigated insects found inside and around their school (Shaffer, Hall, & Lynch, 2009, p. 18-20). The instructors hadn't intended to teach about insects, but noticed a handful of 2 year old children excitedly looking for and watching the insects in one of the gardens (Shaffer et al., 2009, p. 19). They were enraptured and incredibly engaged and they decided to use this as a thread for a long term learning experience, which they viewed was more effective than introducing many topics, but only scratching the surface with each (Shaffer et al., 2009, p. 19-20). Shaffer et. al remarks that they did have to get beyond their own negative or "yucky and gross" perception of insects, but in doing so, they hoped to "foster the children's curiosity about insects at this young age" (Shaffer et al., 2009, p. 20). They found that their children were really engaged and were able to concretely learn about insects and other invertebrates through their own observations and discoveries. Over time, the children "generalized that slugs, pillbugs and worms live under things and ladybugs and spiders live on things" (Shaffer et al., 2009, p. 20).

This infectious attitude towards these typically lowly regarded animals led to children including their parents and adults in their invertebrate adventures. They convinced their parents or adults to come in at the beginning and end of the day to see the insects, spiders and slugs that were brought into the classroom and to continue those adventures around their own home as well, potentially influencing the views and perceptions of their adults (Shaffer et al., 2009, p. 21). In addition to the investigations, instructors at Boulder Journey School used open-ended questions, reading fiction and non-fiction books and drawing in order to continue their learning about these animals

(Shaffer et al., 2009, p. 21-22). These observations really allowed the children to become better naturalists and more observant in their environments, as they noticed that as the months got colder, they were able to find less and less critters (Shaffer et al., 2009, p. 22). This shows that this simple investigation led to students having a sense of purpose when they explored outside, to children learning concretely through hands-on experiences and to increased observational skills. As well, Shaffer et al. show that the children's curiosity about these insects and invertebrates fostered a sense of interest versus disgust, something that will hopefully continue throughout their years in elementary school ad beyond (2009, p. 19-22).

In another case, personal experiences successfully changed perspectives and attitudes towards feared invertebrates. One teacher used cockroaches in a STEM lab in order to have students take a closer look at how animal adaptations impact their survival and investigate their locomotion (Bell & McGill, 2014, 29-30). Cockroaches, like other invertebrates, are not well understood and are intimidating insects. At the beginning of this lab, one particular second grader reacted to the sight of cockroaches by crying (Bell and McGill, 2014, 33). By the end of this lab investigation, they commented, "working with live insects was the best part of STEM Lab" (Bell and McGill, 2014, 33). Classmates had similar opinions with another comment stating, "cockroaches aren't as scary as I thought…I like them now" (Bell and McGill, 2014, 33). This shows that, in this case, a hands-on experience can change the immediate gut reaction and opinions held about particular animals.

Though it depends on how you measure it and what animals are being studied, personal experiences can expand awareness and awaken curiosity in students. Even if it

doesn't change their overall attitude or impact their behavior, making strides towards debunking common myths and misconceptions can be the first step to changing the overall perception. As well, the intimate connection between pollinators and humans could mean that pollinators are viewed more favorably once awareness and knowledge are increased.

Summary

It surprised me that increased awareness was not always linked to a change in behavior or attitude. I was also surprised by how difficult it is to document and objectively measure changes in attitude. I had previously anecdotally noted how I saw a shift in behavior and an acknowledgement for the importance of pollinators while doing informal programming on native bees. You can see the shift in hesitance or sheer fear to come close to a bee shift to a tolerance to a slight interest as they examine them up close. But this short-term shift can be just that and might not last beyond that experience or can be too nuanced to objectively or scientifically measure. This challenges environmental education and nature centers to really think about the desired outcomes of their programs and target something that can realistically be achieved or assessed within their time frame and scope.

There are so many different resources that discuss effective teaching and learning strategies for elementary students and it was refreshing to delve into the research that supports these theories. These theories support what I've learned while working at different visitor centers, camps and environmental learning centers. They show the benefits of inquiry based and exploratory learning and that personal experiences can really increase and improve understanding of concepts. They discuss and show examples

of how hands on experiences can drive investigation and spark curiosity unlike any lesson from a textbook. These resources will be used in order to develop lessons that are developmentally appropriate and are engaging for a variety of learners.

