Illustrated Extension apiculture education STEAM (science, technology, engineering, art, mathematics) book to support educators teaching youth in non-formal learning settings

Dominique Woodham

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Illustrated Extension apiculture education STEAM (science, technology, engineering, art, mathematics) book to support educators teaching youth in non-formal learning settings

by

Dominique M. Woodham

A creative component submitted to the graduate faculty
In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Agricultural Education (Agricultural Extension Education)

Program of Study Committee:
Nancy Grudens-Schuck, Major Professor
Michael S. Retallick
Scott Smalley
Meghan Gillette

The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this creative component. The Graduate College will ensure this creative component is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University

Ames, Iowa

2020
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There are not enough ways to say thank you to everyone who has helped me in my journey back to being a student. Apparently, you can teach an old dog new tricks, but it takes a village.

Thank you to my husband, Aaron, for helping me keep all the wheels rolling at home, on the farm and with the family while I worked on class work. School the second time around without you being in classes with me to keep me focused was interesting, but I love that our Baby Boy got to have special Daddy time with you while I got things done.

Thank you to my Mom, Dad, Sister, Babcia and Papa for traveling all over the U.S. to babysit so I could finish school work and travel to workshops and conferences related to apiculture. The Baby Maverick loves you all and so do I.

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Thank you to the IPM4Bees Midwest Working Group for awarding me a travel stipend to attend the inaugural 2019 IPM4Bees Workshop hosted in Ames, IA. I enjoyed the opportunity to learn integrated pest management methods from and with beekeepers and researchers from the Midwest; and tour the wonderful research apiary at the Iowa State University Horticulture Research Station.

Thank you to the Iowa State University Agricultural Education and Studies faculty for letting me in as a graduate student and teaching me your knowledge. My committee, Dr. Grudens-Schuck, Dr. Retallick, Dr. Smalley and Dr. Gillette, thank you.
Thank you to Montana State University Extension for welcoming me into your world before I even had finished graduate studies, and supporting my travel to apiculture workshops and conferences. I distinctly remember telling someone once how, “I wish I got paid to teach about wildfire and honeybees,” and what do you know? Here I am.
ABSTRACT

Honeybees and pollinators have received much media attention in recent years, leading to increased public curiosity about their wellbeing and role in nature. This curiosity has increased pressure on Extension educators to provide apiculture education to the public, both youth and adults. However, many Extension youth educators are unfamiliar with the complexities of apiculture and its relationship to agricultural sustainability and natural resources stewardship. Art can help people to better understand STEM (science, technology, engineering, mathematics) topics like apiculture, agriculture and natural resources, making STEAM (science, technology, engineering, art, mathematics) a suitable learning framework for those seeking to better understand or teach these topics. This creative component resulted in an illustrated apiculture book to support Extension educators teaching youth in non-formal learning settings. The goal of the book was to increase 5th-7th grade youth understanding of the interconnectedness of the natural world and agriculture so that they recognized the value of bees, made conscientious environmental and food decisions, and applied STEAM skills to future activities. The book was designed using the STEAM framework, and is composed of eight topics in chapters; 16 youth learning objectives (two per chapter); eight activities (one per chapter), and 15 illustrations original to the author.
INTRODUCTION

Honeybees, Apis mellifera, are charismatic mini fauna that have received much media attention in recent years, leading to public curiosity and concern for their welfare. As a result, the general public is much more aware of their importance to our food supply and the environment than ever before. This curiosity has increased pressure on educators to provide apiculture related education (Breece & Sagili, 2015) and resources. New and improved apiculture education materials have been developed that expand educator capacity to teach about honeybees. Improved educator capacity will result in better learning opportunities for youth. The arts can help people to better understand and relate to STEM (science, technology, engineering and mathematics) topics, thus, “STEAM has been capitalized on as an inspirational, motivational, and accessible means to support scientific outreach” (Segarra, Natalizo, Falkenberg, Pulford & Holmes, paragraph 15, 2018). STEAM (science, technology, engineering, art and mathematics) is the addition of art to STEM.

The goals of this creative component were to create a book to assist Extension educators in learning about apiculture as it relates to agriculture and the natural world, so that they better understand the intricate relationships. In turn, they will be better able to teach youth about apiculture, agriculture, and the natural world. An understanding of apiculture among educators and youth helps to build a knowledge base in a unique topic area so sustainable agriculture and environmental stewardship themes can be introduced and expanded upon. Extension educators that are interested in better understanding the world of honeybees and intricate ties to the natural world will benefit from this book, as will those they engage with.

The primary audience of the book is Extension educators who serve 5th-7th grade youth. They will use the book to inform themselves, and use the science-based information, the
illustrations, and the learning objectives to learn and better teach youth about apiculture, agriculture and the natural world.

**Youth: Grades 5-7**

Studies have shown that exposure to science at the elementary and middle school levels is effective in attracting youth into future science and engineering fields (Tai, Liu, Maltese, & Fan, 2006). Non-formal youth education complements STEAM concepts, and conveniently, Bee hives are a science class in a box. They will afford… the perfect vehicle for lessons in Biology, Chemistry, environment, and nutrition right through zoology. They are ideal for connected learning: a unique opportunity to develop practical skills of observation, measurement etc. (Fernandez & Peterson-Roest, n.d., p. 3)

The study of the complex and unique world of the honeybee can lead to increased curiosity and appreciation for the natural world, which is an affective or emotional component. This emotional connection can lead to environmental understanding, the desire to improve environmental stewardship, and can promote interest in sustainable agricultural production. Youth that are engaged in STEAM tend to develop improved critical thinking and problem solving skills (Gunn, 2017) as well. Some youth will be inspired to become beekeepers themselves, and educated beekeepers become better beekeepers, producing or associated with higher colony survival rates (Findlay, Eborn & Jones, 2015).

Honeybees are considered livestock in the U.S., however unlike many other popular forms of livestock managed in the U.S. (e.g., cattle, hogs, poultry), the health and management of honeybees and native pollinators have a direct impact on the ability of many fruits and vegetables to produce a crop. The same cannot be said for other forms of livestock. Vegetables
and fruits do not depend upon livestock other than honeybees to produce a crop which makes it crucial to understand honeybee needs, and factors that impact their health and success.

Goals of this book for Extension educators:

• Teach Extension educators the basics of apiculture through illustrations and brief descriptions so they are informed.

• Show Extension educators through illustrations and descriptions how apiculture is the nexus between agriculture and the natural world so they understand complex relationships better.

• Provide engaging hands on activities and youth learning objectives that Extension educators can use to teach youth about apiculture and its relationship to agriculture and the natural world.

Goals for 5th-7th grade youth:

• Youth will distinguish and describe physical differences between worker, queen and drone bees

• Youth will recall two jobs for each of three honeybee social orders (worker, queen, drone)

• Youth will identify food fed to the worker, queen and drone bees

• Youth will identify and count basic external anatomy of honeybees

• Youth identify why honeybees sting, and why most can only sting once

• Youth recognize the vital role queen bees play in honeybee colony success

• Youth will distinguish between the homes of social and solitary bees

• Youth will be able to distinguish basic types of beehives and the bees they house

• Youth will recognize the importance of following rules for beekeeping

• Youth will recognize needs of bees and identify considerations for beekeeping in rural and urban areas

• Youth will distinguish pollination from gathering nectar
• Youth will recognize the value of bees in pollination
• Youth will describe migratory beekeeping through the story of pollinator dependent crops and draw a possible beekeeper migration route for their geographic area
• Youth will describe how diverse diets help keep bees strong and healthy
• Youth will be able to list three ways that honeybees survive winter conditions
• Youth will describe what the infrared illustration shows in relation to monitoring overwintering hives

LOGIC MODEL
Logic models show the connections between inputs, outputs, outcomes and impacts for a program or initiative. Succinctly, they describe a sequence of actions, events and outcomes that an educational program causes (Braverman, Engle, Arnold & Rennekamp, 2008). They can also help professionals and stakeholders to design educational programs through the stages of planning, describing justification, improvement, and evaluation (Braverman & Engle, 2009). Logic modeling was adopted as a program planning framework by many university Extension programs, and it is the root of a planning and reporting system that is still used within much of Cooperative Extension today (Braverman et al. 2008). They are popular in educational program evaluation as they aid in transparency, as well as map, “how implementing key elements of the program will likely lead to the expected program outcomes” (Newton, Poon, Nunes & Stone, 2013).

