Contribution of Tallow to Beekeeping and Honey Industries, and the Broader Economy

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Antoine Champetier and Daniel A. Sumner*

* Dr. Champetier is a research economist based in Zurich, Switzerland. Professor Sumner is the Frank H. Buck, Jr. Professor in the Department of Agricultural and Resource Economics, University of California, Davis. They have each published extensively on the economics of honeybees, both separately and as co-authors. Champetier and Sumner are responsible for all data collection, analysis, and writing. Nothing in this report should be attributed to their primary employers or funders of this or other projects.

Executive Summary

The honeybee and honey industries in the southern states rely on tallow trees for forage in the spring, which is a crucial season for honeybee colony health, honey production, and crop pollination. This study provides new and detailed data and economic analysis to document the importance of foraging on tallow for the beekeeping economy, especially in an eight-state region that includes Texas, Louisiana, Arkansas, Mississippi, Alabama, Florida, Georgia, and South Carolina.

We consider the significance of tallow availability to honeybee colonies that forage in the tallow region and the role of the honeybee colonies that forage on tallow in the beekeeping industry. We then assess the contribution of honeybee colonies that forage on tallow, "tallow colonies," to broader economic activity, including revenue, economic value added, and jobs.

Tallow provides abundant and crucial forage used by about half of all honeybee colonies in the eight-state region at the time of local tallow bloom. Tallow bloom occurs mainly between April and June and lasts from three to five weeks in each location. Tallow forage allows beekeepers to build colony strength, split hives, and manage successful beekeeping operations. Forage from tallow allows colonies to produce more honey and honey revenue. Tallow forage also facilitates stronger colonies that produce other hive products and pollination services that would not otherwise be available.

Our analysis assesses the economic relationships and impact of tallow and traces the influence of tallow forage through honey production and other markets to economywide impacts. The following figures provide an overview of the economic contribution of tallow:

- Tallow forage contributes about $57.8 million in honey revenue, including $34.8 worth of tallow honey.
- In addition, tallow contributes $69.4 million in pollination revenue and $5.2 million of other colony products.
- The yearly beekeeper revenue contributed by tallow totals $132.4 million.
- Tallow also generates substantial employment of beekeeper labor equivalent to 909 full-time jobs, using the estimate of 500 colonies per worker.
- These direct revenue gains contributed by tallow create direct economic value added in the beekeeping industry of $71 million.

The honey generated by tallow also causes the honey processing and marketing industry to be larger and generate significant direct economic activity. The direct effect of more honey to process generates $143 million in honey revenue, $46 million in direct economic value added, and 416 direct jobs in honey processing.

Economywide impacts include indirect and induced revenue, economic value added, and jobs. When these impacts are added to the direct effects, we find large economywide effects on the broader economy.

- The contribution of tallow to the value of output in the economy is $512 million.
- The contribution of tallow to economic value added is $232 million.
- The contribution of tallow to full-time equivalent jobs is 2,618.

Most of these contributions are dispersed throughout the economy through indirect effects and induced effects of a larger and more vigorous honeybee industry that is supported by access to tallow forage. Tallow generates economic activity and jobs far beyond the honeybees it benefits directly.

Acknowledgments

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Introduction

This report assesses the economic contribution of tallow trees as forage for domesticated honeybees in the United States. Tallow trees, *Triadica sebifera*, are also sometimes referred to as Chinese Tallow, or Chinese Popcorn trees. Tallow trees grow rapidly in favorable conditions and range from 15 to 40 feet tall and 15 to 40 feet wide when mature. The white seeds look like popcorn and may be used to make a vegetable substitute for animal fat, hence the name tallow tree.[1]

Originally from Asia, tallow trees were introduced in South Carolina in the 1700s and in Texas and other states in the 1900s. It is now present in most Southern states (Scheld and Cowles, 1981; DeWalt, Siemann and Rogers, 2011). In these states, the tallow tree is "highly adaptable and grows in a wide range of conditions" so long as there is adequate rainfall.[2] Tallow trees are prevalent in the following eight states: Texas, Arkansas, Louisiana, Mississippi, Alabama, Florida, Georgia, and South Carolina.[3] We refer to these states as "tallow states". The prevalence and density of tallow varies across states and within states.

