ANALYSIS OF THE CURRENT STATE OF THE BEEKEEPING INDUSTRY IN ALABAMA

By

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Abstract

In this thesis, I investigated the following research questions, “What are characteristics of Alabama beekeepers?” “What are revenue sources for beekeepers in Alabama?” and “What are barriers to expansion of beekeeping operations?” To investigate these questions, we used a survey that asked various operations and revenue questions to Alabama beekeepers. We collected 150 responses. Out of the 150, 62%, or 93 beekeepers classified as hobbyists, meaning they manage 25 hives or less. 32% or 48 out of 150 were sideliner beekeepers, managing anywhere between 26 and 299 hives. The remaining 6% were commercial beekeepers, running 300 plus operations. The results reveal that 80% of the survey participated in honey sales, making it the most popular revenue source by far. The second largest source of income was nuc sales, which 24.3% of the survey participated in. 18 beekeepers out of the 150 (12.3%) use their hives for pollination services, and 20 (13.7) partake in queen sales. The smallest source of revenue was packaged bee sales, which only 7 (4.6%) beekeepers participated in. Although it would require more financial and cost data to know whether beekeeping is feasible in Alabama or not, the results from this research point towards improving feasibility.

Table of Contents

List of Tables

Introduction/Background

All over the world, beekeeping provides several benefits to society. It supports agricultural production by pollinating crops and produces honey, which has many proven health and medicinal benefits. Another benefit is that it contributes to maintaining biodiversity (Krishnan et al. 2020). Beekeeping is a source of livelihood for millions of people globally (Amulen et al. 2017). A beekeeper is someone who owns and raises bees. However, according to (Day and White 2022), information and data about productivity and the behavior of beekeepers is lacking. Although bees and beekeepers are crucial for honey production and pollination services, not much is known about them, especially in the state of Alabama. The question(s) this research aims to answer are, "What are characteristics of Alabama beekeepers?" "What are sources of revenue for Alabama beekeepers?" and "What are barriers to expansion of beekeeping operations?" These questions begin to point towards the economic feasibility of beekeeping in Alabama, although a more in-depth study with financial data and opportunity costs are needed to make that determination.

Beekeepers in the United States, more specifically Alabama, primarily raise and use European Honeybees (*Apis Mellifera)* for their operation. Honeybees are one of the most important and ecologically valuable pollinators in the world. These honeybees play multiple key roles during their lifetime, such as encouraging food production and enhancing biodiversity, both through pollination (Warner et al. 2023). A typical honeybee colony ranges from about 20,000 bees during the winter months to 50,000 bees during the warmer months (Degenfellner et al. 2024). Every honeybee colony consists of three types of bees. There are drones, which are male

bees whose only job is to mate with the queen. There are queens, who are crucial to a hive because they are the only bee that can lay eggs and reproduce. Lastly, there are worker bees, non-reproductive females who carry the bulk of the workload within the hive, such as building the hive, feeding drones and queens, and collecting pollen, water, propolis, and nectar. Each hive typically consists of one queen, tens of thousands of worker bees, and a few hundred drones ("European honey bee- apis mellifera" accessed July 21, 2024).

This thesis aims to describe beekeepers and identify key sources of revenue for beekeepers in Alabama. There are several diverse sources of revenue that come from beekeeping operations. The revenue sources covered in this thesis include honey sales, pollination services, queen sales, nuc sales (defined below), and packaged bee sales.

A common revenue source is honey production. In 2021, Alabama produced 320,000 pounds of honey ("Southern Region News Release Honey" accessed July 21, 2024). In 2022, the total amount of honey produced in Alabama increased to 400,000 pounds ("Southern Region News Release Honey" accessed July 21, 2024). Then worker bees go out and pollinate different flowers and crops, they collect nectar from the plants and bring it back to the hives. Once they return with the nectar, the bees break down the nectar into simple sugars and store it inside the honeycomb in the hive. Then, a constant fanning of the bees' wings causes the honey moisture to evaporate, leaving a sweet, rich liquid known as honey ("How Honey is Made" accessed July 19, 2024). The beekeeper then removes the honey from the comb, bottles it up and marks it with a label, and sells it. The most popular variety of honey that is sold in Alabama is Wildflower honey (personal communication with beekeeper Justin Cagle). The bees pollinate and collect nectar from a wide variety of native plants and flowers such as white and red clover, dandelions,

gallberry, cotton, sunflowers, alfalfa and many more, which is why it received the name Wildflower honey.

Another revenue source for beekeepers is pollination services. Pollination is a process that takes place between wild or managed bees and plants of all sorts: fruits, vegetables, flowers, and trees. Honeybees are such good pollinators for multiple reasons. First, they can pollinate many plant species. Second, a hive consists of 30,000 bees on average, and they can pollinate year-round. Third, honeybees can forage over large distances, so they can provide pollination services over a wide area. Lastly, the bees can communicate with other hive members and tell them where abundant food sources are (Alebachew 2018). Pollination is essential for plants to produce fruit and for bees to eat and make honey. Among the leading crops that benefit from animal pollination, 13 are entirely reliant upon animal pollinators, 27 are moderately dependent, meaning they can still become fertilized without animal pollination (Gallai and Vaissière 2009).

Some of the most popular crops that honeybees pollinate in Alabama are cucumbers, blueberries, watermelon, squash, cantaloupe, peaches, strawberries, and apples. During the pollination process, bees collect pollen from the plant's anthers (male part) and transfer it to the stigma (female part). This process allows the flower to be fertilized and ends in the flower producing fruit and seeds. Crop producers all over the country will pay beekeepers for their hives to come and pollinate their crops so that they will produce a sufficient yield. The pollination service market is booming, especially in the Pacific Northwest. Beekeepers load up their hives and haul them to California from all over the country for pollination services. California leads all states by far in total fees paid by farmers to beekeepers, totaling $270 million for pollination in 2017 ("Southern Region News Release Honey" accessed July 21, 2024). Washington is the second largest state in pollination service fees with $12.6 million paid in 2017. Bees' pollination

services are worth $215 billion worldwide per year (Abro et al. 2022). Though the pollination service market in Alabama is much smaller than that, beekeepers will load up their hives and transport them to states like California and Washington to pollinate because the price farmers pay for pollination services are worth more than the transportation costs. The average cost that beekeepers charged farmers for pollination services in California in 2023 was $202 per hive (Wells 2022). The almond bloom typically lasts from 4-6 weeks, so beekeepers are getting paid that $202 rate for up to 6 weeks at a time.

The other revenue sources covered in this thesis are queen sales, nuc sales and packaged bee sales. All three of these sources are key factors to build a new hive or hives. A queen bee is the central part of a hive and plays a critical role in the functioning of the hive. The queen regulates the colonies' population and potential by releasing pheromones and laying eggs (Kocher et al. 2009). Queen fertility is a crucial factor for a colony, and colony productivity is most directly related to the overall reproductive health of the queen (Li et al. 2023). So, to build a hive, the first, and most crucial step is to purchase a healthy queen bee. After that, depending on how many hives a beekeeper wants to build, the next step would be to buy a nuc or packaged bees. A nuc is a small colony of bees, typically about 4 frames, that can be used to start new hives or help repair damaged ones. Nucs are a good option for up-and-coming beekeepers because they are affordable and manageable, given that the bees are already on frames. Packaged bees come in a screened in box with no frames and contain roughly 3 pounds of bees. Each one of these revenue sources is practiced in Alabama to some extent, and we aim to show the reader the current activity in each market.