The logic model for my illustrated book, “Honeybees in Agriculture & the Natural World: An Illustrated STEAM Learning Book for Extension Educators Teaching 5th-7th Grade Youth” focuses on youth learning because the illustrated book is meant to better prepare Extension educators to teach apiculture to 5th-7th grade youth so that their understanding and appreciation
for sustainable agriculture and environmental stewardship increases. The logic model helps to describe and map how and why the illustrated book leads to youth understanding agricultural sustainability and environmental stewardship, where:

• *If* the apiculture information within the book is processed and understood by Extension educators who extend the information and activities within to youth, and

• *if* youth are able to recall the lessons taught and *then* demonstrate understanding through completion of activities,

• *then* this could lead to youth understanding and appreciating agricultural sustainability and environmental stewardship.

The logic model is located in Appendix A.

**LITERATURE REVIEW**

The STEM movement strives to attract more youth to STEM fields as the demand for a robust STEM workforce continues to grow (Segarra et al., 2018). The Rhode Island School of Design first called for the modification of the acronym to STEAM with the incorporation of “A” for art and design. Similar to how apiculture education engages students in many topics under the environmental and agriscience umbrella creatively, the STEAM movement encourages creativity, highlights natural curiosity, and can help communicate STEM topics (Gunn, 2017). STEAM is at the nexus of environmental stewardship, agriscience and apiculture education. Today, most Americans are not well versed in agriculture in general, and, “using agriculture to teach STEAM addresses this knowledge deficit and engages students in projects and activities that use real-world application, critical thinking, creativity, innovation, and collaboration” (Recko, paragraph 5, 2018).
Currently, youth experience a disconnect from the natural world, with many youth lacking an understanding of science (Warren, 2015). There is also a demonstrated need for youth to learn the ecology of the natural world to promote environmental stewardship (Ballantyne & Packer, 2002). Many people are fascinated by honeybees, particularly youth. Despite the fascination, there is still fear of honeybees due to their ability to sting and a misunderstanding of their value. Increased understanding of the vital role honeybees play in the ecosystem and food supply could lead to more conservation conscientious youth and future environmental stewards as positive attitudes towards the natural world often lead to increased conservation stewardship (Gupta et al., 2012). This understanding of their value could lead to appreciation and lessening of fear.

Research suggests sustainable agriculture and natural resources education themes should begin early in youth, and that those who engage in outdoor learning develop a deep sense of environmental responsibility (Brooks & Moroney, 2014). According to the National Science Education Standards (National Research Council, 1996), 5th-8th grade youth are capable of critical thinking and communicating logically, as well as recognizing alternative predictions and results. It has also been determined that 5th-8th grade youth are prepared to investigate environmental systems, and environmental and social themes in great detail according to the North American Association for Environmental Education (NAAEE, 2004).

A study from Iowa recommends beginning agriculture education with 4th-6th grade youth before they have began to develop perceptions of agriculture since these opinions begin to form by the time youth are in the 6th-8th grade (Holz-Claude & Jost, 1995). In line with this theory, natural resources education should begin around the same age since sustainable natural resources stewardship is what makes agriculture possible and sustainable. Warren (2015)
describes that basic understanding of the natural world through studying fundamental processes like the carbon cycle can promote better understanding of the concept of sustainability, promoting better environmental stewardship. Additional literature also supports that 5th-7th grade youth that understand the costs and benefits of sustainable natural resources use, should develop, “a deeper appreciation for management practices that sustain natural resources for generations to come” (Brooks & Moroney, 2014).

This research indicates that the middle school age youth (5th-7th grade) I chose to target have the ability think abstractly and make connections between seemingly disparate ideas and concepts. For many people, the relationships between apiculture to sustainable agriculture and environmental stewardship, are not obvious. The connections are there, although it takes a detailed understanding of the basics to understand the relationships which is why I chose to target the 5th-7th grade youth Extension educators interface with since understanding the connections could be considered somewhat abstract.

Extension educators are often called upon to assist with community and individual problem solving, as well as with extending science and research from universities to the public through non-formal learning opportunities. Many Extension educators are receiving an increase in pollinator related questions due to increased public awareness and interest in pollinator issues (Griffin & Braman, 2018). In the 1970s, the public demand for home and urban gardening information increased pressure on horticulture researchers and educators, which led to the creation of Master Gardener programs (Chalker-Scott & Collman, 2006). Similarly, Master Beekeeper programs were developed in response to the increasing popularity of pollinators in general, and the demand for credible educational programs related to apiculture. Most of these programs are rigorous, targeting adult learners that are active beekeepers. To meet the needs of
learners, “there is a need to individualize both delivery and teaching methods of beekeeping education” (Bromenshenk, 2016), whether learners are youth or adults.

Currently, there are many science based apicultural education resources and materials available both in print and online which educators and youth can access. As the current President of the Bitterroot Beekeepers, Loren Stormo (personal correspondence, 2019) said, “honey bee education tends to draw kids of all ages into a wonderful environment of learning.” Many formal, informal and non-formal materials and learning opportunities exist in the realm of apiculture education for 5th-7th grade youth. Materials have been created and distributed by federal, state, and county agencies non-profit organizations, agricultural organizations, agricultural literacy specialists, hobbyist and commercial beekeepers alike. Some meet Next Generation Science Standards (NGSS Lead States, 2013), others are STEAM based lessons, and some meet state-level science standards. Additionally there are numerous programs and initiatives related to pollinator education and awareness. Educators could get lost in the resources available, and spend days studying materials in an effort to prepare lessons and curriculum for their students related to apiculture education.

This book will help Extension educators to better understand the relationships between apiculture, agriculture and natural resources stewardship in a condensed book so they do not need to devote countless hours to research in all three areas. The illustrations emphasize important details that could be subtle and missed in a photograph. It is this combination of synthesized information from apiculture, agriculture and natural resources combined with illustrations that sets this educational resource apart from others.
LEARNING OBJECTIVES

Based on my experiences both substitute teaching and organizing non-formal learning opportunities for youth through Cooperative Extension, I’ve noticed some similarities across the learners. My formal graduate studies have helped me to clarify and better understand these consistencies. Allen’s (2018) Ages and Stages of Youth Development describes middle school youth as very enthusiastic and curious, but with short attention spans. Allen (2018, p. 3) also states that youth in this general age range are active, curious, have interests that change often, and are easily motivated. The implication of this knowledge is that when engaging youth in learning; the senses and a variety of active learning experiences are used, exploration and inquiry is encouraged, and positive adult encouragement and assistance is provided (Allen, 2018, p. 3).

It is my hope that the illustrated book helps Extension educators better understand apiculture and its importance to both agriculture and the natural world so that they are better able to guide youth in understanding apiculture and conservation concepts. Youth fears of stinging bees could be lessened once they understand the importance of honeybees as pollinators, and begin to see how the natural world is interconnected. Once these basics are understood, then youth can build on their knowledge base through engaging in learning activities that teach youth the importance of honeybees to agriculture and pollination in general to food supply.

Ultimately, it is my hope that the illustrated book helps Extension educators to better understand apiculture and sustainable agriculture and environmental stewardship concepts so that they can be better educators to youth. Through this improved understanding and arsenal of suggested activities, I hope that youth gain an appreciation of the natural world, and this perhaps inspires them to take action themselves, like preserving or creating habitat for honeybees and native pollinators.
METHODS

This Methods section addresses these aspects of the book: topics; readability; illustrations; learning objectives; additional resources; and review process. The complete book can be found in Appendix B.