Flowers from tallow trees are a valuable source of forage for honeybees. Tallow trees are used by bees to feed themselves and grow their numbers. Nectar from tallow trees is transformed into tallow honey by honeybees. Many beekeepers from the tallow states as well as from other regions of the United States, place colonies in proximity to tallow trees to allow their bees to forage on them.

The economic contribution of tallow trees as bee forage, like any other beekeeping forage, is best assessed in the context of annual population cycles of honeybee colonies. These population dynamics are reflective of bee biology, breed, and many other biophysical factors but are also carefully managed by beekeepers. Beekeepers increase their colonies in numbers and strength in months of forage abundance and reduce them in periods of dearth or cold. Spring and summer are typically the seasons favorable to increasing colony inventory, often done by splitting existing colonies.[4]

Predictable flows of forage, honey production, and pollination revenues allow beekeepers to manage their inventory over the course of a year. When forage is not available, or insufficient in quantity or quality, beekeepers feed carbohydrate syrups and protein paddy to the bees they hold at that time. Feeding is costly in direct outlay for the feed and in term of labor, and therefore forage access is key to beekeeping profitability.

Tallow trees bloom for a period of several weeks during the period from March through June or July depending on the region. April through June is the main tallow blooming period across the tallow states.[5] There are relatively few other forage opportunities in much of the tallow region during tallow bloom periods. Other non-cultivated trees that have overlapping

[1] North Carolina State University Extension
[2] North Carolina State University Extension
[3] University of Florida IFAS Blogs
[4] Purchase of stock is also common, notably for the replacement of queen bees.
[5] University of Arkansas

bloom are less abundant (e.g. tupelo). Florida citrus, another key forage source in the region blooms from February through March.[6]

In this report, we develop estimates of the contributions of tallow to U.S. beekeeping and the U.S. economy. We first estimate the number of colonies that are placed on tallow during its bloom. We use survey data from our detailed survey of beekeepers that gathered information on almost 300,000 colonies in the tallow region. We rely on data on colony inventories for April 1, 2022, from the USDA to extrapolate from our survey respondents to the broader population of colonies in the tallow states.

With our survey responses and USDA aggregate data, we track the honey production that colonies that forage on tallow are likely to produce on average. We also use our survey and USDA data to estimate pollination services and other products these tallow colonies are likely to provide. Given the extensive migration of colonies throughout the United States, colonies on tallow during the tallow bloom often participate in honey production in the northern plains in summer and almond pollination in California in February and early March.

We estimate beekeeping revenue contributed by colonies that forage on tallow and the amount of labor employed by such beekeeping operations. We then use IMPLAN data and models to estimate the contribution of tallow-based beekeeping activity on the wider economy in terms of revenue, economic value added, and jobs.

[6] Florida Department of Agriculture (accessed 2023).

1) Honeybee colonies and tallow foraging

The number of colonies that are placed on tallow during bloom is key to assessing the contribution of tallow to beekeeping. Colony counts by state are published by the USDA; however, they do not track where colonies are placed whether on tallow or on other forage.[7] To fill that gap, we surveyed beekeepers in the eight tallow states focusing on the use of tallow as a forage.[8] In this section, we combine the most relevant USDA colony count with the results of our tallow survey to develop a best available estimate of the number of colonies placed on tallow.

The USDA report, "Honey Bee Colonies," provides the most detailed colony inventory available with colony counts on the first day of each quarter for the years 2016 - 2022. This study, however, focuses solely on the most recent data from 2022. The data include colonies whether they produce honey or not. Table 1 provides the number of colonies at the start of each quarter for each tallow state as well as totals for tallow states, non-tallow states, and the United States.

Table 1: Number of colonies at the beginning of each quarter in 2022 (thousands).