In 2023 Florida had a total of 295,000 honeybee colonies, Georgia had 118,000 colonies and Mississippi had 20,000. All these states border Alabama, and they all outnumber Alabama

by a seemingly significant amount. Alabama only had 7,500 colonies in 2023 ("Honey bee colonies" accessed July 21, 2024).

Literature Review

Honey

Honey is a natural product produced by honeybees by using nectar collected from a single plant species (mono-floral honey) or by multiple flowering plant species (poly-floral honey) (Ndungu et al. 2024). There are distinctive characteristics of each type of honey that bees produce, such as aroma, flavor, color, and chemical composition based on its geographical, botanical, and seasonal origin (Ndungu et al. 2024). Its sweet, rich flavor, high nutritional value, and many medical benefits have been used as medicine in humans' daily lives for centuries (Huang et al. 2021).

However, in recent years, due to worldwide climate change and pesticide abuse, honeybee colonies have been directly influenced in a negative way, which has led to a considerable decrease in honey yields (Huang et al. 2021). Due to the decrease in the honey supply, the market has become an attractive target for mislabeling for commercial profits. Food fraud can be defined as the economically motivated adulteration or misrepresentation of food products with lower cost substances (Gustafson et al. 2024). Most of the honey fraud occurs in China, where some honey processors aim to use fraudulent activities to illegally divert Chinese honey into countries with bans or tariffs directed towards Chinese honey imports (Jones Ritten et al. 2019). In 2011, a multinational investigation on honey market fraud led to one of the biggest food fraud busts in history. Fifteen people across multiple countries were indicted for illegally diverting more than $80 billion worth of honey from China into the United States (Jones Ritten

et al. 2019). The most frequent form of adulteration is the addition of cheap sugar-based sweeteners, such as corn syrup, invert sugar syrup, rice syrup, and high fructose corn syrup (Huang et al. 2021). The addition of these sweeteners allows for more "honey" to be bottled and sold to meet the market demand, while also extending the shelf life of the honey. Pure, raw honey that has no additives or preservatives is supposed to crystalize or harden due to the natural sugars in the honey. Consumers are likely not aware of this, so they continue to buy the fake honey that is imported internationally.

Beekeepers across the United States can suffer monetary losses from the effects of food fraud and a lack of knowledge from the public on what real honey is. There are several factors that influence the consumption of honey, such as price, how the honey is labeled, whether it is liquid or crystalized, origin, and whether it was produced locally or imported from abroad (Sgroi and Modica 2023). Consumers may think that they are buying a certain variety or quality of honey, but what they may not know is that the honey has added sugars that take away the natural nutrients and health benefits of real honey. This misinformation of honey products to the public can lead to a decrease in honey sales for the beekeepers who are selling the real thing. Mislabeling of products is a major concern of human health and economic sustainability of high-quality products (Gustafson et al. 2024). Honey is one of the leading targets of food fraud, undermining honey prices and reducing demand for real, authentic honey. Up to 10% of honey samples are found to be fraudulent with honey traded internationally (Gustafson et al. 2024). One study found that when consumers are given honey laundering information, their willingness to pay a premium for fraud-free honey increased by as much as 27% (Jones Ritten et al. 2019). These results suggest that by educating the public on honey laundering and teaching them how to

know the difference between pure honey and the fake stuff, honey producers can potentially increase revenues and reduce the prevalence of food fraud.

Pollination Services

Pollination from honeybees is an essential step in growing all sorts of fruits and vegetables that humans eat daily that the public may not realize. The honeybee is managed for both honey and pollination services and is the single most important crop pollinator (Aizen and Harder 2009). Honeybees pollinate everything from almonds, blueberries, watermelons, strawberries, squash, and cucumbers to all sorts of different flowers that lead to the production of honey. Klein et al. (2007) stated that "One of every three bites of food that we take depends on bees." With the importance of honeybee pollination to produce crops in mind, concerns have begun to arise about the declining health of honeybee colonies over recent years.

Due to the diminishing wild pollinator populations worldwide from agricultural pesticides (Crenna et al. 2020), the role of pollination markets has increased, and in some instances, commercial crop pollination has almost completely substituted for wild pollinators altogether (Narjes and Lippert 2019). Hiring pollination services has become an important strategy to ensure fruit harvests in many pollinator-dependent crops (Narjes and Lippert 2019). Aizen and Harder (2009) estimate that the world's demand for managed honeybee pollination is growing faster than the population of honeybee colonies due to the rapid loss of wild pollinators. The global stock of commercial honeybee colonies has increased by 45% since 1961, though the main exceptions to this global increase take place in the United States and European countries. The American population of honeybee hives has declined consistently since 1961, at an average of -1.79% per year (Aizen and Harder 2009). As a result of this decline in the United States,

agriculture production might suffer from the lack of available pollinators. With the rising demand for managed pollinators, it is important for farmers and beekeepers to arrange contracts to ensure that farmers get enough pollinators and beekeepers get paid according to the work from their hives.

California almonds is the largest market for managed pollination services in the world, relying almost solely on managed pollinators to help produce a sufficient crop (Goodrich and Goodhue 2020). Beekeepers will load their hives up and transport them to California from all corners of the country just to pollinate almonds each year. However, all colonies are not equal. Goodrich's (2019) research suggests that colony strength is an important determinant of pollination fees for beekeepers. Her findings suggest that providing weak colonies for almond pollination results in a poor job of pollinating, which ultimately leads to lower fees collected by the beekeeper from the farmer. Weaker colonies can result from a few different occurrences, such as harsh winter weather, storms and strong winds, pesticide/herbicide exposure, pests like Varroa mites, American foulbrood, and hive beetles. In her findings, Goodrich (2019) found that a 10% increase in a beekeeper's winter mortality rates leads to an average decrease of 16% in total revenue loss from almond pollination. For commercial beekeepers in the United States, given the fact that almond pollination is one of their primary sources of revenue, 16% is a substantial loss for them. When arranging for pollination services, beekeepers and growers must communicate and arrange a contract so that the beekeeper gets paid for their services. The most common contract is known as a "forward contract," which matches beekeepers and growers before the time of pollination (Goodrich and Goodhue 2020). According to Goodrich and Goodhue (2020), beekeepers are paid according to their delivered colony strength each year. Although growers cannot monitor a beekeeper's colony strength prior to pollination season, there

is a minimum colony strength requirement that growers can include in their contracts to ensure that they get efficient pollination.

Honeybee Pests/Diseases

There are currently multiple stress factors that have a negative impact on honeybee health within colonies (Frizzera et al. 2023). The most destructive pest to honeybees is the *Varroa Destructor,* an invasive, ectoparasitic mite that damages honeybee colonies (Scaramella et al. 2023). These mites are the largest pathogenic threat to honeybee health around the globe. In the United States, a 43% colony loss was reported from April 2019 to April 2020, with Varroa mites playing the leading role in damage done (Warner et al. 2023).

The reason that these Varroa mites are so destructive is because of their ability to exploit the worker brood for reproduction, which leads to a massive population growth rate in the new host (Scaramella et al. 2023). The uncontrollable expansion of these mites has resulted in an alarming decrease in the wild pollinator population in Europe and North America. During the mite's reproductive cycle, they feed on developing bee pupae, bearing devastating honeybee viruses such as Deformed Wing Virus (DWV) that causes crippled honeybees that are not able to fly and end up dying much quicker.