As well, I was surprised by the estimated economic value of wild pollinators. If we solely approach this issue from a financial lens, it makes sense to protect pollinator populations and to push to increase awareness and habitat for these insects. They provide an incredible service that we are not able to effectively and efficiently recreate in their absence. Without them, life will be infinitely more costly and challenging.

CHAPTER THREE

METHODS

Introduction

In this section I will explain the methods and strategies that I employed while writing and developing my activity guide and answering my question: *how can I develop a pollinator activity guide for preK-6 formal and non-formal educators?* I describe the overall project and the thoughts behind its origination, as well the theories that support its design. As well, I provide a more detailed description of the types of activities included, discuss the audience that it was designed for, and the standards that are met within the activity guide.

Overview

I utilized curriculum development to answer my question, as I was interested in creating and adapting various pollinator lessons and activities that were hands-on, place-based and engaging for students. These activities are written to be used by both formal and non-formal educators in urban, suburban and rural settings and are age appropriate for preK-6 students. In order to achieve my goal of increasing awareness and understanding of the importance of native pollinators, I used the backward design theory proposed by Wiggins and McTighe to frame my thinking and throughout the creation of this guide as a whole (2005). This activity guide was completed in December 2017 and will be utilized at the Ecological Services Twin Cities Field Office and Minnesota Valley and Sherburne National Wildlife Refuges in 2018.

Project Description

I designed a pollinator activity guide that will be used by preK-6 formal and non-formal educators. The goals of this activity guide are to raise awareness of the diversity

and importance, to both ecosystems and humans, of native pollinators in Minnesota. This guide is meant to supplement and provide resources and lessons for educators who are incorporating pollinators, insects and animal-plant interactions into their units in a similar format to the Project WILD and Project Learning Tree activity guides (Project WILD, & Council for Environmental Education, 2013; American Forest Foundation, 2012). As well, the lessons and activities are meant to be intuitive and include all of the necessary information for instruction, with the hope of encouraging hesitant educators to include material of this nature.

The activities included within the guide provide educators with creative and engaging methods to introduce pollinators to their students, as well as activities that drive investigations and creative thought processes. Introductory activities are often filled with surprising facts about pollinators themselves or their direct connection to our daily lives and are meant to intrigue students. As well, many of the investigative activities are highly student-guided. When students complete activities that are guided by their own questions and hypotheses, they are that much more interesting and meaningful to a particular student.

Following the backward design theory, this activity guide is meant to provide lessons and activities to students that ultimately lead to a larger priority and understanding. If teachers utilize multiple lessons, they are constructivist and the concepts build on each other in order to increase overall knowledge and understanding as a whole. As well, the activities are designed to fit into an educator's larger curriculum plan and are meant to serve as a basis from which to start from and build off of.

Research Method

The research method used was curriculum development. In order to raise awareness for the importance and diversity of native pollinators, as well as change perceptions and attitudes surrounding them, I decided to design interactive activities and lessons and create a guide that can be used by preK-6 non-formal and formal educators. These lessons allow students to explore and investigate pollinators. By encouraging close examination and scientific observations, students will concretely learn about these important topics. Through education, I aim to increase understanding and awareness of these insects and inspire change and activism.

Project Audience

The intended audience for the pollinator activity guide are preK-6th grade students in urban, suburban and rural settings. These activities are meant to be used both by formal educators in preschool, elementary and middle school settings, as well as outreach programming in communities and field trip based programming at nature centers.

Formal educators can use this activity guide both in the classroom and outside in the schoolyard. They can use it to introduce or reinforce multidisciplinary lessons centering on animals, insects, morphology, taxonomy, pollinators, the link between pollinators and the food we eat, plant life cycles or a myriad of other topics. These experiential lessons can be used to introduce and reinforce newly learned skills and knowledge, including measuring using a ruler, writing sentences using descriptive words and labeling body parts on sketches. In addition, they can use the literature connections suggested to create extensions and encourage inquiry based reading.