States	January 1	April 1	July 1	October 1
Florida	295	295	245	270
Texas	270	345	194	210
Georgia	118	128	118	109
Louisiana	35	42	41	32
Mississippi	20	46	20	18
Arkansas	19	19	26	13
South Carolina	17	22	16	13
Alabama	8	12	14	11
Total tallow states	**781**	**909**	**674**	**675**
Share of nation	*27%*	*31%*	*22%*	*23%*
Other States	**2,095**	**2,000**	**2,434**	**2,213**
All states	**2,876**	**2,909**	**3,107**	**2,888**

Source: "Honey Bee Colonies" 2022, NASS-USDA.
Note: The sum of states may not add up to totals due to rounding.

Of the four inventory dates, April 1st is the closest date to tallow bloom which occurs between April and June in most tallow regions.[9] The total for the tallow states in Table 1 indicates that on April 1, 2022, there were 909,000 colonies in the eight tallow states which

[7] Colonies rented for pollination are tracked but forage without pollination revenues like tallow, most citrus or wildflowers are not tracked. In published USDA datasets, tallow is only mentioned in some records of honey prices published in the "National Honey Reports" (see references).
[8] See Appendix for a complete description of our survey procedures and responses.
[9] See survey results in Appendix for detailed bloom dates by state according to respondents.

represented 31% of all US colonies on that date. Among tallow states, Florida and Texas have the largest number of colonies throughout the year.

To assess tallow use by the beekeepers managing these 909,000 colonies, we surveyed beekeepers in the eight tallow states from October 2022 through January 2023.[10] Ninety-five respondents with at least five colonies completed the questionnaire and provided their maximum and minimum number of colonies as well as the number of colonies placed on tallow in 2022.[11] Table 2 shows these colony counts by state and for the total of the eight states.

Table 2: Summary of colony inventories from survey respondents.

	Minimum inventory	**Maximum inventory**	**Colonies on tallow**
		(1,000 colonies)	
Texas	112.7	162.6	103.7
Florida	11.4	17.1	3.7
Georgia	12.3	14.5	1.6
Louisiana	30.3	45.9	32.7
Mississippi	22.3	35.7	20.5
Arkansas	~0	~0	~0
South Carolina	0.2	0.3	0.2
Alabama	2.1	2.6	1.9
Total tallow states	**191.2**	**278.8**	**164.2**
Other states	**9.3**	**16.1**	**5.0**
All respondents	**200.5**	**294.9**	**169.2**

Source: Tallow survey, see appendix.
Note: The sum of states may not add to totals due to rounding.

The 95 respondent beekeepers in our survey of tallow states reported a total of 295,000 colonies, at the peaks of their colony counts during 2022. Survey respondents placed about 169,000 colonies on tallow for forage in 2022, which represents about 57% of the maximum number of colonies (169/295) operated by respondents over the year.

In our survey, the mean number of colonies per operation was just over 300 colonies. In percentile terms, 44% of operations had fewer than 250 colonies. Almost all colonies (96%) were operated by beekeepers with at least 1,000 colonies, and about 85% of colonies were operated by beekeepers with at least 5,000 colonies. We thus focus attention on the production patterns of commercial colonies.

Our survey gathered information about almost one-third of the 909,000 colonies that were based in the tallow states on April 1, 2022. We received responses representing a maximum