The losses that colonies suffer due to Varroa mites affects the bees in another negative way also. Thermoregulation is the bee's ability to regulate the hive temperature regardless of outside weather fluctuations. Bees usually maintain a hive temperature of 34.5 degrees Celsius year-round (Frizzera et al. 2023). It takes a group effort to do this, usually a group of 50 or more bees warming up their thorax after consuming enough honey to be able to do so. Mite infestation can influence the physiology of individual bees, the number of bees involved in colony

thermoregulation as well as the supply of honey that is needed to perform thermoregulation (Frizzera et al. 2023). The peak Varroa season occurs during the hotter summer months, so colonies suffer losses right before they endure harsh winter conditions.

Another harmful honeybee disease that can cause severe damage to colonies is American Foulbrood. American Foulbrood is responsible for colony collapse disorder (El-Meihy et al. 2024). This disease is caused by a spore-forming bacterium called *Paenibacillus larvae* (Ghorbani-Nezami et al. 2015). This disease spreads incredibly fast and is almost impossible to contain once it enters the hive. Common treatment methods for American Foulbrood include the use of antibiotics, and if those are unsuccessful, the hives must be destroyed, often by burning them (Genersch 2010). Antibiotics are not sufficient to fight American Foulbrood disease because of the increasing resistance among *Paenibacillus larvae* strains (Evans 2003). Symptoms of AFB include soft brown decayed brood that is easily distinguishable from healthy brood in the hive (El-Meihy et al. 2024).

Chalkbrood disease is caused by the fungal pathogen, *Ascosphaera apis,* which grows and damages colonies through exposure to larvae (Pasho, Applegate, and Hopkins 2021). The larvae of bees are exposed to the fungi once it grows in the hive, and once they ingest it, infection happens almost immediately (Krutmuang et al. 2022). Once the larvae are dead, they are covered in a fluffy white mold that eventually turns dry and black (Sarwar 2016). Chalkbrood disease has been reported to thrive during the spring months when the hives are cold and damp, which gives the fungi a thriving environment to grow in (Krutmuang et al. 2022). After a thorough study, Krutmuang et al. (2022) found that cinnamon extract, in combination with multiple other extracts such as spearmint, lemongrass, and palmarosa has the potential to curb this disease.

Methods

To investigate Alabama beekeepers, we collected survey data both over the phone and by email. We used Qualtrics to design and create a survey that asks a variety of operations and revenue questions to beekeepers. First, we collected data through phone interviews. We started with a list of 21 Alabama beekeeper contacts obtained from a member of the Alabama Famers Federation. The list included the name of the beekeeper, their cell phone number, their email, where their operation was located, and the address of their operation. The research team (Scarbrough) started by cold calling each beekeeper on the list and asking them to answer a few questions for us. If they agreed, Scarbrough proceeded to ask them each question of the survey and record their responses in Qualtrics. The survey took about 20 minutes to complete from start to finish. Scarbrough was able to complete 17 surveys with beekeepers over the phone.

In order to speed up the rate of data collection, we additionally collected data by emailing the link to the survey (and a QR code) to a wider range of beekeepers. The Alabama Master Beekeepers program sent out an introduction email and link to their current and former participants. Additionally, the Alabama Beekeepers Association sent out a similar introductory email to their email list. For any master beekeepers wishing to receive public service credits toward their certification, survey participants could provide their contact information at the end of the survey.

The link to the survey and a QR code was included in the email so each beekeeper could click the link and take the survey themselves. After all the responses had been recorded, we transferred all the data from Qualtrics to Excel. After exporting the data to Excel, we then moved it to Stata, where we began to clean and analyze all the data from each recorded response to the survey. The tables we created based on the survey results are listed in the results section below.

We also used Stata to run a regression using "number of hives" as the dependent variable. The equation for the regression looked like:

$$\#hives = \partial_0 + \partial_1 yearsoperation + \partial_2\ primaryincome + \partial_3 otherjob + \partial_4\ honeysales + \partial_5\ pollinationservices + \partial_6\ queensales + \partial_7\ nucsales + \partial_8 packagedbeesales$$

We wanted to see how strongly or weakly correlated the number of hives were with variables such as "years of operation," "primary income," "other job besides beekeeping," "honey sales," "pollination services," "queen sales," "nuc sales," and "packaged bee sales." The description of the variables are in the same order as the equation. The p value we used to show statistical significance is $p < 0.1$. The table with the results from the regression is found in the results section below.

Results and Discussion

Operations Questions

A total of 199 respondents took the survey. Our results are based on 150 respondents who provided complete information for our variables of interest. In Table 1, the answers to the basic operations questions that we asked the beekeepers were analyzed and shown in this table for better understanding to the reader. The mean number of hives out of the 150 beekeepers that took the survey was roughly 70 hives. A hobbyist beekeeper has at most 25 hives. A sideliner is a beekeeper who has more than 25 hives, but no more than 300. A commercial beekeeper is one who manages at least 300 hives or more in their operation. The results also show that the total percent of hobbyist beekeepers that took the survey was 62%. The percentage of the survey that are sideliner beekeepers was 32% and the commercial beekeepers were responsible for 6% of the survey. These results show that most beekeepers that took this survey would be listed as hobbyist beekeepers.

Table 1: Operations questions results from beekeeper survey.

Variable	Mean/Pct
Number Hives (mean)	70.3
Years Operation (mean)	11.9
Have another Job	60.3%
Beekeeping Primary Income	2.9%
Hobbyist (<26 hives)	62%
Sideliner (between 26 and 299 hives)	32%

Commercial (300 or more hives)	6%
Buys Queens	62%
Buys Nucs	39.3%
Monitor for Varroa	90.7%
Number of Observations	150

The mean years of operation was about 12. Of those who took the survey, 60% of beekeepers have another job besides beekeeping. Also, only about 3% of respondents said that beekeeping was their primary source of income. Since 40% of the sample did not have another job but the vast majority also did not use beekeeping as a primary source of income, this might imply that some of these beekeepers are retired or stay at home parents. In our survey, we included a free-response question at the very end that asked each beekeeper what suggestions they had to help grow and expand beekeeping in the state of Alabama, and out of the 150 responses, over 30 beekeepers, or 20%, had very similar answers: educate the public on beekeeping to help recruit new beekeepers in the younger generation.

We also asked beekeepers if they purchased queens and nucs for their hives. Our purpose behind asking these questions was to see if there was a market for queen and nuc sales in Alabama or if queens and nucs were raised by beekeepers for personal use only or purchased elsewhere. 62% of our sample said yes to purchasing queens and roughly 39% confirmed that they buy nucs. Out of these responses, many of the beekeepers said that they purchase queens from other states than Alabama. To name a few, Georgia, Louisiana, South Carolina, Florida, California, Kentucky, and Mississippi were included in the states that Alabama beekeepers purchase queens from. 45.6% of beekeepers that buy queens specifically said that they buy

queens from states other than Alabama. The other 54.4% either said they buy queens in Alabama or did not specify. There is thus demand for queens and nucs in Alabama that is not being served by Alabama beekeepers. These results suggest a market opportunity for Alabama beekeepers to sell queens.

Varroa Monitoring

As previously discussed in the literature review and background, Varroa mites are a terribly invasive and destructive pest that can cause massive losses to honeybee colonies. The losses these intrusive mites are responsible for can and often lead to monetary losses for beekeepers. Beekeepers either must buy more bees to get their hive counts back up or they must try and make do with the bees they have left, which are often weaker and not as efficient due to the impact of the Varroa mites. In the survey, we asked beekeepers first if they monitor their hives for Varroa mites and if so, how they go about that process. Varroa monitoring is a process that beekeepers carry out to check their hives for mites and treat them if needed. There are several different methods that beekeepers use to monitor their colonies for Varroa, we did so by listing all the most common ways to monitor and asked the beekeeper to choose which method(s) they used most often to see which one was the most popular.