Topics

I divided the book into chapters by topic. The eight book topics divided by chapters are:

• Distinguish Queen, Drone and Worker Bees
• Identify Anatomy of the Honeybee
• Recognize the Queen Bee
• Distinguish Bee Hives
• Recognize Apiary Position and Location
• Describe Pollination
• Describe Migratory Beekeeping
• Recognize Overwintering Bees

This book is 41 pages long with 15 illustrations. The information in this book is research based, paired with illustration of the information. Information in this book is extracted from peer reviewed journals, industry professionals (researchers and beekeepers), professional agency publications (federal, state), and books.

Readability

I conducted a readability analysis, which is recommended for narratives of all types for adult as well as youth learners. I used the free, online Automatic Readability Checker tool found at ReadabilityFormulas.com (ReadabilityFormulas.com, n.d.) which assesses text based on various readability formulas. This tool counted the words, syllables, sentences and characters in
writing samples from my book. It then input these numbers into seven readability formulas (the Flesch Reading Ease formula, the Flesch-Kincaid Grade Level, the Fog Scale of the Gunning FOG Formula, the SMOG Index, the Coleman-Liau Index, the Automated Readability Index, and the Linear Write Formula) and provided feedback regarding the reading and grade level of my book (ReadabilityFormulas.com, n.d.). Due to the scientific nature of the topic area and resulting descriptive text, the Automatic Readability Checker tool assessed the text in my book between the eighth grade and college reading levels (ReadabilityFormulas.com, n.d.). This is appropriate for Extension educators as they are required at a minimum to hold undergraduate degrees in a relevant field to their specialty (agriculture, youth development, family and consumer sciences, natural resources, etc).

Based upon the U.S. Department of Education’s National Center for Education Statistics (1999, p.151), “Achievement Levels of Reading Proficiency,” eighth through twelfth grade students reading at the Basic reading level on the National Assessment of Educational Progress reading scale, should be able to:

• relate text to its overall meaning
• make connections to expand thoughts between ideas
• relate concepts in text to personal experiences in an effort to reach conclusions.

With this in mind, a qualified Extension educator should be able to understand information in the book, and then extend their new found knowledge to youth learners. There are many terms specific to apiculture that had to be defined, and made relatable so that they could be better understood by Extension educators potentially unfamiliar with them. According to the National Academy of Sciences (p. 2, 2017), “The most effective approach for communicating science will depend on the communicator’s goal.” Using a science communication approach
attempts to bridge the potential gap between Extension educator understanding and the information presented in the book, many definitions and concepts are repeated in an effort to clarify the content to the reader, and sentences shortened to improve readability and make the science based material more understandable, and framing used to relate new information with learner knowledge. I edited so that the text would be, “…responsive both to people’s needs for scientific information and their ways of understanding, perceiving, and using science to make decisions” (National Academy of Sciences, 2017, p. 24). Additionally, each chapter concludes with a “Remember” section, highlighting important concepts for Extension educators to be able to understand and then be able to teach to learners.

Illustrations

I painted all the illustrations myself, and I exercised creative freedom by highlighting certain things I wanted to bring attention to. Examples of things I chose to highlight were: certain key features of the different types of bees that might be missed in a photograph; women being beekeepers as well as men, and symmetry of honeybee external anatomy. The illustrations are completed with watercolor paint on watercolor paper. Once they dried, I outlined the illustrations with a black ink pen to give them more definition and detail. The intent is that between the text, illustrations and suggested activities, Extension educators will have an understanding of the topic and feel comfortable teaching youth learners the material. There are 15 illustrations included in this book:
<table>
<thead>
<tr>
<th>Illustration Number</th>
<th>Illustration Title</th>
<th>Illustration Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Beekeeper checking on bees in apiary</td>
<td>Cover of book</td>
</tr>
<tr>
<td>2</td>
<td>Pollinator planting in corn rows creates habitat, biodiversity and forage</td>
<td>Between the table of contents and first chapter</td>
</tr>
<tr>
<td>3</td>
<td>Simplified illustration of a worker bee, queen bee and drone bee.</td>
<td>At the end of the Queen, Drone and Worker Bee chapter</td>
</tr>
<tr>
<td>4</td>
<td>Basic external anatomy of honeybee- see the symmetry?</td>
<td>At the end of the Honeybee Development and Anatomy chapter</td>
</tr>
<tr>
<td>5</td>
<td>Identify and locate the queen bee, worker bees and drone bees</td>
<td>At the end of the Identifying the Queen Bee chapter</td>
</tr>
<tr>
<td>6</td>
<td>Beekeeper catching a swarm of bees to re-home elsewhere</td>
<td>At the end of the identifying the Queen Bee Chapter following the &quot;Identify and locate the queen bee, worker bees and drone bees&quot; illustration</td>
</tr>
<tr>
<td>7</td>
<td>Types of beehives for honeybees</td>
<td>At the end of the Beehives chapter</td>
</tr>
<tr>
<td>8</td>
<td>Beehive positioning south east to maximize warming by sun</td>
<td>At the end of the identifying the Queen Bee Chapter following the &quot;Types of beehives for honeybees&quot; illustration</td>
</tr>
<tr>
<td>9</td>
<td>Beekeeping in rural and urban locations</td>
<td>At the end of the Apiary Positioning and Location chapter.</td>
</tr>
<tr>
<td>10</td>
<td>A honeybee foraging and pollinating an almond blossom</td>
<td>Before the start of the Pollination chapter</td>
</tr>
<tr>
<td>Illustration Number</td>
<td>Illustration Title</td>
<td>Illustration Location</td>
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<td>---------------------</td>
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<td>---------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>11</td>
<td>Fruits dependent upon pollinators for pollination</td>
<td>At the end of the Pollination chapter</td>
</tr>
<tr>
<td>12</td>
<td>Example map of migratory beekeeping routes in the U.S. and crops to be pollinated</td>
<td>At the end of the Migratory Beekeeping chapter</td>
</tr>
<tr>
<td>13</td>
<td>How migratory beekeepers transport beehives across the U.S.</td>
<td>At the end of the Migratory Beekeeping chapter after the &quot;Example map of migratory beekeeping routes in the U.S.&quot; illustration</td>
</tr>
<tr>
<td>14</td>
<td>Illustration of a beehive viewed via thermal imaging</td>
<td>At the end of the Overwintering Bees chapter</td>
</tr>
<tr>
<td>15</td>
<td>The basic beekeeping tools needed to manage honeybees</td>
<td>On the last page in between the &quot;Illustration of a beehive viewed via thermal imaging&quot; illustration and the Resources list.</td>
</tr>
</tbody>
</table>

**Learning Objectives**

For each topic area, I identified two learning objectives for youth and provided them at the beginning of each chapter. Extension educators can review them, and consider them as they are reading and learning the material for their own leaning. The suggested actives in each section will assist Extension educators in teaching the bee related content. Youth will be able to learn apiculture and conservation concepts through the activities that Extension educators guide them in and the associated illustrations within the book. As each activity has a STEAM component, youth will also be developing critical thinking and problem solving skills.
Between engaging youth in the suggested activities, using the illustrations to help with comprehension and visualization, and employing their own unique teaching style and methods, Extension educators will be able to successfully educate youth in the realm of apiculture, agriculture, and the natural world so that they develop a basic understanding and appreciation for the significant role pollinators like honeybees play in ecosystem function and crop production.

**Additional Resources**

I provided a list of additional apiculture education resources for educators at the end of the book. It is a list with links to other apiculture education materials and ideas that they can refer to. Additionally, there is a list of the advanced Master Beekeeper type programs in the U.S. today included, just in case Extension educators, or those they teach, are interested in pursuing advanced apiculture education in depth.