Informal educators conducting outreach programming can use this activity guide to help plan place-based lessons at the variety of facilities that they visit. The age-appropriate, hands-on activities and games provide great outlines and additions to after school, library or drop-in programs with a variety of age ranges. They can choose to use these activities for a one-time program or combine a series of them for weekly or monthly programs.

Informal educators conducting field trip programming at nature centers or similar facilities can utilize these activities to enhance their established lessons or as a basis for creating new curricula. Educators can use these activities on site at the nature center or as a pre-lesson in the teacher's classroom. As the desire to increase awareness about pollinators grows, I see more and more nature centers offering pollinator and insect-centered field trip programs.

I designed this activity guide to be versatile and easily adaptable to a wide variety of educational programming. As insects can be found in the most urban and the most rural of settings, I believe that these activities can be conducted regardless of the setting of the facility. While this guide focuses on pollinators native to Minnesota, it can be utilized and slightly modified for formal and non-formal educations in neighboring Midwest states that have similar habitats, including Wisconsin, Michigan, Iowa and Illinois.

Curriculum Development Theory

While constructing my activity guide, I utilized the backward design concept described by Wiggins and McTighe (2005, p. 14). Using this method, I created a more effective guide, by first considering the primary objectives and goals that I wanted to

achieve, then determining appropriate assessments that educators can use to decide whether students have met those goals and, only then, designing the actual lessons and activities to achieve the objectives and goals (Wiggins & McTighe, 2005, p. 17-19). I used this overarching concept and method to help answer my question: *how can I develop a pollinator activity guide for preK-6 formal and non-formal educators?*

The first step that I completed while using this theory was to determine my desired results and the ultimate goals of this activity guide. Wiggins and McTighe propose that any curriculum can be improved by first deciding the end goals and priorities that are to be reached (2005, p. 17). In this case, the priorities that I focused on were increasing positive perceptions of pollinators, awareness of the diversity, importance and threats facing pollinators and understanding of the connection between humans and pollinators. Depending on the age range, different topics and priorities were addressed. With younger students (preK-3), the priorities were pared down to increasing positive perceptions of pollinators and awareness of the diversity and importance of pollinators. Only with older students (grades 4-6), were the priorities broadened to include the threats facing pollinators and the potential long-term consequences, especially in regards to crop production and other products that are used in daily life.

These topics were selected based on the developmental life stages that students are at. According to Sobel, students that are in 3rd grade or younger should not have the burden of large abstract problems placed on their shoulders (1996, p. 33). Instead, they should learn more concretely and be allowed to form a connection with the land. This philosophy encourages investigation and play-acting when students are age four to seven and shifts to exploration of new areas when students are age seven to eleven (Sobel,

1996, p. 16-23). Once students are in 4th grade, they can begin to learn about larger-scale issues, but should have a mechanism to act and create change on a more local scale (Sobel, 1996, p. 33). Even at that young age, any tragedies, declines in pollinator populations included, should be presented with solutions for the issue. This provides hope and inspires activism, instead of causing students to shut down and avoid the issue (Sobel, 1996, p. 8-13).

Following Wiggins and McTighe's template, the next steps were to address the understanding, knowledge, questions and actionable items that the activity guide would lead to (Appendix A, 2005, Figure 1.2, p. 22). The big idea that I wanted to address was the importance of pollinators. As well, I wanted students to be able to understand the big idea that pollinators help flowering plants produce fruit, and ultimately seeds, and that without them we wouldn't have the wide variety and plentiful amount of flowers and fruits that we take for granted. The misunderstandings that can be foreseen are that all pollinators are in decline and that all plants and crops require pollination by insects, when in fact some pollinators are thriving and some flowers are wind pollinated or are self-fertilizing. These types of misconceptions will be addressed in the background information sections of the lessons in the activity to prevent these misunderstandings.