Table 2: Results from a list of questions asking beekeepers about how they monitor for Varroa Mites

Variable	Pct
Alcohol Wash Method	61.7%
Drone Brood Sample	3.4%
Powdered Sugar Roll	4.5%
Sticky Board Count	6.4%
Visual Inspection	14.2%
Other	9.2%
Number of Observations	136

The alcohol wash method was by far the most popular, given that nearly 62% of respondents chose this method of sampling. The alcohol wash method takes place by collecting a sample of bees and placing them in a jar or bottle with some rubbing alcohol and a strainer in it, shaking the jar or bottle for a few seconds. The Varroa mites cling to the bees with their legs, and when the jar is shaken along with the alcohol in it, the Varroa are separated from the bees and left floating around in the liquid. The only drawback from this method, according to a few personal conversations with beekeepers, is that not only does the alcohol kill all the mites, but it also kills all the bees in the sample.

The next form of monitoring that we included was the drone brood sampling method, in which only about 3% of the survey used. The drone brood sampling method occurs by directly examining drone brood, which are male eggs developing in little chambers within the hive, by

using a special tool called a capping-scratcher. Once the brood are removed, they are individually inspected and each adult female Varroa mite is recorded.

Another method used to sample mites and included in the survey is the powdered sugar roll practice. This method was chosen by 4.5% of the beekeepers, which still falls significantly short of the alcohol wash technique. The powdered sugar roll method is very similar to the alcohol wash, the only difference is the use of powdered sugar instead of rubbing alcohol. The replacement of alcohol with powdered sugar also does not end in the death of all the bees that are being sampled. This method is highly encouraged because of its effectiveness in detecting Varroa and its ability to not kill any bees and cause damage to any hives (Roth et al. 2022).

The next method of sampling in the survey is the sticky board count procedure. This method was used by 6.4% of the survey, or 10 out of the 150 beekeepers. This is the least invasive monitoring technique, given that a sticky board is placed under the hive to catch fallen or dead mites (Roth et al. 2022).

The last sampling method we included in the survey is the visual inspection method. This method is quite self-explanatory: beekeepers get to a point in their experience where they can look at their bees and see if they have any damage or signs of Varroa mites. This method was the second most popular choice, with 21 beekeepers, 14.2% of the survey, selecting this option as their method of choice. According to some of the beekeepers, the reason that they choose not to use any of the previous methods and just look at their bees, is because the Varroa mites have become so intrusive that they just assume that they are going to have mites in their hives and just go ahead and prepare to treat them.

We also included another answer option labeled “other” for the sampling method question, which 9.2% or 14 beekeepers chose, to see what else they used to check their hives. In

the free responses, there were no new techniques they used; the beekeepers said they used a combination of each of the methods offered, not just one.

Revenue Sources

To get a thorough understanding of the current honeybee industry in the state of Alabama, we wanted to see which revenue streams were most popular and which ones were not as common. We asked beekeepers if they participated in a certain revenue-generating activity, and we recorded the number of survey participants who answered "yes" to each revenue source. The results are shown in Table 3. Note that respondents could choose multiple sources of revenue, so the total percentage added up to be more than 100.

Table 3: Results from the different revenue sources for beekeepers listed in the survey.

Variable	Pct
Sells Honey	80%
Sells Queens	13.7%
Pollination Services	12.3%
Sells Nucs	24.3%
Sells Package Bees	4.6%
Number of Observations	150

As shown in the table, 80% of the entire survey, which is 120 beekeepers, use their hives to produce, collect, and ultimately sell honey. 20 beekeepers, or 13.7% of the sample, sold queens. With most of our respondents (62%) being hobbyist beekeepers, we expected this

number to be low. Rearing queens takes a lot of time and commitment, so part-time hobbyist beekeepers are less likely to have the time and resources to raise and sell queen bees. 12.3% of respondents offer their hives for pollination services. This number is also not surprising because, as mentioned before, pollination services in Alabama are nowhere near as big as they are in states like California and Washington. The next source of revenue covered in the survey is nuc sales, which totaled to be 24.3% of beekeepers, or 36 out of the 150. After honey sales, nuc sales was the second largest revenue source that was selected. Our last revenue stream that we included in the survey was selling packaged bees. This was the least common activity for beekeepers that participated in this survey, with only 4.6%, or 7 beekeepers, saying that they sell packaged bees.

Honey Sales

Honey is a rich, sweet liquid that is produced by bees. Worker bees go out and collect nectar from plants and flowers, bring it back into the hive, and store it in cells within the hive. The liquid nectar becomes dehydrated from the constant fanning of the bees' wings, resulting in honey. Beekeepers remove the comb from the hives and, through various methods, remove the honey from the comb. Once the honey is removed, beekeepers can bottle it up either themselves or pay someone else to, then sell the honey, hopefully for a profit. Table 4 describes the operations of the beekeepers who reported selling honey.

Table 4: Results from the "Honey Sales" section of the survey.

Variable	Pct

Bottles Own Honey	97.5%
Extracts Honey Manually	21.7%
Automated Extractor	2.5%
Motorized Extractor	70.8%
Other Extractor	5%
Uses Sweet Grown Alabama Label	9.1%
Gets Honey Tested for Pollen Content	5.9%
Happy, but Would Like to Expand Honey Sales	61.7%
Not Happy, Would Like to Expand	15%
Would Not Like to Expand	20.8%
Indifferent regarding expanding	2.5%
Number of Observations	120

As the previous table revealed, honey sales were by far the top source of revenue for the Alabama beekeepers that participated in this survey. 120 out of 150 beekeepers sell honey in their operation. We aimed to get a better understanding of how beekeepers went about collecting and processing their honey. Nearly 98% of the beekeepers that sell honey choose to bottle their own.

We also asked beekeepers what kind of extractor they used to collect honey from their hives. A honey extractor is a device used to remove honey from the comb without damaging the comb or the bees within it. There are several types of extractors, some motorized, and others that

have a hand crank. In the survey, 73.1% of beekeepers use a motorized extractor. To use a motorized honey extractor, the combs must be placed in the slots which are inside of a circular steel drum, and once turned on, they hives are spun around quickly, and the honey is forced out of the comb and hits the side of the drum, running down to the bottom where it collects. A motorized extractor is easily the most efficient and requires the least amount of physical labor. The next option was the hand crank extractor. Around 22% of respondents said they used a hand crank extractor to remove honey. A hand crank extractor is very similar to the motorized, the only difference is that instead of a motor spinning the comb around, the hives are spun when someone cranks the handle. The same thing happens with the honey once the hand crank is used - it comes out of the comb onto the wall and drips down into the bottom and is then gathered by the beekeeper. The benefits of a hand crank extractor are that there is no need for a power source, and they are cheaper than motorized extractors. The remaining 4.9% of beekeepers that selected "other" said that they use a combination of both motorized and manual extractors in their operation.

We also asked whether the beekeeper uses the Sweet Grown Alabama label on their honey. Sweet Grown Alabama is a non-profit foundation that enhances marketing opportunities for farmers in Alabama by connecting retailers and consumers to foods and other agricultural products produced in Alabama ("About Sweet Grown Alabama" accessed July 21 This foundation was created to help support local farmers, including beekeepers, by encouraging consumers to buy locally grown products. Our goal behind this question was to see if beekeepers were familiar with this program, because as mentioned numerous times before, most beekeepers in our survey are part time beekeepers. Only 8.9%, or 11 beekeepers use this label on their honey.