**Review Process**

The review process for the book included countless rounds of edits of the creative component proposal, the book itself, and the final write up with my graduate college advisor, Professor Grudens-Schuck. Email, Canvas, and CyBox were all platforms used to share documents back and forth for editing. The final review of materials and my oral exam were carried out by my program of study committee: Drs. Grudens-Schuck, Retallick, Smalley, and Gillette.
CONCLUSION AND RECOMMENDATIONS

Potential Future Applicability and Uses

The future applicability and uses for this illustrated book are many such as: digital copies, hard copies, adaptation to a 4-H curriculum, or conversion to a video option. Creation of this resource was in partial fulfillment of a MS Agriculture Education degree at Iowa State University, but the idea was born out of a usefulness and need I identified while working in Extension education.

• Digital Copies: A digital copy of the creative component will be available online through Iowa State University. At this time, this is the only planned and known use for the book.

• Another potential applicability could be for it to live on “virtually” through a university’s Extension Publications page where it could be viewed and downloaded for free, or a hard copy requested. For that to happen, the university housing it would need to edit, format and make ADA (Americans with Disabilities Act) Compliant the digital online version. Typically there would be a service and maintenance fee involved.

• Hard Copies: I have no immediate plans to create and distribute a hardcopy version of this book at this time. A potential location for hard copies to be stored and distributed is through a university’s Extension Publications and distribution center. For this to happen, a printing and handling fee would be assessed.

• Adaptation to 4-H Curriculum: Every university Extension program has their own unique internal process, requirements and review standards for creating 4-H curriculum. Typically, 4-H curriculum is required to follow the 4-H Experiential Learning Model framework (do, apply and reflect through: experience, sharing, processing, generalizing and applying) (Iowa State
University Extension and Outreach, n.d.). To adapt this book to 4-H curriculum, it would need to first be reviewed by subject matter experts, and state 4-H and curriculum development specialists. Once the curriculum met all state specific 4-H requirements and was approved by the state 4-H Center, it could be adopted as a state 4-H curriculum. The curriculum could also be submitted to the National 4-H Council for adoption.

• Video Option: The video option I envision for this book is a short video posted online in conjunction with a link to a digital option for viewing or download. The video would describe the concept behind the book, a description of what can be found within, and a description of how educators could use it best in their programming. The video would be a combination of video of segments of the book with narration that is also available in closed captioning.

Evaluation

As a Natural Resources Extension educator, my ultimate goal would be for everyone, all youth and adults, to be knowledgeable in the intricacies of the natural world so that sustainability and better environmental stewardship were common concepts understood, supported and practiced by all. It would be difficult to measure and evaluate this understanding, support and practice, but the success of the book could be measured with metrics identified in the logic model. Realistically, short term goals identified in the logic model indicate general understanding of learning objectives through simple recall. Midterm goals include demonstrating understanding through completion of suggested activities (demonstration), whereas long term goals suggest a change in behavior or practice that may not be measurable by an educator who is merely crossing paths with a learner.
Literature and my personal experiences have informed me that there is a lack of understanding of broad environmental concepts, and basic facts as well, which is why I believe despite many technological and research advances in the world today, we still observe environmental degradation regularly and struggle to understand and communicate concepts like climate variability. I chose to focus this illustrated book on educating Extension educators who teach 5th-7th grade youth. The Cooperative Extension Service is a constant connector in communities across the U.S. and youth in this age group are sponges, eager to learn and still have an entire lifetime ahead of themselves with which to focus on supporting sustainability, as well as promoting and practicing environmental stewardship.

**REFLECTION**

I am still working on improving my teaching capabilities every day. Whether it’s brainstorming new workshop offerings, writing grant proposals, assisting clientele with problem solving, or coordinating and teaching, every day is different and satisfyingly challenging. Although I offer educational opportunities for both adults and youth in various natural resources related topics, I most often am contacted by educators to teach youth about honeybees. Without a doubt, being able to meet community needs in youth enrichment and development opportunities as they relate to honeybees and conservation, is the best part of my job.

There are distinct differences between teaching to an adult audience versus a youth audience. Adult learners typically attend Extension organized workshops because they want to learn more about a topic, they are interested in the topic, and thus you are potentially teaching them information or skills which they can take home and apply to their own situation. Youth learners on the other hand, may not be interested in the topic being taught, the decision to be in the learning opportunity was most likely made for them, and they may or may not apply the
knowledge extended to them for many years. However, research has shown that teaching youth about the natural world and conservation at a young age has a significantly greater impact in affecting their mindset towards conservation oriented behavior as they grow. It is for this same reason I bought my one year old his own beekeeping suit to grow into, and we talk to our own bees in our backyard in the summer. Although he is much too young to understand much related to honeybees, the natural world and agriculture right now, by continuing these activities together as he matures, he will hopefully develop an appreciation for animal husbandry, holistic and sustainable agriculture and an appreciation for the role honeybees and other pollinators play in the world.

Honeybees have received much attention in recent years due to extensive media coverage and hype surrounding Colony Collapse Disorder. Everyone wants to do their part to, “Save the Bees,” which has led to many requests for honeybee education. Interestingly enough, my personal interests and skillset prepared me well for these requests and what I discovered are yes, there are many educational resources available to teach adults and youth alike about honeybees. However, as a non-formal educator, I am very aware that many teachers simply don’t have the time to engage in a master beekeeper program to learn more, or research all the education sources, curriculum and lessons available to help with teaching about honeybees. Additionally, as a beekeeper and 4-H volunteer beekeeping project leader, I am quite aware that not everyone needs to be a beekeeper, but everyone can and should do their part to help in environmental conservation which has direct positive impacts on pollinators like honeybees, as well as human kind. This is why I thought an illustrated Extension apiculture education STEAM book for non-formal learning settings would be beneficial. This learning resource has illustrations that would attract students (adults and youth) to read between the illustrations, and art is a great tool for
teaching STEM concepts which formal and non-formal educators try to offer in interesting and creative ways.

I am a visual learner myself, but also enjoy hands on experiential learning which is why I concluded that an illustrated book is a great learning tool if combined with hands on activities. Very quickly when beginning on this project, I realized that although I love to draw with colored pencils, in order to actually complete my project in a realistic time frame I would need to switch my medium. My illustrations ended up being watercolor paintings which allowed me to complete illustrations quicker and work on many concurrently. Adding water to water color paint stretches the paint further. As I waited for parts of one illustration to dry, I could work on parts of another. I had brainstormed a list of important information that students would need to understand about apiculture prior to learning about conservation and then began painting.

In my situation, completing illustrations first helped to guide and direct what text would be included in each segment. Additionally, I do not enjoy following established curriculum and lesson plans, and I can’t imagine I am the only non-formal educator that feels constrained by the parameters outlined in curricula and lessons. I’d much prefer to learn about the information I am requested to teach, and adapt lessons and activities to my audience needs based on experience. That is why the book is more focused on the research based, factual information and a suggested activity. I understand that this may not be true for all Extension educators, that is why learning objectives and suggested teaching activities are provided in each topical section. This book was developed based on apiculture and conservation lessons I have taught to youth for the past two years. This book itself could be shared with youth so they can learn about apiculture and environmental conservation through a combination of reading, viewing the illustrations, and self investigation, if the reading level was appropriate for their abilities. The book has the
information needed to provide educators with a background in apiculture and suggested activities
to strengthen learning for youth.

Typically I have traveled often and far to teach youth about honeybees and conservation.
A resource like this illustrated STEAM guide could help expand the number of educators
comfortable teaching about apiculture and conservation, and take pressure off their shoulders for
developing engaging activities. The educators and youth could learn together, and I could see a
summer school or after school program tackling learning about apiculture and conservation one
day at a time, reading the booklet together and engaging in activities as a classroom.