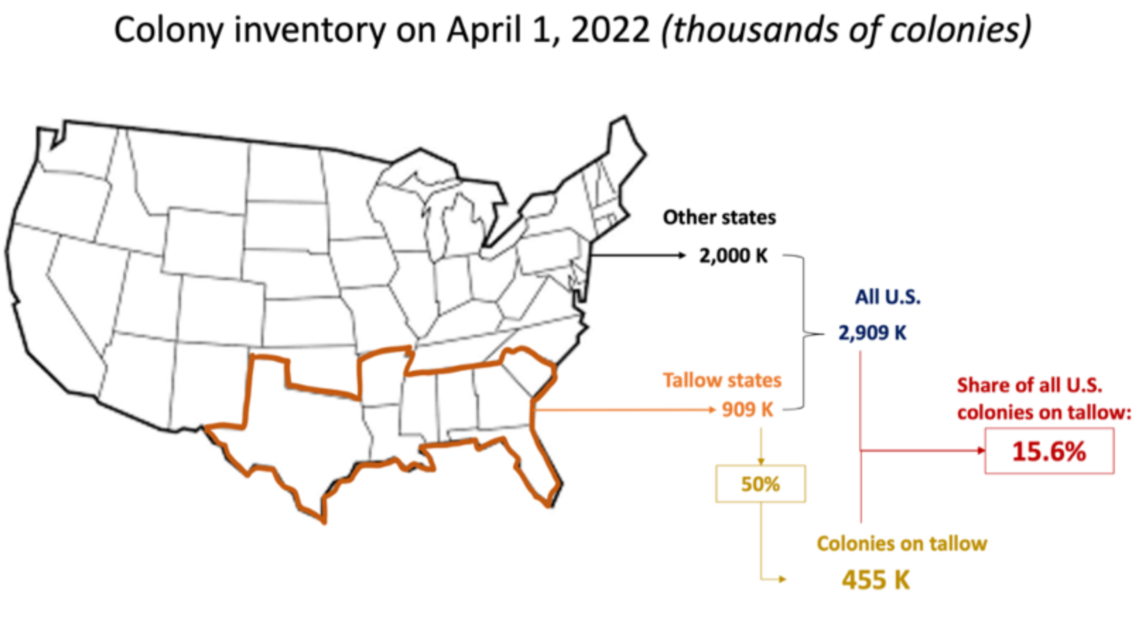
[10] See Appendix for a complete description of our survey procedures and responses.
[11] The USDA "Honey bee colonies" report also provides a maximum number of colonies per state during each quarter however these are not directly comparable to the maximum in our survey, which is the yearly maximum for respondents no matter which states the operations placed colonies during the year.

inventory of about 162,600 colonies in Texas, 45,900 colonies in Louisiana, and about 35,700 colonies in Mississippi. This represents about 56.4% of the 433,000 colonies in these three states on April 1 according to USDA data. The survey represented about 17,100 colonies in Florida and 14,500 in Georgia –about 7.5% of all colonies in these two states. Accordingly, our results are likely to be more representative of the more western states in the tallow region.

Our survey was not designed to be representative of the many tiny beekeeping operations in the region, but rather to be representative of the honeybee colonies in the region. By collecting data on almost one-third of the colonies and more than half of all colonies in the western states of the region, the survey successfully achieved that aim. However, allowing for the possibility that our survey captured a higher proportion of colonies placed on tallow and to generally be conservative in claims about the importance of tallow, we assumed that 50% of 909,000 colonies in the tallow states foraged on tallow rather than the 57.2% of survey respondents. We therefore estimate that about 455,000 colonies forage on tallow, or 15.6% of all colonies in the US on April 1. The results of our simulations and related calculations are proportional to the regional share of colonies that use tallow, therefore it is transparent to scale results up or down if the share on tallow were thought to be higher or lower than our best estimate of 50%.

We assess the implications of the number of colonies on tallow in terms of honey production and almond pollination, two measures for which USDA data is available. These assessments confirm the plausibility of our estimate of the number of tallow colonies. The calculations are detailed in the honey and pollination sections below. Figure 1 illustrates April 1 inventories and shares of colonies in the tallow states and estimated to be on tallow.

Figure 1: Number of colonies on April 1, 2022, and share assumed to be on tallow.



In addition to the best available estimate of tallow colonies, the quarterly USDA inventories and our survey provide evidence of the importance of tallow in country-wide migration patterns of many colonies. As shown in Table 1, April 1 has the highest number of colonies in tallow states (at 909 thousand colonies) followed on July 1 by the lowest number of colonies with 674 thousand colonies. In contrast, the peak colony inventory for the United States as a whole is in the summer. This offset in peak inventories is illustrated in the share of US colonies in tallow states reaching 31% at the time of tallow bloom and falling to only 22% on July 1. This pattern reflects the fact that tallow states draw colonies from the rest of the United States during tallow bloom.[12] The pattern of shares of national colonies in the tallow states over the year is consistent with migration patterns of inflows before the tallow bloom period and exits after the tallow bloom.