We also asked if beekeepers send their honey to a lab to get tested for pollen content. The significance of getting honey tested for pollen count is to determine the quality and origin of the honey. This allows beekeepers to see if their honey may contain chemicals collected by the bees when they were pollinating, or to see what exactly their bees were pollinating if they did not have their hives rented out for pollination services. Only 5.8% of beekeepers send their honey to get tested. These results imply that most beekeepers in the survey are not concerned with testing their honey, because they likely do not want to have to pay the cost for testing when the consumers they sell to are already satisfied.

We then asked if beekeepers were satisfied or not with their honey sales, and if they were, whether they planned to expand their operations. 62.3% of beekeepers answered that they were happy with their current level of honey sales, but they were interested in expanding in the future. 14.8% of the participants said that they were not happy about their current level of honey sales and planned to increase their sales. About 21%, or 32 beekeepers, said that they were satisfied with their current level of honey sales and did not have any plans to expand their operation. Only 2.5% of the survey said that they were indifferent when asked if they had any plans to increase sales or not.

These results imply that most beekeepers wish to expand their operations, while a significant minority are satisfied and have no intention to expand. Since most of the beekeepers are part-time hobbyists, those who do not wish to expand possibly do not have enough time, money, or labor to expand their operation.

Out of the 120 beekeepers that sell honey, 94 of them either selected that they were either happy but had plans to grow, they were not happy and had plans to grow, or they were indifferent, meaning that if they sold more, they would be satisfied and if they did not, they

would also be satisfied. We included a free response question asking what barriers these beekeepers faced when trying to expand their operation. Below are the results revealing the most common responses.

Table 6: Results showing barriers to expansion of honey sales

Variable	Pct
No new markets to sell into, trouble competing with fake honey in grocery stores	26.6%
Producing more honey, lack of time	66%
Other	7.4%
Number of observations	94

The results from this table reveal that most beekeepers struggle to expand their business due to a lack of producing enough honey to be able to sell more (62 beekeepers) The most common reason why was because of a lack of time to devote to expanding. Another likely reason beekeepers struggle to produce more honey is because of a lack of hives, without more bees there will not be more honey. 25 beekeepers said that they were unable to find new markets to sell their honey into. The main reason for this barrier is because of the fake imported honey that is sold at major grocery stores. The price of imported honey is cheaper because the quality has been lowered by adding artificial sweeteners to extend shelf life. These results could also tie into

Table 5, with such a high number of beekeepers that sell their honey informally, there is a need for new marketing strategies.

Pollination Services

Pollination services take place when beekeepers interact with farmers and negotiate a contract allowing the beekeeper to bring their bees to pollinate the farmers crop(s) for a certain price. The price of pollination services is based on how much acreage is being pollinated and the quality of the beekeeper's hives.

Table 7: Results from the “Pollination Services” section of the survey

Variable	Pct
In State Only	72.2%
Out of State Only	0%
Both	27.8%
Suffered Losses While Pollinating	47.4%
Happy, but Would Like to Expand Pollination Services	52.6%
Not Happy, Would Like to Expand	10.5%
Would Not Like to Expand	26.3%
Indifferent	10.5%
Number of observations	18

Only 18 beekeepers out of 150, or 12% of the sample, offer their hives for pollination services. Out of the 18 beekeepers that offer pollination services, most offer them within the state (79%). And of that 79%, according to personal conversations with beekeepers, most of them consisted of small contracts with local farmers in their areas to pollinate their crops. Beekeepers also noted that in many cases, their bees pollinate crops in the surrounding area already, and contracts are too complicated to deal with and not worth the trouble. We asked the beekeepers what crops their bees have pollinated under contract in Alabama, a few of them included watermelons, blueberries, cotton, and cucumbers.

There were no beekeepers that offer pollination services out of state that do not also offer them in Alabama as well. Of the 18 beekeepers that offer pollination services, 5 (27%) offer pollination services in Alabama as well as other states. Of the five, the states included were Florida, Georgia, and California. All five beekeepers offer their services in California for almond pollination. Also, the number of hives that these five beekeepers manage in their operation are 60, 450, 350, 1750 and 2000, classifying all of them but one as commercial beekeepers. These results suggest that the commercial beekeepers with hundreds of hives make up most of those who find it worthwhile to load up their honeybees and haul them from Alabama to California for almond pollination. Before the bees can be released to pollinate almonds, they must be inspected once they cross state borders to ensure that they are not carrying any diseases or pests that could damage other beekeepers' bees. This can be a complicated and timely process, and along with transportation costs and the risk of losing bees on the cross-country journey, the commercial beekeepers are likely the only ones who can afford to make the trip.

Among the 18 beekeepers that offer pollination services, over 47% of them said that they have suffered losses to their colonies due to pesticide or herbicide exposure. When farmers plant

their crops and begin to grow, they must be sprayed with chemicals to keep pests and diseases away from them to grow properly and produce a sufficient yield for the farmer. This is an extremely necessary step for farmers during the growing process. However, it is also essential for bees to pollinate for many reasons, survival being the primary, and these pesticides and herbicides contain poisonous chemicals that are extremely dangerous to all types of pollinators, wild and managed. So, if there is a lack of communication between the farmer who is applying these chemicals and the beekeepers who are offering their bees pollination services, then this could lead to major losses for beekeepers. These losses can lead to weaker, less productive colonies, which could also lead to losses in potential revenue for other markets such as honey sales or queen rearing. This has been an issue in beekeeping for many years now, according to local beekeepers.

When asked if they had any interest in expanding their pollination services, 52.6%, or 9 beekeepers answered that they were happy with their current position in this market but would like to expand their services. On the contrary, 10.5%, or 2 beekeepers said that they were unhappy, and planned to expand in the future. There were 5 beekeepers that were content with their current level of pollination services and had no desire to grow their presence in the market. The remaining 2 beekeepers said that they were indifferent, or had no preference, when asked if they had any plans to increase their pollination services.

Since only 18 beekeepers participated in pollination services, we asked the question, “Why don’t you offer pollination services?” to the 132 beekeepers that do not participate. We wanted to examine the barriers to entry for those that choose not to offer their hives for pollination.

Table 8: Results revealing the barriers to enter the pollination services market.

Variable	Pct
Lack of time, knowledge, money, resources, and/or operation is too small	63.6%
Lack of interest, no demand	22.7%
Losses due to pesticides	7.6%
Other	6.1%
Number of Observations	132

There were 84 beekeepers that said that the reason they did not offer pollination services was because either their operation was too small, they did not have enough time, they did not know how to get started in pollination services, or they did not have enough money or help to participate, or a combination of these. 30 beekeepers answered that they had no interest or desire to start offering pollination services. There were 10 beekeepers said that they had either suffered losses to pesticides in the past and did not want to lose bees again, or they had not suffered losses yet but were not willing to risk their hives.

Queen Sales

Some beekeepers use their hives to produce and raise queen bees, and once fully grown, they are sold to other beekeepers to use in their hives. Typically, larger beekeepers raise and sell queens to smaller beekeepers who are just getting started, or to beekeepers who suffered losses for various reasons and need queens to keep their hives going.

Table 9: Results from the "Queen Sales" section of the survey

Variable	Mean/Pct
Queen Sales per Year (Mean)	152
Price per Queen (Mean)	32.8
Happy, but Would Like to Expand	31.6%
Not Happy, Would Like to Expand	21.1%
Would Not Like to Expand	31.6%
Indifferent	15.8%
Number of Observations	20

Of the 150 beekeepers, 20 participate in queen rearing and selling. Out of the 20 observations, the mean number of queen sales per year was 152. The average price per queen was $32.80, with the maximum price being $45 and the minimum at $15 a queen.