To be engaging and effective, learning should be fun. As an Extension educator, I am
biased in my belief that non-formal learning opportunities can be better at truly engaging and
inspiring some youth than formal learning situations can. Illustrations combined with group
activities seem like a great way to teach youth the importance and interconnectedness of
apiculture and environmental conservation, as well STEAM concepts. For youth that are visual
learners, the illustrations may last longer in their memory and mean more than the text of the
book would, or even the associated learning activities. If some youth were inspired to put more
effort into their creative and artistic skills as a result of the illustrated book, I would consider that
a success of the illustrated book as well.
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APPENDIX A

**Illustrated Apiculture Education Book:** Few Extension educators are trained in apiculture, but there is a growing demand for apiculture education. This book provides educators with information, illustrations and activities to guide youth in developing STEAM skills as they study the relationships between apiculture, agriculture and the natural world.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
<th>Outcomes -- Impact</th>
</tr>
</thead>
</table>
| • Instructors - Extension educators  
• Materials - teaching supplies (glitter, cotton balls, paper, colored pencils, glue, wooden blocks)  
• Illustrated book “Honeybees in Agriculture & the Natural World:  
• Time | • 8 STEAM based apiculture activities  
• 15 illustrations  
• 23 Remember points  
• 16 Learning Objectives | • youth identify bees & the importance of queens & identify which bees sting & why, becoming less fearful  
• youth describe migratory beekeeping through the story of pollinator dependent crops  
• youth recognize the value of bees in pollination  
• youth develop increased environmental stewardship knowledge and appreciation for bees  
• youth develop increased understanding of interconnectedness of natural world & agriculture.  
• youth recognize the value of bees & make conscientious food decisions  
• youth apply STEAM skills and knowledge to future activities  
• youth develop appreciation for bees and natural world leading to environmentally conscience decision making |

<table>
<thead>
<tr>
<th>Activities</th>
<th>Participation</th>
<th>Short</th>
<th>Medium</th>
<th>Long</th>
</tr>
</thead>
</table>
| 5th-7th grade youth in 4-H  
5- 7th grade youth not in 4-H | • youth distinguish & describe types of bees & their jobs  
• youth identify basic anatomy of bees & how their diet impacts development  
• youth distinguish between the homes of social and solitary bees  
• youth recognize the importance of rules about bees and bee needs in rural and urban areas  
• youth describe three ways that honeybees keep warm in winter and how beekeepers monitor colony health | • youth identify bees & the importance of queens & identify which bees sting & why, becoming less fearful  
• youth describe migratory beekeeping through the story of pollinator dependent crops  
• youth recognize the value of bees in pollination  
• youth develop increased environmental stewardship knowledge and appreciation for bees |  |

**Assumptions:** There is a budget available to purchase the materials. Extension educators either have work assigned youth education responsibilities, or want to teach youth.

**External Factors:** Ability of educators to guide youth in STEAM activities, as well as speed and degree to which learning and change in behavior take place. Fear of bees could prevent decision makers from allowing bee materials being allowed into the educational setting.
Illustration 1: Beekeeper checking on bees in apiary.
Foreword

Hello! I hope you enjoy the following illustrated learning book, Honeybees in Agriculture & the Natural World. This project is the result of the combination of the popularity of pollinators (honeybees in particular) and my education and experiences. As an Extension educator, I am asked to teach about honeybees frequently. Teaching about bees is definitely one of the highlights of my job. I am a beekeeper and a graduate of the University of Montana’s Master Beekeeper program. This book explains the basic science of apiculture, and paves the way to quick learning through activities and illustrations.

I painted the illustrations myself. Illustrations can explain concepts and ideas where words fail, and where photos are unclear. I wrote and illustrated this book for Extension educators and other youth leaders who want to learn the basics of apiculture and about the importance of honeybees to both agriculture and natural world without having to commit much time to research, and without having to gain a formal education in apiculture, like I did. After working through the book, you will be more prepared to answer basic questions about apiculture, and to teach basic lessons in apiculture, agriculture, and natural resources to youth.

The book provides a couple of ways to engage the 5-7th grade age group. Activities are provided to strengthen learning and develop STEAM (science, technology, engineering, art and mathematics) skills. The eight topics list learning objectives and there is one suggested activity at the end of each section. The book has 15 watercolor illustrations. Many of the learning activities refer to the illustrations.
This book can be useful to those new to apiculture and to those who already keep or know about bees. Extension educators can use the illustrations to show youth visual differences between queen bees, worker bees, and drone bees as well as what different kinds of bee hives look like rather than relying on verbal or written descriptions alone. The incorporation of STEAM activities can offer another element of development and learning to curious youth. For educators looking to expand their knowledge and explore, a list of resources is included at the end.

Happy learning!
Dominique Woodham
Big Timber, MT
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Illustration 2: Pollinator planting in corn rows creates habitat, biodiversity and forage.
1. Queen, Drone and Worker Bee.

Youth Learning Objectives:

• Youth will distinguish and describe physical differences between worker, queen and drone bees

• Youth will recall two jobs for each of three honeybee social orders (worker, queen, drone)

Did you know there are thousands of kinds of bees in the U.S.? Honeybees are just one of the thousands of bee species in America. Honeybees also have a scientific name in the Latin language: Apis mellifera. Most of us just call them by their common name, honeybees. There were no honeybees in the U.S. until they were introduced from Europe a long time ago. European honeybees are really good at producing honey and can be cared for and managed like livestock by beekeepers. A rancher has to care for their cows; give them shelter, pasture, safety, and medicine when they’re sick. Beekeepers do the same for their honeybees.

Honeybees are an amazing insect. A group of honeybees that live together in a hive are called a colony. You can think of each colony as its own village. A honeybee colony operates as a super organism. This means the bees in the colony can only survive as a colony, not as individuals. All the bees within a colony play a very important role in their colony’s success and survival. Within the colony, there are three social orders of bees: queens, workers and drones. Bees within each order have very specific jobs. The queen, the workers, and the drones each have important responsibilities and are necessary for the colony to survive.
All worker bees in a colony are female and they do ALL the work in the colony. Worker bees are short, skinny, and small compared to other bees in a colony. The jobs of worker bees change as they mature. Worker bees start with simple jobs like caring for young bees and keeping the hive clean. They eventually mature to collecting food, caring for the queen, and guarding the hive. As the worker bees age, they return to jobs such as caring for young and sick bees, and keeping the colony clean and healthy.

During the summer, most worker bees live for about 6-8 weeks because flying and looking for food wears them out. Worker bees that are born in the fall maintain a honeybee colony through winter. These bees may live many months because they are not being worn out by foraging. They will not wear out as rapidly over the winter because they are clustered in a ball around the queen bee within the hive, trying to keep the colony warm. They don’t fly in cold temperatures.

There is only one queen bee in each colony. Queen bees are long and skinny compared to the other bees in a colony. They have a distinct space between their large eyes similar to worker bees and are often followed by a group of worker bees. Queen bees are the only female bee within a honeybee colony that breed and lay eggs to produce young honeybees. A queen bee lives between 2-8 years. Within 3-5 days of a young queen bee hatching, she can fly up to 8 miles away breeding with 8-15 male bees before returning to her colony and beginning to lay eggs. The queen bee determines whether she will lay eggs destined to be female or male bees.

Speaking of male bees, they are referred to as drones in a bee colony. Drones are very large and blocky shaped compared to the other bees in the hive, and they have very large compound eyes. The one job of drones is to breed with a queen bee so she
can produce fertilized eggs. Upon successfully breeding with a queen bee, they die. Drones that never breed with a queen bee serve no purpose within a colony. If drones don’t die of old age (8 weeks) or any other natural and unnatural causes, the worker bees will kick them out of the hive in the fall. As non-producers within a colony, the drones are removed prior to the onset of winter so precious food and energy is not wasted on keeping drones alive throughout the winter.

Biology Questions:

Ask students to select a social order of honeybee they would like to illustrate. Ask them to describe the features that distinguish the illustrated bee and what it’s job is within the colony. Ask students if they know what a bee's job is in agriculture and nature.