This pattern of migration of hundreds of thousands of colonies in and out of tallow states is further supported by responses to our survey questions about the placement of colonies in non-tallow states for pollination or honey (see Appendix).

2) Honey production and honey revenue

Table 3 shows the quantity and value of honey production for tallow states and non-tallow states in 2022 according to the "Honey" reports of USDA.[13] Honey production and value are the most detailed and longstanding data series for beekeeping published by the USDA. The total honey production in tallow states was 25.6 million pounds and its value was $81.8 million. Tallow states contribute 20% of US honey production by weight and 22% by value.

Two challenges limit the precision in determining how much honey is produced by the colonies placed on tallow during bloom. First, not all colonies placed on tallow produce honey while foraging on tallow. Tallow is also extensively used and valued to rebuild the numbers and strength of colonies. Such building of the colony stock was indicated by our survey respondents. Moreover, our survey findings of a frequent use of tallow forage for renovating and building up colonies are consistent with USDA data on renovated colonies (see Section 5). This means that simply multiplying the expected honey yield per colony on tallow (around 70 pounds per colony according to our survey) by the number of colonies on tallow would overestimate the quantity of tallow honey produced.[14]

Second, colonies that forage on tallow, and especially the colonies being renovated, will produce honey on other sources of forage during subsequent periods of the year, including in other states such as the Dakotas. As a result, simply multiplying honey production in tallow states (25.6 million lbs.) by the share of tallow colonies in tallow states on April 1 (about 50%)

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[12] Large migratory flows of colonies are characteristic of US beekeeping with almond pollination being their dominant driver as discussed in detail by Rucker et al. (2012), Goodrich et al. (2016), and Lee et al. (2019). Honey season in the Northern Plains is another driver of migration.

[13] The "Honey" reports for 2023 and previous years can be found at https://usda.library.cornell.edu/concern/publications/hd76s004z?locale=en. Note that this "Honey" report is annual and is not the same as the monthly "National Honey Report".

[14] The yield of 70 pounds per colony from our survey is likely that of a fully productive colony in good weather conditions. A yield of 70 pounds is high but plausible. For instance, the average yields in 2021 were 71lbs in Mississippi and 93 pounds in Hawaii according to the "Honey" report of the USDA.

would underestimate honey contributed by tallow foraging by omitting non-tallow honey that was facilitated by tallow foraging.

Table 3: Value and quantity of honey production and sales in 2022.

State	Production (*million lbs.*)	Value of production (*million $*)
Texas	8.3	27.4
Florida	7.3	23.9
Georgia	3.3	10.1
Louisiana	2.6	6.3
Mississippi	2.0	6.2
Arkansas	1.1	3.0
South Carolina	0.5	2.9
Alabama	0.4	1.9
Total tallow states	**25.6**	**81.8**
Share of nation	*(20%)*	*(22%)*
Other States	**99.8**	**295.4**
Share of nation	*(80%)*	*(78%)*
All states	**125.3**	**371.0**

Source: "Honey" report 2022, NASS, USDA. Note: In the Honey report for 2022, the sum of values of honey produced by each state (377 million dollars) does not add up to the value reported for the entire US (371 million dollars) as indicated in a footnote of page 3 of the "Honey" report. We use the lower value of the two.

To overcome these two challenges, we assume that the colonies placed on tallow will have on average a yield per colony for an entire year that is approximately equal to the average yield of all US colonies. This is consistent with the extensive migration of colonies across states as this migration. The Honey report from the USDA for 2022 indicates an average of 47.0 pounds per colony for the US.[15] This average is consistent with the fact that not all colonies in tallow are engaged in tallow honey production as this would mean an average closer to the expected yield of 70 pounds per colony as stated by beekeepers in our survey for productive tallow-honey-producing colonies.