When asked about their plans for queen sales in the future, 6 beekeepers, or 31.6% said that they were happy with their current number of sales but also had interest in growing their business. There were 4 beekeepers that were not happy about their current queen sales and would

like to expand them as well. Another 6 beekeepers said they were good with their numbers and had no plans to expand. The last 4 said that they were indifferent and had no opinion on growing or not. Based on the results, the market for selling queens in Alabama is seemingly small. We asked the beekeepers that do sell queens what barriers they faced to expanding their business. The most popular answers were lack of time and hives to produce superior quality queens. Another answer that we found quite interesting was that there is not enough genetic diversity to build queens that are resistant to disease. This was not the focus of our study, but disease-resistant queens may be worth further study.

Packaged Bee Sales

Table 12 summarizes the information collected in the survey about sales of packaged bees. Packaged bees are live honeybees shipped to beekeepers in wooden boxes wanting to start new colonies or strengthen weaker ones. These wooden crates typically contain about 3,000-5,000 bees per pound, and each crate is roughly three pounds. So, each crate has between 10-12 thousand bees. A crate or package also comes with a queen unless otherwise specified. Packaged bee sales are the least popular source of revenue selected in the survey.

Table 12: Results from the "Packaged Bee Sales" section of the survey.

Variable	Pct/Mean
Packaged Bee Sales per Year (Mean)	23.3
Price per Package (Mean)	147.5
Happy, but Would Like to Expand	16.7%

Not Happy, Would Like to Expand	0%
Would Not Like to Expand	33.3%
Indifferent	50%
Number of Observations	7

Only 4.7% of the whole survey, or 7 beekeepers, sell packaged bees. In order to sell large numbers of packaged bees, a beekeeper must have enough hives to produce enough bees to sell. The proportion of beekeepers that sell packaged bees is so small possibly because of the significant amount of hobbyist beekeepers in the survey. Of the beekeepers that sell packaged bees, the average number of packages sold per year was just over 23. The price range per package will differ based on many things such as availability of bees and location of the buyer, including transportation costs. The mean price per package based on the responses given is $147.50.

When asked if beekeepers wanted to expand their packaged bee sales, only 16.7% said that they had interest in expanding, both those who were happy and unhappy with their current level of sales. There were 2 beekeepers, (33.3%) who said they were content with their sales and had no interest in expanding their packaged bee operation. The remaining 4 beekeepers that sell packaged bees selected that they were indifferent when asked if they would like to increase their sales.

Nuc Sales

A nuc is a small hive of bees that can be used to start new hives or repair damaged hives. The difference between nucs and packaged bees is that nucs are quite small and do not contain as

many bees as packages do. Nucs are primarily for beginner beekeepers who are learning how to manage their own hives for the first time. Also, if hives receive damage from winter losses, diseases, or pesticide exposure, nucs are an effective way to build back numbers to increase the strength and productivity of the damaged hives.

Table 13: Results from the "Nuc Sales" section of the survey.

Variable	Pct/Mean
Nuc Sales per Year (Mean)	73.7
Price per Nuc (Mean)	166.5
Happy, but Would Like to Expand	45.7%
Not Happy, Would Like to Expand	11.4%
Would Not Like to Expand	31.4%
Indifferent	11.4%
Number of Observations	35

Nuc sales was the second largest source of revenue selected behind honey sales, with 23.3%, or 35 out of 150 beekeepers participating in this business. The average number of nuc sales each year was nearly 74, and the average price per nuc was $166.50. The average number of nuc sales is more than triple the mean number of packaged bee sales per year. This is likely partly due to the much smaller quantity of bees that nucs consist of compared to packages. Nucs require less work and hassle to transport, given that beekeepers can simply remove the frames

that hold the bees from the hive and place it in a container or bag and transport it, as opposed to having to transport a whole hive.

For this revenue source, 45.7% of beekeepers said that they were happy, but would like to increase their nuc sales in the future. Also, 11.4% said that they were not satisfied, and would like to expand their business. That makes a total of 57.1%, or 20 beekeepers put of 35, that have a desire to increase and expand their nuc sales. There were 11 beekeepers, 31.4%, that selected that they had no interest in expanding, and the remaining 4 beekeepers were indifferent.

There were 35 beekeepers that sell nucs, and out of those 35, 24 of them chose that they would expand their business if the opportunity arose. We wanted to see what restraints these beekeepers were facing that are keeping them from the expansion of nuc sales.

Table 14: Results showing barriers for the expansion of nuc sales

Variable	Pct
Lack of time, equipment, or labor	62.5%
Other	37.5%
Number of Observations	24

The results reveal that most of the beekeepers in this observation struggle with a lack of time to produce and sell nucs, the equipment necessary to produce nucs, and/or the help needed to carry out this process. These results could be related to the large number of part time beekeepers in the survey that also work another job besides beekeeping or are retired.

Expansion Focus

We asked beekeepers that if they planned to expand their business in the future, what revenue source(s) would they focus on? We listed all the revenue sources and allowed for multiple answers to be selected.

Table 15: Results from the "Expansion Focus" question

Variable	Pct
Honey Sales	32.1%
Honey Sales plus another source	46.4%
Other revenue sources than honey	21.4%
Number of Observations	140

78.5%, 110 beekeepers, chose honey sales in their response, whether by itself or with another revenue source. These results were not shocking, given that 80% of the survey sells honey. The remaining 30 beekeepers chose other revenue sources by themselves or a combination of the revenue sources that were included in this survey.

Regression Results

Table 13 shows the descriptive statistics of our dependent variable (number of hives) and each independent variables.

Table 13: Descriptive Statistics

Variable	Mean/St Dev	Min	Max
Number of hives	84	0	2000
	(243.59)		
Years of operation	12.32	1	85
	(14.46)		
Other job	0.5865	0	1
	(0.4943)		
Honey sales	0.8271	0	1
	(0.3796)		
Pollination	0.1278	0	1
	(0.3352)		
Queen sales	0.1278	0	1
	(0.3352)		
Nuc sales	0.2481	0	1
	(0.4336)		
Packaged bee sales	0.0301	0	1
	(0.1714)		

Note: Table 13 displays the mean, standard deviation, minimum, and maximum for our dependent variable (number of hives), and our dummy variables (years of operation, other job besides beekeeping, honey sales, pollination services, queen sales, nuc sales, and packaged bee sales). Standard deviation in parenthesis.

The determinants of the numbers of hives in this regression are: years of operation, another job besides beekeeping, honey sales, pollination services, queen sales, nuc sales, and packaged bee sales. We chose these determinates to see the correlation between them and the number of hives in a given operation.

Table 14: Regression results using "Number of Hives" as the dependent variable.

Variable	Coefficient	p value
Years of operation	1.7344	0.166
	(1.2449)	
Another job besides	-51.0493	0.161
beekeeping	(36.2234)	
Honey sales	6.8502	0.875
	(43.5507)	
Pollination services	218.2088	0.000***
	(55.5495)	
Queen sales	-35.3927	0.526
	(55.6568)	
Nuc sales	135.5188	0.004**
	(46.448)	
Packaged bee sales	-8.3879	0.920
	(82.9331)	
Number of observations	150	150

Table 14 displays the coefficients and standard errors from a regression of the "number of hives" on several dependent variables. The first independent variable is years of operation, and though the estimate is close, it is outside the statistically significant value of 0.1. The coefficient for years of operation means that one additional year of operation is correlated with having 1.7344 more hives. Similarly, having another job besides beekeeping is associated with fewer hives, though the estimate is also just above the threshold of 0.1. Whether the beekeeper sells honey is not associated with number of hives. Offering pollination services, however, has an extraordinarily strong positive correlation with the number of hives. The coefficient for pollination services (218.2088) implies that there is a strong chance that a beekeeper will participate in pollination services if they have a large number of hives. In contrast, whether the beekeeper sells queens does not have a significant correlation with the number of hives. Similar to pollination services, there is a strong positive correlation between whether the beekeeper sells nucs and the number of hives a beekeeper manages. The coefficient for nuc sales (135.5188) implies that if a beekeeper has a large number of hives, they are more likely to sell nucs. Whether the beekeeper sells packaged bee sales is not associated with number of hives.