Remember:

• Worker bee physical description and job: short, skinny and relatively small compared to other bees in a colony. Worker bees take care of the entire colony! They feed the colony, clean the hive, guard the hive, collect pollen and nectar, and convert nectar collected from flowers into honey.

• Queen bee physical description and job: long, skinny, space between large eyes and is often followed by an entourage of worker bees. Her job is to lay eggs which will grow into future queens, workers or drones.

• Drone bee physical description and job: These are the male bees in a colony. Their only job is to breed with a queen bee so she can lay eggs to produce baby bees. Drones are very large and blocky shaped compared to the other bees in the hive, and they have very large compound eyes.

• The job of bees in the world is as pollinators- a valuable ecosystem service.
Illustration 3: Simplified illustration of a worker bee, queen bee and drone bee.
2. Honeybee Development and Anatomy

Youth Learning Objectives:

• Youth will identify food fed to the worker, queen and drone bees
• Youth will identify and count basic external anatomy of honeybees

Queen bees decide whether they will lay male or female bee eggs. Then once hatched, the food fed to the young larva (active but not yet developed honeybees) will determine how quickly the bees develop or grow. The four stages of honeybee development are: egg (unhatched developing young), larva (active, immature young), pupa (inactive, immature young) and adult (fully developed).

A queen bee will lay one egg per each hexagon shaped cell inside the honeycomb, laying up to 2,000 eggs a day within her beehive. The worker bees caring for young bees determine whether the female bees will become workers or future queens based on the food they feed the young larva. They eat royal jelly. This is the best food because royal jelly is very high in nutrients that bees need. Royal jelly is made by bees and if fed exclusively to female honeybee larva, will lead to the development of a future queen bee. A simple diet of honey and pollen fed to a female larva will lead to the development of a worker bee.

Queen bees emerge from their cells within 16 days of being laid due to their very nutrient and protein rich diet of royal jelly. Worker bees emerge within 21 days. Drone bees are fed a diet similar to that of a worker, but take longer to develop. Drones leave their cells within 24 days of being laid.

Honeybees are an insect so they have an exoskeleton, a hard external skeleton/shell instead of bones under skin like us. They are also fuzzy. Their
exoskeleton is made up of three main parts, the: head, thorax and abdomen. The exoskeleton plates on the underside of the honeybee’s abdomen have wax glands. Wax comes out and honeybees use this wax to produce build honeycomb.

Honeybees have two sets of eyes; large compound eyes made up of many smaller optical units that see brightness and color, and five smaller eyes on top of their head called ocelli which see light and movement. Together, these sets of eyes help a honeybee travel by assessing distances and shapes. A honeybee also has two antennae on their head which are used to smell and feel.

The thorax is the middle part of the bee. The thorax is where all the legs and all the wings attach. Honeybees have six legs and four wings attached to their thorax. When viewed from above, bees have three legs on their left side, and three legs on their right, as well as two wings on their left and two wings on their right. The fore wing (front wing on both the left and right side closest to the head) and hind wing (back wing, closest to the abdomen) on each side of the thorax work together as one wing which is why it appears that honeybees only have two wings.

Anatomy and Math Questions:
Discuss symmetry with students- when one half of something is looks the same as the other half. Use a mirror to see how the left half of the following illustration of a honeybee is identical to the right half when viewed from above. Then identify and count parts of the bee (legs, wings, eyes, etc). What are other things that have symmetry (some types of flowers)? What are things that are asymmetrical (not symmetrical)? Discuss with students what the usefulness of each anatomy part is to the bee.

Remember:
• When viewed from above, the left half of the honeybee will be identical to the right half.

• Honeybees have a total of: 6 legs, 2 antennae, 4 wings (2 forewings, 2 hind wings), 2 compound eyes, and 5 ocelli. Legs help with landing and holding onto things. Antennae help with smell and interpreting through feel. Wings help bees to travel by flying. Eyes help bees to navigate with vision. These features all help a bee to seek and forage for nectar and pollen to eat.

• Things that have symmetry when comparing one half to another: squares, circles, an isosceles triangle, your face, a butterfly.

• Things that are asymmetrical: maybe a rock found on the ground, a book cover illustration, or chewed up gum.
Illustration 4: Basic external anatomy of honeybee- see the symmetry?
3. Identifying Queen Bees

Youth Learning Objectives:

- Youth identify why honeybees sting, and why most can only sting once
- Youth recognize the vital role queen bees play in honeybee colony success

Queen bees are long and slender bees, typically longer than worker bees but not as fat as drones. Worker bees are the smaller bees in a colony, shorter than queens and smaller than drones. Drones are large in comparison to workers, and boxy when compared to queens. Their compound eyes are very large and touch each other whereas there is a space between the compound eyes of both worker bees and queens.

Queen bees and worker bees look similar but queens are long and skinny and worker bees are short and skinny. Drone bees are fatter and longer than workers, but shorter than queens. Drones are kind of blocky shaped and also have two very large compound eyes that touch on top of their head. There is a small group of worker bees that follow the queen bee everywhere, making sure she is fed, clean and well taken care of so she can focus on laying up to 200,000 eggs a day!

Queen bees are the only bees in a honeybee colony that could repetitively sting someone since their stinger is barbless, but since they only leave their colony once in their lifetime, it is unlikely to be stung by a queen bee. Worker bees will sting if they feel threatened, but can only sting once since their stingers have barbs. Barbed stingers remain stuck in the victim and as a bee pulls away, her intestines (which are attached to her stinger) are pulled outside her body, causing to her death. Drone bees lack stingers,
and instead of a stinger they have a male reproductive organ for mating with a queen bee.

Science Questions:

Ask students to identify and find the queen bee in the next picture. Can they identify the drones too? How did they tell the difference? Why should a beekeeper be able to identify which bee is the queen? What is the impact of honeybee colony losses to agriculture and the natural world?

Remember:

• Queen bees are slender and long. They are thinner than a drone and longer than a worker bee. Queens are surrounded by a group of worker bees that follow her and take care of her. If beekeepers can find and identify their queen bee, they know their colony is healthy. Without a queen bee, the whole colony will die.

• Drones are large, boxy in shape, fatter than queen bees and workers, and their compound eyes are so large they touch on top of their heads. The compound eyes of both queens and workers do not touch. If a beekeeper notices their hive is full of drone bees instead of workers, they know their colony is doomed because something happened to the queen and a worker bee started laying eggs (and worker bees can only lay male (unfertilized eggs).

• Worker bees are short and slender when compared to a queen bee or drones. Worker bees can only sting once. A worker bee’s barbed stinger will remain stuck in her victim and as she pulls away, pulling her intestines outside her body and killing her.

• Honeybees are valuable pollinators for both agricultural production and ecosystem services. Colony losses have both agricultural and environmental impacts as a result.
Illustration 5: Identify and locate the queen bee, worker bees and drone bees.
Illustration 6: Beekeeper catching a swarm of bees to rehome elsewhere.
4. Bee Hives

Youth Learning Objectives:

• Youth will distinguish between the homes of social and solitary bees

• Youth will be able to distinguish basic types of beehives and the bees they house

What type of beehive makes the best house for bees? When honeybees are looking for a suitable home, they really are just looking for a safe, dark space which they can begin to build wax honeycomb in and raise baby bees and store food for the winter. That dark space could be a hollow tree, inside the wall of a building, or even a dark corner of a barn. There are many different styles of human made beehives, each as functional as the next for honeybees, it just depends on a beekeeper’s preference, goals and capabilities. Remember, honeybees are just one example of a type of bee. Most of the other bees in the world are solitary meaning they live by themselves instead of with other bees. As a result they need a much smaller house since they don’t need to store lots of food or raise lots of baby bees like honeybees do.