If the average honey yield for tallow colonies is approximately the national average, the quantity of honey produced by these colonies is equal to the total US production (125.3 million pounds) multiplied by the share of tallow colonies of total US colonies (15.6%). We thus estimate that tallow colonies produce 19.6 million pounds of honey. This quantity includes tallow and non-tallow honey, including production within and outside of the tallow states. Using the share of tallow honey in total honey production for our survey respondents (60.3%),

[15] The data in the Honey report also allows one to calculate a weighted average of 45.9 pounds per colony for tallow states, but using this average would ignore the honey produced because of migration outside of tallow states.

we estimate that these tallow colonies produce 11.8 million pounds of tallow honey. This estimate would be consistent with tallow honey representing about 46% of the 25.6 million pounds of total honey produced in tallow states.[16]

We now turn to honey revenues. Tallow is an important direct source of honey produced in the tallow states, some of it is labeled and sold as tallow honey. USDA reports that tallow honey receives a similar range of prices as other commercial honey when sold to large buyers on commercial wholesale markets. The average price reported by large buyers for tallow honey purchased in 2022 was $2.68 per pound (USDA Monthly Honey Reports).

Accordingly, absent in other information, we also estimate that revenue per tallow colony is equal to the national average revenue per colony. Hence, the honey revenue contributed by tallow colonies is 15.6% of the national honey revenue ($371.0 million) and we estimate that the honey revenue from colonies that forage on tallow is about $58.0 million. This honey revenue includes the honey made by tallow colonies from other forage sources and in non-tallow states such as cotton and soybeans in Texas or Mississippi and wildflowers or canola in the Dakotas.[17] This honey and the revenue and economic activity it generates may be attributed to the availability of tallow forage that strengthens colonies. Given the evidence in USDA's Monthly Honey Reports that the price of tallow honey is similar to other honeys, we can also calculate the value of tallow honey as $34.9 million as a single place means that the same share of 15.6% applies to both quantity and value.

Table 4 provides a summary of the results of our estimation of honey revenue.

Table 4: Quantities, values, and the share of honey production contributed by tallow

Quantity of honey produced in all US		125.3	*million pounds*
Value of honey produced in the US		371.0	*million dollars*
Share of tallow colonies in the US on April 1	15.6%		
Quantity of honey produced by tallow colonies (all honeys, per year)		19.6	*million pounds*
Value of honey produced by tallow colonies		**58.0**	***million dollars***
Share of tallow honey in honey production	60.2%		
Quantity of tallow honey produced		11.8	*million pounds*
Value of tallow honey produced		**34.9**	***million dollars***

Source: Author calculations based on "Honey" report 2022, NASS, USDA, and the Tallow Survey Appendix.

[16] The figure 60.3% is obtained by dividing the total amount of tallow honey produced by respondents by the total amount of all honeys produced. This provides a share of tallow weighted by amount of honey instead of by colonies or operation as shown in figure 5 of the survey appendix.
[17] See appendix on tallow survey for further details.

3) Pollination and other beekeeper revenue

Pollination services are a major source of revenue for beekeepers including tallow beekeepers who rent colonies for pollination of crops in tallow states and elsewhere in the east and, especially, for almonds in California. Table 5 shows the number of colonies used and the value of pollination services for the 6 separate regions tracked by recent USDA pollination surveys (USDA, "Cost of Pollination").

Table 5: Colonies used and value of pollination in 2022 by region.

Region		**Colonies used** *(thousands)*	**Value of pollination** *($ millions)*
1	Northeast and Great Lakes	250	21.9
2	Southeast	94	6.6
3	Southwest	130	7.4
4	Midwest	13	0.6
5	Northwest	313	17.5
6&7	West	2,233	386.8
Total		**3,032**	**440.7**

Source: "Cost of Pollination." NASS, USDA.

Within the tallow states and surrounding states (regions 2 and 3), beekeepers receive about $14 million in pollination revenue for supplying services from about 224,000 colonies to a wide variety of crops. We assume that 80% of the pollination in the tallow region is supplied by colonies from that region allowing for some migration from other states and for the fact that some pollination opportunities occur during tallow bloom and therefore excluding tallow colonies from participation. Assuming as before that half of the colonies in tallow states foraged on tallow, we estimate $5.6 million in pollination revenue contributed by tallow.