This activity guide includes hands-on and minds-on lessons and activities that will engage students. These lessons have a deeper purpose and utilize inquiry to lead students to their own conclusions which makes them all that more powerful and impactful. These experiential lessons were designed to align with long term goals (Wiggins & McTighe, 2005, p. 23). After utilizing lessons from this activity guide, students will know that there are a wide variety of pollinators, including beetles, ants, bats and hummingbirds. As well,

students will know that there are more than one species of bees, and that there are, in fact, hundreds of species native to Minnesota. Students will understand that pollinators are part of a larger, more complex ecosystem and that they are a keystone species in many different habitats. Students will learn, develop and practice skills through lessons that include measuring, improving observation, and utilizing field microscopes.

This pollinator activity guide was designed with the Minnesota state standards in mind and meets many of the different standards across the different grade levels. Included are Standard K.4.2.1 (natural systems have many components that interact to maintain the system), Standard K.4.1.1, 1.4.1.1 and 2.4.1.1 (living things are diverse with many different observable characteristics), Standard 3.4.1.1 and 5.4.11 (living things are diverse with many different characteristics that enable them to grow, reproduce and survive), Standard 4.1.2.3 (the needs of any society influence the technologies that are developed and how they are used), Standard 5.4.4.1 (humans change environments in ways that can be either beneficial or harmful to themselves and other organisms), and Standard 6.1.3.1 (designed and natural systems exist in the world, these systems consist of components that act within the system and interact with different systems) (SciMathMN and Minnesota Department of Education, 2017).

Timeline for Project Completion

My project was completed in December 2017. I completed the Capstone Practicum course in May 2017 and the Capstone Project course in December 2017. While this activity guide was not field tested, it will be utilized by the Ecological Services Twin Cities Field Office and Minnesota Valley and Sherburne National Wildlife Refuges in 2018 and the hope is that other institutions will find this work enlightening and useful.

This activity guide is meant to offer non-formal and formal educators a relatively easy and simple way to incorporate lessons about pollinators into their overarching curriculum.

Summary

In conclusion, I looked at the appropriate methods for how to answer the question *how can I develop a pollinator activity guide for preK-6 formal and non-formal educators?* I outlined the topics and overall goals and detailed my reasoning for choosing curriculum design for this project. As well, I discussed the backward design model of Wiggins and McTighe and how that helped develop and structure the format for the activity guide, along with the philosophy of David Sobel that helped to determine age-appropriate topics. This model ensured that lessons led to a larger purpose and a more comprehensive student understanding of the diversity, importance and plight of pollinators in Minnesota. In the upcoming chapter, I reflect about the activity guide that I developed. I discuss what I learned through this process and how I discovered limitations and strengths of developing a project of this character. As well, I detail how I plan to communicate and distribute this activity guide to educators throughout the state of Minnesota.

CHAPTER FOUR

CONCLUSIONS

Introduction

My project answers the question *how can I develop a pollinator activity guide for preK-6 formal and non-formal educators?* I chose to focus on pollinators, or insects that visit the flowers of plants and transfer pollen in order for the plant to produce fruit, as this topic is becoming increasingly important and connected to the average human lifestyle. I wanted to create a resource that provided educators with engaging lessons that were fairly simple in instruction and exploratory in nature. This endeavor involved developing an activity guide that contained lessons that are place-based and developmentally appropriate for preK-6 students. These lessons are also hands-on and student-driven in order to engage students fully and support multiple learning styles. Overall, I designed 20 activities that culminated in a PDF pollinator activity guide.

What I have Learned

Throughout this process as a researcher, I discovered the challenges and joys of completing a project of this nature. I realized how challenging it is for me to write a literature review; no matter how interesting it is to read and discover each individual piece of research, it can be challenging to synthesize and incorporate all of those individual strings of ideas. As well, it was a daunting task. It's no small feat to write twenty pages, and it's intimidating to begin. I learned to break it up into pieces and get words down onto the paper, waiting to worry about editing until later on in the process. I also learned the merits of highlighters. I felt silly walking into Target and purchasing matching highlighters and sticky notes, but that was the most helpful piece of advice I

received throughout this process. When it came time to add material to my literature review, I only had to reread the relevant portions that were highlighted, saving me infinite time and stress. Overall, I learned to break up some of the bigger portions of this project and to keep chipping away at it, utilizing whatever advantages and strategies that I could. Looking at the big picture made me want to balk, and instead I needed to think of small pieces to complete in order to finish this project.