Skep beehives were the original managed beehive. Skep beehives look like a basket made of grasses. Honeybees build honeycomb inside of these to raise baby bees and store food in. They are mobile, and transportable, but not convenient for close honeybee health monitoring.

The most common beehive used by beekeepers in the United States is the Langstroth hive. These are the hives people see most often in fields and in orchards. The Langstroth hive is made of stackable boxes, each of which is filled with 8-10 wooden frames. The frames are where honeybees build their honeycomb to house
developing bees and store food. These hives are easily managed by beekeepers and easy to transport which is why many professional beekeepers use them.

Warre hives are similar to Langstroth hives in many ways. They are vertically managed hives, but rather than adding empty boxes on top of the hive, the empty boxes are placed below the upper boxes. This works with the honeybee’s natural tendency to build honeycomb in a downward direction.

Another popular style of hive is the Top Bar Hive. The Top Bar Hive is convenient for beekeepers not wanting to be lifting and hefting heavy boxes often. The Top Bar is essentially a long, elevated hollow space which has top bars placed inside that the honeybees will build wax comb from instead of filling in frames like in a Langstroth hive. All the hives described provide a safe dark place for an entire colony.

Engineering Questions:
Build a bee boarding house. They can be built by drilling holes into a block of wood, or by tying together a bundle of hollow reeds and straws. Talk through each step of the engineering process with students, making sure that everyone gets the opportunity to help with construction or at least external painting of the house. Explain that bee boarding houses are not built for honeybees, but solitary bees that can and like to live alone and need less space. A honeybee colony is a super organism and individual honeybees would not be able to survive alone. Bee boarding houses are built to provide shelter for any of the various other thousands of varieties of bees in the wild.

Remember:
• Honeybees are just one example of bee species in the United States. There are many species of bees in the wild- some live in holes in the ground, some live in hollow trees,
some might live in a junk pile! They are all just looking for a safe, dry place to build a nest.

- Unlike honeybees which depend on queens, workers and drones working together in a colony to survive, some kinds of bees in the wild like to live by themselves. Solitary bees are valuable pollinators just like honeybees, sometimes, they are even more efficient than honeybees!
- Bee boarding houses can be built and placed outside for bees that live by themselves.
- Remember to place the completed bee boarding houses in a sunny location and near water so they are appealing to wild bees looking for a home.
Illustration 7: Types of beehives for honeybees.
Illustration 8: Beehive positioning south east to maximize warming by sun.
5. Apiary Positioning & Location

Youth Learning Objectives:

• Youth will recognize the importance of following rules for beekeeping
• Youth will recognize needs of bees and identify considerations for beekeeping in rural and urban areas

Many states have rules guiding beekeeping. It is best to check with your state’s department of agriculture to learn about any beekeeping rules. We have beekeeping rules to help keep bees healthy and limit the transfer of sickness between bee colonies. Some cities also have beekeeping laws for public safety. If you want to keep bees in a city (urban beekeeping), check before you get started!

It is best to place beehives where they face the south or south east. This positioning takes full advantage of the rising sun to heat the hive entrance and encourage bee activity earlier in the day. Honeybees are poikilothermic, which means that their body temperature changes with surrounding air temperature. This means that they move slowly in colder temperatures, and are more active as temperatures rise. As long as temperatures are below 50 degree Fahrenheit, bees are typically not very active, but as temperatures increase, their activity will increase. This affects where we place their hives.

Hives should be off the ground and protected from scavenging animals such as raccoons and skunks that love to eat honeybees and honey, so an elevated hive can help to keep these pests from entering the hives. The elevation also allows air to circulate beneath the hives and can help prevent the hive from rotting.
Honeybees need food and water. Honeybees can and will fly up to three miles regularly from their hive in search of food and water, potentially further. Honeybees will forage on any pollen and nectar producing blossoms. As for water, they will collect water in the form of dew, from puddles, lakes and rivers, even stock tanks or swimming pools. Some beekeepers place dishes of water near hive entrances with rocks so that the bees do not fall into the water and drown.

Both urban (big cities) and rural (smaller towns or the countryside) areas can be good places for bees to find food. Honeybees within or near urban areas feed on flowering trees and shrubs in parks and along streets, flowers in pots and window boxes, and even in urban gardens. In rural areas, honeybees forage on both native flowering forbs, shrubs and trees, as well as agricultural crops that produce blossoms.

A concern in rural agricultural areas is the use of chemicals to control pests that damage crops. Some chemicals can negatively impact honeybee health or even kill them. All chemicals have a label that clearly states the appropriate time, amount and manner which the chemicals may be applied so that the negative impacts to honeybees and other pollinators are removed or lessened.

Science Questions:
Discuss the challenges and benefits of urban compared to rural beekeeping with students. What special considerations need to be taken into account in both situations with respect to hive locations (closeness to water, forage, potential for chemical contamination)? Ask students to draw a picture of where they live and where they would position a beehive or bee boarding house if they have one and why.

Remember:
• Discuss challenges of urban beekeeping: there might be rules to follow, neighbors may not like or be scared of bees, where can you place a beehive if you don’t have a yard or live in a small apartment?
• Discuss benefits of urban beekeeping: keeping bees can help to pollinate flowers growing in window boxes or plants growing in urban gardens, there is less likelihood the bees will be accidentally sprayed by agro-chemicals used to control pests.
• Discuss challenges of rural beekeeping: wild animals might break into your hives, drought conditions can impact availability of natural flowers, hives might accidentally be sprayed by agro-chemicals being applied to crops.
• Discuss benefits of rural beekeeping: potentially wide variety and diversity of flowering plants to forage on, more space to keep bees and less likely they will irritate neighbors.
Illustration 9: Beekeeping in rural and urban locations.
Illustration 10: A honeybee foraging and pollinating an almond blossom.
6. Pollination

Youth Learning Objectives:

• Youth will distinguish pollination from gathering nectar
• Youth will recognize the value of bees in pollination

Pollination benefits the natural world and humans. This makes it an ecosystem service, or a natural benefit to others by simply existing. Pollination is considered an ecosystem service provided by honeybees and other pollinators. Pollination is the act of fertilization. The transfer of male parts of a flowering plant to the female parts. As pollinators visit multiple flowers, seeking food, they often end up pollinating the flowers they visit as a result. About 80% of the flowering plants in the world rely on pollinators (like honeybees) for fertilization and plant growth.

Pollinators are organisms (like honeybees) that transfer pollen between flowers, helping to pollinate. There are thousands of pollinators; some examples include hummingbirds, bats, beetles, ants, bees and wasps. Honeybees are very efficient and effective at pollination due to their natural foraging behavior. A honeybee collects and consumes both nectar (juices produced by flowers) and pollen (powder from male parts of flowers) from flowering plants. Nectar is the carbohydrate energy source that honeybees convert into honey, and pollen is a protein energy source for honeybees. What is not consumed or fed to other bees is stored in cells within the wax comb inside a bee hive for later.

As honeybees forage on a flower for nectar and/or pollen, pollen granules will stick to the honeybee’s body. Then when the honeybee leaves that flower and lands on another flower to feed, the pollen granules stuck to her body may come into contact with
the female parts of that next flower, thus fertilizing the flower. Honeybees are very efficient at pollination because they will fly between many flowers of the same variety on any one foraging trip outside the hive; spreading pollen granules between many flowers.

Science Questions:
Demonstrate pollination by using a cotton ball (which represents the honeybee) to transfer glitter sprinkled on one faux flower to another. Then ask students to illustrate the male and female parts of a flower, and describe where bees gather nectar and pollen from, place glue and glitter in the appropriate locations to indicate pollen (anthers of flowers, legs of bees, etc). Discuss why pollination is a valuable ecosystem service and if youth can identify any foods they enjoy that require pollination to produce a crop.