Conclusion

Honeybees are undoubtedly one of the most important pollinators in the world, given the fact that one in every three bites of food we human beings eat is reliant on bees to pollinate. Honeybees provide a variety of income sources through their production of honey, their ability to pollinate and the production and selling of queens, nucs, and packaged bees. This thesis aimed to

establish the current state of the honeybee industry in Alabama according to beekeepers' responses to our survey. We created and sent out a survey to gather information on beekeeping operations and their revenue sources. We found that many of the beekeepers that participated in the survey were hobbyist beekeepers (62%), meaning that they manage 25 hives or less. We also found that honey is by far the biggest source of income for beekeepers in Alabama, given that 80% of the entire survey, or 120 beekeepers, participated in honey sales. We also discovered that 70%, or 105 beekeepers sell their honey "informally," which is also known as word-of-mouth advertisement, thus there is room for better marketing strategies to sell more honey. Beekeepers in Alabama may be restricted in how much honey they can sell for a couple different reasons. The first is the fake, imported honey being sold at all major grocery stores across the state. That honey is cheaper to buy in bulk due to the artificial sweeteners that take away the purity of the honey. The general public may also not be aware that raw, unfiltered honey is supposed to crystallize due to the natural sugars it contains. This, according to conversations with beekeepers, keeps people from buying real honey when the crystallization process only proves the honey's quality. This is one of the main reasons that beekeepers were so adamant that it is crucially important that the public becomes educated and aware of beekeeping and what all it entails.

The second largest revenue source was nuc sales, with 35 beekeepers participating in this revenue source. Only 3 beekeepers out of the 59 who buy nucs specifically said that they bought their nucs from out of state. These results were surprising due to the low number of beekeepers that participate in nuc sales in our survey. There were only 18 out of 150 beekeepers that participated in pollination services. Among them, 47.4% have experienced losses due to pesticide exposure. Therefore, communication between beekeepers and farmers is crucial and should be taken more seriously. Queen sales was also one of the smaller revenue sources among

participants, with only 20 beekeepers growing and selling them. Also, 68% of beekeepers sell their queens informally, or by word-of-mouth advertisement. These results reveal an opportunity for better marketing strategies and more queen sales. It is worth noting that 62% of beekeepers purchase queens, and 47% of them buy them from out of state. These results reveal a marketing opportunity for Alabama beekeepers to grow and sell queens. The revenue source with the least participants was selling packaged bees, only 4.7% of the entire survey sells them. Packaged bee sales require a beekeeper to have enough time, equipment, and bees to load 10,000 plus bees into a box and sell repeatedly. With the large quantity of beekeepers in our survey being hobbyist, the number of beekeepers that sell packaged bees was expectedly low.

We wanted to examine the barriers that beekeepers face when trying to expand their presence in a specific market. In each section of revenue sources, if the beekeeper selected that they had interest in growing their business, we included a free response question asking the beekeeper to elaborate on what constraints they faced that was keeping them from growing. The most common responses for barriers to honey growth was a lack of new market opportunities to sell their honey, mostly due to competing with the cheaper, imported honey at major grocery stores. The most frequent response though was a lack of hives to produce more honey and a lack of time to pour into selling more. The most common barrier to expanding nuc sales was a lack of time, equipment and/or labor to sell more nucs. For pollination services, the most common restraint was a lack of time, money, and/or knowledge to either expand or enter the pollination services market. Another popular response was that they had no interest in starting or that there was no demand for crop pollination in their area.

We also asked beekeepers that in their plans to expand their current operation in the future, what revenue source would they focus on the most? We allowed multiple answers to be

selected for this question. Without surprise, 78.5% of responses included honey in them. 32.1% were strictly honey and 46.4% said honey and one of the other revenue sources. The remaining 21.4% chose one or multiple of the other revenue sources that were covered in the survey, but the results were not big enough to separate each remaining revenue source.

Another notable results from the survey that are not revealed in the tables are that 36 beekeepers sell wax products from their operation. We asked if there were any other revenue sources that beekeepers take in from their operation, and out of the 133 respondents, 36 said that they sold wax products such as lip balms and candles. These results are very interesting, because this makes wax sales the second largest revenue source in the survey, and it was not even included in the questions. These results indicate that there is a market for wax sales for beekeepers.

The results in this study have implications for the economic feasibility of beekeeping in Alabama. Although, a more thorough study that includes detailed costs and financial data from beekeepers is needed to really know if beekeeping in Alabama is economically feasible. Our results imply that there are opportunities to make money from a beekeeping operation, but a lack of marketing strategies and opportunities for beekeepers to sell their products.

Also, with a large portion of our survey being part time hobbyists, it would be difficult for economic feasibility to be the primary focus for this research. This also presents an opportunity for further study. It is important to understand the motivations of hobbyist beekeepers in order to answer the question, “Is beekeeping economically feasible in Alabama?” Motivations such as, “Do they even want to grow from hobbyist to sideliner and so on?” and “Are they hoping to one day become a full-time beekeeper?”

After analyzing the results from the survey, we discovered that there is a need for ways to engage hobbyist beekeepers that wish to grow their business with potentially profitable sources of revenue. An example strategy is pairing a hobbyist beekeeper with either a large sideliner or a commercial beekeeper to engage and learn more about specific revenue sources that they wish to expand in. Additionally, it may be possible to coordinate hobbyist beekeepers to reach the scale necessary to provide pollination services. Finally, since individual hobbyist beekeepers do not have the time or resources to inform customers about local honey, improving consumer information and marketing coordination between hobbyist beekeepers may help them expand into new markets.

Reference:

"About." Sweet Grown Alabama. Accessed July 21, 2024. https://www.sweetgrownalabama.org/.

Abro, Z, M Kassie, HA Tiku, B Taye, ZA Ayele, and W Ayalew. 2022. The impact of beekeeping on household income: evidence from north-western Ethiopia. Heliyon, 8 (5), e09492.

Aizen, Marcelo A, and Lawrence D Harder. 2009. "The global stock of domesticated honey bees is growing slower than agricultural demand for pollination." *Current biology* 19 (11): 915-918.

Alebachew, Getachew Worku. 2018. "Economic value of pollination service of agricultural crops in Ethiopia: biological pollinators." *Journal of apicultural science* 62 (2): 265-273.

Amulen, Deborah Ruth, Marijke D'Haese, Elizabeth Ahikiriza, Jacob Godfrey Agea, Frans J Jacobs, Dirk C de Graaf, Guy Smagghe, and Paul Cross. 2017. "The buzz about bees and poverty alleviation: Identifying drivers and barriers of beekeeping in sub-Saharan Africa." *PLoS one* 12 (2): e0172820.

Crenna, Eleonora, Olivier Jolliet, Elena Collina, Serenella Sala, and Peter Fantke. 2020. "Characterizing honey bee exposure and effects from pesticides for chemical prioritization and life cycle assessment." *Environment international* 138: 105642.