Connection to the Literature Review

The parts of the literature review that proved to be most valuable in the development of the activity guide were the works of Rachel Carson, David Sobel and Wiggins and McTighe. Wiggins and McTighe's backward design theory helped to shape the goals of the entire activity guide and to think about the steps and direction that needed to be taken in order to achieve that ultimate goal. Exploratory and hands-on lessons are great, but they do need to be purposeful. Their example of the "activity-oriented" lesson that focused on apples brought to light that while activities might be engaging, multidisciplinary and address multiple learning strategies, they still might lack validity within the classroom (Wiggins & McTighe, 2005, p. 2-3). From their findings, I realized that I needed to step back, look at what I wanted students to ultimately understand and then figure out activities, that were mainly "activity oriented", that would help students achieve that understanding.

David Sobel's theories helped to determine developmentally appropriate topics for different age ranges for my activity guide. His works outline the developmental stages that young children go through and provides examples of how understanding is not achieved when environmental education strays from providing appropriate topics (Sobel,

1996, p. 14-15). Sobel's theories were incredibly valuable in determining at what age students could handle a more complex and abstract concept. Introducing abstract concepts when students are too young leads to a lack of understanding and confusion, but these concepts are valuable when taught to the right age range (Sobel, 1996, p. 7-8). The concepts click and students gain a higher level of understanding when the material is developmentally appropriate for them.

Rachel Carson's message was to inspire interest in a topic prior to filling a student or child with information. Her take home message is that the long term effects of teaching children knowledge without passion or curiosity leads to little long term knowledge (Carson, 1956, p. 56). Instead it's better for them to explore, discover and ask questions in order to acquire this knowledge and that the exploration is more beneficial than a structured experience filled with facts and scientific names (Carson, 1956, p. 56). This method of teaching is really powerful, but can be difficult to achieve. It was something to aspire to while creating my activity guide and I definitely kept the works and words of Rachel Carson in my mind throughout this process.

Implications

Native pollinators is a topic that is important to convey to the next generation and more and more nature centers are incorporating pollinator lessons into their field trips and summer camps. This guide strives to adapt and combine lessons that I've taught throughout the past several years into one concise resource. This resource gives educators a go-to guide that includes place-based and age-appropriate activities that they can easily conduct in their own area, whether or not they work at a traditional school, a nature center, a community center or a different setting.

Through these investigations, I hope that students increase their knowledge about pollinators and their connection to humans and in turn that can increase their awareness and perhaps change their perception about these insects and animals. Instead of an immediate "yucky" or scared response, they might observe and admire them going forward. These activities also include ways that students can act to increase pollinator habitat and change simple behaviors. There is the chance that these messages will also inspire students to create change in their community and change policies that would ultimately benefit pollinators on a local scale.

Limitations

There are several limitations to this particular project. It is largely dependent on others utilizing these activities. This activity guide is simply a resource, its contents and material are not mandatory to incorporate into an educator's curriculum. It requires educators to voluntarily include it into their lesson plans, which means there is no leverage for wide-scale implementation. Once an activity guide is created, no matter the quality, it can be necessary for educators to be trained in how to successfully incorporate lessons into their classroom.

This was a driving factor for me while designing this project. I strived to design an activity guide that was simple and short enough so that educators can use it without a lot of direction or training. When educators use these activities to help their students discover and learn about pollinators, the end goals of the project can be achieved. Only through educators enacting these lessons can perceptions and behaviors be altered. This guide provides them with the necessary tools, but alone is not enough. I am hopeful that I've designed this activity guide in a manner that educators will find useful and

innovative, but I also need their help in achieving the ultimate goal of this project – raising awareness about the diversity of pollinators in Minnesota and changing negative perceptions towards these animals.