Remember:
• The cotton ball, glitter and faux flowers teach how the honeybee transfers pollen between flowers. To show how fertilization works, the illustration of the male and female parts of a flower is necessary.
• On the student’s illustration of male and female parts, you as the instructor will place glue and glitter on the male pollen producing parts of the flower and glue a glitter covered cotton ball to the illustration to indicate how the honeybee transferred the pollen to the female part of a flower. This will help keep the associated mess with glitter and glue to a minimum.
• Pollination is a valuable ecosystem service because so many flowering plants in nature and agriculture could not produce reproduce without pollinators.
Illustration 11: Fruits dependent upon pollinators for pollination.
7. Migratory Beekeeping

Youth Learning Objectives:

- Youth will describe migratory beekeeping through the story of pollinator dependent crops and draw a possible beekeeper migration route for their geographic area
- Youth will describe how diverse diets help keep bees strong and healthy

One example of a pollinator dependent crop is the almond. Almonds grow on trees. To produce an almond, a flower blossoming on an almond tree must first be pollinated. 80% of the almonds grown in the world, are grown in California. When those almond trees bloom, over half of the honeybee colonies in the U.S. are transported to California for pollination services.

Managing honeybees for pollination services has become profitable. Pollination services are needed by certain farmers (like almond farmers) growing produce that is cross pollination dependent and cannot readily be open pollinated. Honeybee pollination services are a by-product of their natural foraging behavior. Beekeepers are able to make money on this behavior by transporting their honeybee colonies between different farms requesting pollination of their crop. The beekeepers then charge the farmer requesting pollination services a fee per each colony needed for pollinations.

The following calendar describes one example of a potential migratory beekeeping route. Not all migratory beekeepers follow this specific rotation or calendar. Some beekeepers travel to other states at different times, and have contracts to pollinate other crops. This just helps to describe when and where the bees are being moved, and why.
<table>
<thead>
<tr>
<th>Month</th>
<th>Where</th>
<th>Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>February-March</td>
<td>California</td>
<td>Pollinating almonds</td>
</tr>
<tr>
<td>April-May</td>
<td>Oregon or Washington</td>
<td>Pollinating cranberry bogs, blueberry fields, apple and cherry orchards</td>
</tr>
<tr>
<td>June-September</td>
<td>Montana or North Dakota or South Dakota</td>
<td>Rest and recover; but will still pollinate anything they come into contact with</td>
</tr>
<tr>
<td>October-February</td>
<td>Texas or Southern Idaho</td>
<td>Texas for the winter where it is warmer, or kept in climate controlled storage facility like those used to store potatoes in southern Idaho</td>
</tr>
</tbody>
</table>

Map and Science Questions:
Honeybees produce the most honey while they are, “resting and recovering,” from their migratory journey and contracted pollination services. Ask students why they think this is? Research migratory bee routes in the United States and ask students to draw a map illustrating the routes and the crops in each location that require pollination services from managed honeybee colonies (examples include almonds in California, blueberries in Maine, oranges in Florida, etc).

Remember:

• This activity can be strengthened with place based learning. Are there crops dependent upon pollination in your area? If so, emphasize this in your activity.
• Honeybees are stronger and healthier, and produce the most honey while they are resting and recovering from intense single crop pollination services. Why? They have a more diverse diet rather than feeding on a single source of food, and are healthier as a result. They are also expending much less energy to forage since they are not competing with as many other bees for forage.
Illustration 12: Example map of migratory beekeeping routes in the U.S. and crops to be pollinated.
Illustration 13: How migratory beekeepers transport beehives across the U.S.
8. Overwintering Bees

Youth Learning Objectives:

• Youth will be able to list three ways that honeybees survive winter conditions
• Youth will describe what the infrared illustration shows in relation to monitoring overwintering hives

Bees live under cold conditions as long as they are healthy and have a food supply. Some beekeepers help their bees during cold winters by feeding them, providing wind breaks, and insulating the hives. The combination of cold and wet conditions can negatively affect honeybees, but cold conditions alone can be survived.

Honeybees survive cold temperatures by several ways. They can cluster into a ball for warmth. The queen is always positioned at the center of the cluster, while worker bees shiver to build heat and warmth, taking turns rotating from being on the outside of the cluster (colder) to the center (warmest). The colder it is, the tighter the cluster. As temperatures rise, the cluster loosens, eventually dissolving as bees begin to venture outside the hive.

Bee hives should not be opened for inspection unless temperatures are above 45 degrees Fahrenheit. With advances in technology, beekeepers can now monitor bee conditions throughout the winter without opening their hives and exposing their bees to the cooler temperatures.

Technology Questions:

Beekeepers can monitor their hives using infrared technology. Infrared technology allows us to see images of heat energy, something we can not visually see otherwise. This imagining can help search and rescue to find people they would not otherwise see.
in the dark, or help firefighters to find hot spots on a fireline that do not have flames and are no longer producing smoke. Based on the illustration showing an infrared photo of a bee colony, ask students to describe observations and what the technology helps them to see. Ask the students to illustrate what they think might be happening within the hive from the infrared illustration.

Remember:

• During colder temperatures, such as in the fall or winter, bees cluster together for warmth. Worker bees form a ball with the queen at the center (the warmest part of the cluster) and the bees surrounding her shiver to produce heat. The workers take turns rotating from within the cluster, to the outside, so that each has a chance to be warm after being on the outside of the cluster where it is cooler.
Illustration 14: Illustration of a beehive viewed via thermal imaging.
Illustration 15: The basic beekeeping tools needed to manage honeybees.
Resources


tanpollinator


The Honeybee Conservancy. (n.d.) The honeybee conservancy lesson plans and resources. Retrieved from https://thehoneybeeconservancy.org/bee-lesson-plans/
Advanced Beekeeper Programs in the U.S.

Alabama Master Beekeeper Program
http://www.alabamamasterbeekeepers.com

Colorado State Beekeeper Association-Master Beekeeper Certification Program
http://coloradobeekeepers.org/education/csba-master-beekeeper-program/

Cornell University Master Beekeeper Certificate
https://pollinator.cals.cornell.edu/master-beekeeper-program/

Eastern Apiculture Society (EAS)- Master Beekeeper Certificate Program
http://www.easternapiculture.org/master-beekeepers/certification.html

University of Maryland- Graduate Certificate of Professional Studies in Beekeeping
https://oes.umd.edu/graduates-post-baccalaureates-professionals/professional-graduate-programs/graduate-programs-applied-entomology

Midwest Master Beekeeper Certification Program

North Carolina State Beekeepers Association-Master Beekeeper

Ohio State Beekeepers Certified Master Beekeeper Program
http://www.ohiostatebeeknees.org/resources/master-beekeeper-program/

Oregon Master Beekeeper Program
https://extension.oregonstate.edu/mb

South Carolina Master Beekeeper Program
https://scstatebeekeepers.com/master-beekeeper-program/

Texas Master Beekeeper Program
https://masterbeekeeper.tamu.edu

University of Tennessee Master Beekeeper Program
https://ag.tennessee.edu/EPP/Pages/Bees%20and%20Beekeeping/UT-Beemaster-Program.aspx

University of California-Davis- California Master Beekeeper Program
https://cambp.ucdavis.edu
University of Florida
https://entnemdept.ifas.ufl.edu/honey-bee/extension/master-beekeeper-program/

University of Georgia Master Beekeeper Program
http://bees.caes.uga.edu/georgia-master-beekeeper-program/master-beekeepers.html

University of Montana Online Beekeeping Certificate Program
https://www.umt.edu/sell/programs/bee/about.php

University of Nebraska- Great Plains Master Beekeeping
https://entomology.unl.edu/bee-lab

Virginia State Beekeepers Association-Master Beekeeper
https://www.virginiabeekkeepers.org/master-beekeeper

Washington State Beekeepers Association (WASBA)- Master Beekeeper Program
http://wamasterbeekeepers.org

West Virginia Beekeepers Association- Master Beekeeper Program
http://www.wvbeekeepers.org/certification-levels.html