Day, Cheryl, and Benedict White. 2022. "A survey dataset to better understand the honey bee industry, use and value of natural resources and challenges for beekeepers in Western Australia: A beekeepers' perspective." *Data in Brief* 45: 108639.

Degenfellner, Jürgen, and Matthias Templ. 2024. "Modeling bee hive dynamics: Assessing colony health using hive weight and environmental parameters." *Computers and Electronics in Agriculture* 218: 108742.

El-Meihy, Rasha M, Eman O Hassan, Soha A Alamoudi, Sally Negm, Nawal Al-Hoshani, Mariam S Al-Ghamdi, and Elhosseny E Nowar. 2024. "Probing the interaction of Paenibacillus larvae bacteriophage as a biological agent to control the american foulbrood disease in honeybee." *Saudi Journal of Biological Sciences* 31 (6): 104002.

"European honey bee - apis mellifera." Accessed July 21, 2024. https://entnemdept.ufl.edu/creatures/misc/BEES/euro_honey_bee.htm.

Evans, Jay D. 2003. "Diverse origins of tetracycline resistance in the honey bee bacterial pathogen Paenibacillus larvae." *Journal of Invertebrate Pathology* 83 (1): 46-50.

Frizzera, Davide, Virginia Zanni, Mauro D'Agaro, Giulia Boaro, Laura Andreuzza, Simone Del Fabbro, Desiderato Annoscia, and Francesco Nazzi. 2023. "Varroa destructor exacerbates the negative effect of cold contributing to honey bee mortality." *Journal of Insect Physiology* 151: 104571.

Gallai, Nicola, and Bernard E Vaissière. 2009. "Guidelines for the economic valuation of pollination services at a national scale."

Genersch, Elke. 2010. "American Foulbrood in honeybees and its causative agent, Paenibacillus larvae." *Journal of invertebrate pathology* 103: S10-S19.

Ghorbani-Nezami, Sara, Lucy LeBlanc, Diane G Yost, and Penny S Amy. 2015. "Phage therapy is effective in protecting honeybee larvae from American foulbrood disease." *Journal of Insect Science* 15 (1): 84.

Goodrich, Brittney K. 2019. "Do more bees imply higher fees? Honey bee colony strength as a determinant of almond pollination fees." *Food Policy* 83: 150-160.

Goodrich, Brittney K, and Rachael E Goodhue. 2020. "Are all colonies created equal? The role of honey bee colony strength in almond pollination contracts." *Ecological economics* 177: 106744.

Gustafson, Christopher R, Antoine Champetier, Olivier Tuyizere, and Henriette Gitungwa. 2024. "The impact of honey fraud information on the valuation of honey origin: Evidence from an incentivized economic experiment." *Food Control* 155: 110070.

"Honey bee colonies." Accessed July 21, 2024. https://downloads.usda.library.cornell.edu/usda-esmis/files/rn301137d/4m90gc28p/gq67m7401/hcny0823.pdf.

Huang, Ta-Kang, Min-Chieh Chuang, Yi Kung, and Bo-Chuan Hsieh. 2021. "Impedimetric sensing of honey adulterated with high fructose corn syrup." *Food Control* 130: 108326.

"How Honey Is Made." National Honey Board. Accessed July 19, 2024. https://honey.com/about-honey/how-honey-is-made#:~:text=Honey%20starts%20as%20flower%20nectar,nectar%20collected%20by%20the%20bees.

Jones Ritten, Chian, Linda Thunström, Mariah Ehmke, Jenny Beiermann, and Donald McLeod. 2019. "International honey laundering and consumer willingness to pay a premium for local honey: an experimental study." *Australian Journal of Agricultural and Resource Economics* 63 (4): 726-741.

Klein, Alexandra-Maria, Bernard E Vaissière, James H Cane, Ingolf Steffan-Dewenter, Saul A Cunningham, Claire Kremen, and Teja Tscharntke. 2007. "Importance of pollinators in changing landscapes for world crops." *Proceedings of the royal society B: biological sciences* 274 (1608): 303-313.

Kocher, Sarah D, Freddie-Jeanne Richard, David R Tarpy, and Christina M Grozinger. 2009. "Queen reproductive state modulates pheromone production and queen-worker interactions in honeybees." *Behavioral Ecology* 20 (5): 1007-1014.

Krishnan, Smitha, Gabriela Wiederkehr Guerra, Damien Bertrand, Shiela Wertz-Kanounnikoff, and Christopher J Kettle. 2020. "The pollination services of forests: A review of forest and landscape interventions to enhance their cross-sectoral benefits."

Krutmuang, Patcharin, Julius Rajula, Sarayut Pittarate, Chanchai Chatima, Malee Thungrabeab, Supamit Mekchay, and Sengottayan Senthil-Nathan. 2022. "The inhibitory action of plant extracts on the mycelial growth of Ascosphaera apis, the causative agent of chalkbrood disease in Honey bee." *Toxicology Reports* 9: 713-719.

Li, Wan-Li, Qi Huang, Jia-Li Li, Ping Wu, Bangrong Wei, Xi-Jie Li, Qi-He Tang, Zhi-Xiang Dong, Jian Xiong, and Hong Tang. 2023. "Gut microbiota-driven regulation of queen bee ovarian metabolism." *Microbiology Spectrum* 11 (5): e02145-23.

Narjes, Manuel Ernesto, and Christian Lippert. 2019. "The optimal supply of crop pollination and honey from wild and managed bees: An analytical framework for diverse socio-economic and ecological settings." *Ecological Economics* 157: 278-290.

Ndungu, Nelly N, Timothy M Kegode, Justus K Kurgat, Steve BS Baleba, Xavier Cheseto, S Turner, Geraud C Tasse Taboue, JM Kasina, Sevgan Subramanian, and Beatrice T Nganso. 2024. "Bio-functional properties and phytochemical composition of selected Apis mellifera honey from Africa." *Heliyon*.

Pasho, Deborah JM, Jeffrey R Applegate, and Don I Hopkins. 2021. "Diseases and pests of honey bees (Apis mellifera)." *Veterinary Clinics: Food Animal Practice* 37 (3): 401-412.

Roth, Morgan A, James M Wilson, and Aaron D Gross. "Varroa Mite Sampling Methods." Department of Entomology | Virginia Tech, January 14, 2022. https://www.ento.vt.edu/the-bee-group-at-vt/beekeeping/mites2.html.

Sarwar, Muhammad. 2016. "Fungal diseases of honey bees (Hymenoptera: Apidae) that induce considerable losses to colonies and protocol for treatment." *Int. J. Zool. Stud* 1 (1): 8-13.

Scaramella, Nicholas, Ashley Burke, Melissa Oddie, Bjørn Dahle, Joachim R de Miranda, Fanny Mondet, Peter Rosenkranz, Peter Neumann, and Barbara Locke. 2023. "Host brood traits, independent of adult behaviours, reduce Varroa destructor mite reproduction in resistant honeybee populations." *International journal for parasitology* 53 (10): 565-571.

Sgroi, Filippo, and Federico Modica. 2023. "An experimental analysis of consumers' attitudes towards honey: The case of the Sicilian market." *Future Foods* 7: 100223.

Warner, Summer, Lok R Pokhrel, Shaw M Akula, Chukwudi S Ubah, Stephanie L Richards, Heidi Jensen, and Gregory D Kearney. 2023. "A scoping review on the effects of Varroa mite (Varroa destructor) on global honey bee decline." *Science of The Total Environment*: 167492.

Wells, Wyatt. "2022 Almond Pollination Prices." Thebeecorp, December 22, 2022. https://www.thebeecorp.com/post/2022-almond-pollination-prices.