Future Projects

Naturalists and educators in the environmental world are always looking at how to increase environmental education in the average public school classroom, and because of this, I see the potential for future projects similar to mine. It's easiest to conduct these activities when they are immediately relevant to your area, and provide you with information about local species. The more an educator has to adapt their activity or research local information about the topic, the less likely they are to utilize that resource. The choice to include these is completely voluntary for an educator, which makes it critical that these lessons are self-explanatory and engaging. There are several other projects along similar lines that are currently in process. A colleague is making a guide to Minnesota's reptiles and amphibians and another is creating a Project Learning Tree guide specific to Minnesota. This trend is positive and I can see future guides being developed in order to encourage more outdoor and natural history exploration and teachings within the average classroom.

Along those lines, a future project could be to conduct a training outlining these resources for educators. Too often, great activities are hidden within a binder or a large book and both formal and non-formal educators often lack the time to discover them. Instead, I've found that attending trainings that highlight instructor's favorite activities proves fruitful and gives provides educators with a reason to crack open the large manual.

Communications

I plan to distribute these findings and activity guide digitally. As a PDF, it will be easy to distribute to naturalists and educators throughout the state. I plan to circulate it to naturalists through the Minnesota Naturalist's Association quarterly newsletter and to environmental educators through SEEK MN. As well, I will distribute this activity guide to the Environmental Education Cohort, U.S. Fish & Wildlife Service Twin Cities Office of Ecological Services, Minnesota Valley National Wildlife Service and Sherburne National Wildlife Service.

I will use my results and activity guide directly within my own career. This activity guide will give me and my coworkers the resources and written lessons to provide quality programs to preK-6 students. Having these lessons in a written form allows me to have coworkers and volunteers lead programs independently, as well as give me the ability to distribute this guide to teachers that are partnering with the refuge. It will give teachers that visit the refuge an extra tool that they can use to enhance the environmental education programming occurring in their classrooms.

Long-term benefits

This activity guide has the potential to increase the number of students introduced to native pollinators throughout the state. This then has the potential to increase the percentage of Minnesotans that are aware of the importance and diversity of pollinators and those individuals might choose to advocate for practices the benefit native pollinators, whether on a legislative level or within their own families. This activity guide gives educators multiple lessons that allow them to introduce native pollinators to Minnesota and to investigate topics connected to these animals using simple or common tools.

Conclusion

This project has given me the ability to answer my question *how can I develop a pollinator activity guide for preK-6 formal and non-formal educators?* As well, it has given me the ability to provide educators in Minnesota with a resource that gives them the tools to raise awareness and a connection to these important animals. This is a topic that I am passionate about and am happy to have developed an activity guide that has the potential to change the perceptions and behaviors of the next generation of Minnesotans.

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APPENDIX A

Stage 1—Desired Results

Established Goals:

- What relevant goals (e.g., content standards, course or program objectives, learning outcomes) will this design address?

Understandings:

Students will understand that…

- What are the big ideas?
- What specific understandings about them are desired?
- What misunderstandings are predictable?

Essential Questions:

- What provocative questions will foster inquiry, understanding, and transfer of learning?

Students will know…

Students will be able to…

- What key knowledge and skills will students acquire as a result of this unit?
- What should they eventually be able to do as a result of such knowledge and skills?

Stage 2—Assessment Evidence

Performance Tasks:

- Through what authentic performance tasks will students demonstrate the desired understandings?
- By what criteria will performances of understanding be judged?

Other Evidence:

- Through what other evidence (e.g., quizzes, tests, academic prompts, observations, homework, journals) will students demonstrate achievement of the desired results?
- How will students reflect upon and self-asses their learning?

Stage 3—Learning Plan

Learning Activities:

What learning experiences and instruction will enable students to achieve the desired results? How will the design
W = Help the students know **W**here the unit is going and **W**hat is expected? Help the teacher know **W**here the students are coming from (prior knowledge, interests)?
H = **H**ook all students and **H**old their interest?
E = **E**quip students, help them **E**xperience the key ideas and **E**xplore the issues?
R = Provide opportunities to **R**ethink and **R**evise their understandings and work?
E = Allow students to **E**valuate their work and its implications?
T = Be **T**ailored (personalized) to the different needs, interests, and abilities of learners?
O = Be **O**rganized to maximize initial and sustained engagement as well as effective learning?