About 83% of all pollination revenue in the United States is from almond pollination in California in the late winter (USDA, "Cost of Pollination"). The total revenue from western pollination in 2022 was $386.8 of which almond pollination was $364.7 million (USDA, "Cost of Pollination"). Almonds alone used 1.88 million colonies with a payment rate of $194 per colony. About 31.2% of U.S. colonies were in the tallow states on April 1, 2022. We assume that this share approximates the share of the tallow region in almond pollination in both the number of colonies and revenue. Shipping data from 2018 indicates that around 400,000 of the 1.88 million colonies supplied to almonds were from the tallow states (Goodrich, Williams, and Goodhue, 2019). This figure is consistent in order of magnitude with the respondents in our survey reporting around 100,000 colonies for almond pollination.[18] The western pollination revenue for tallow-region colonies is therefore $120.85 million in our estimates. Assuming that one-half of those tallow-region colonies that supply western pollination foraged on tallow, we estimate that the tallow-colony pollination revenue from western states is $60.43 million.

[18] While the published shipping data is from 2018, we are not aware of major shifts in almond pollination markets that would have occurred since and resulted in drastically different migration patterns for almonds.

We estimate that revenue from tallow colonies pollinating crops in other regions, such as fruits and berries in the northeast, is $3.4 million using the same regional and tallow-colony shares. We however assume no share of tallow colony participation in the Northwest (region 5), an important region in pollination demand with apples, cherries, and blueberries.

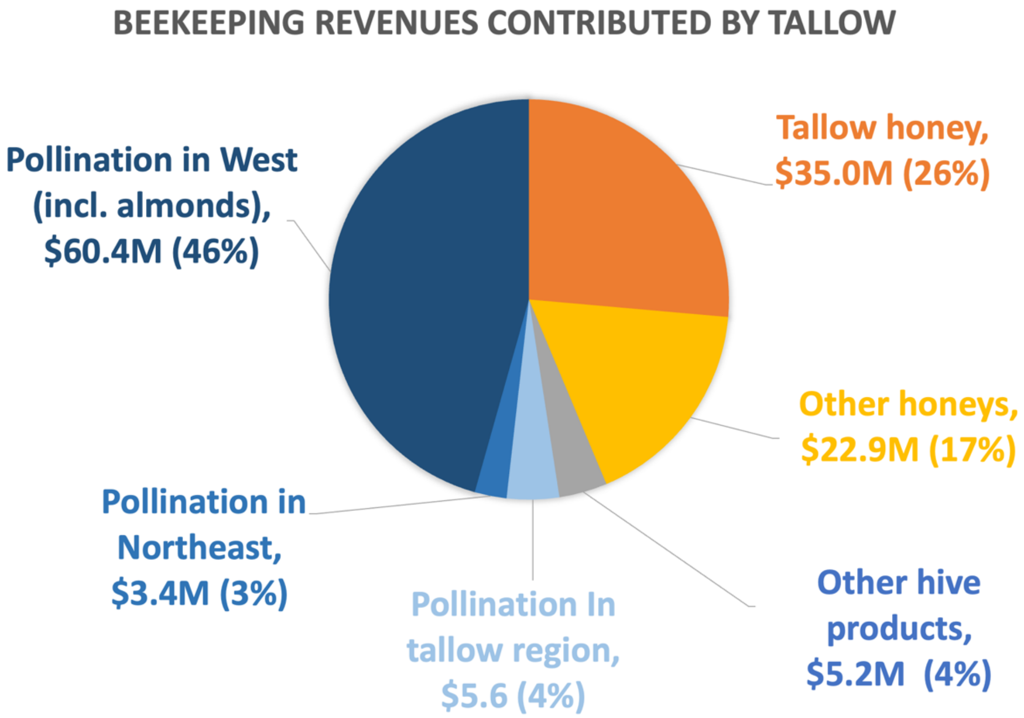
Summing the three pollination revenue sources, we estimate that revenue from pollination services for tallow colonies was $69.4 million in 2022.

4) Summary of beekeeping revenues contributed by tallow

In addition to honey and pollination revenues, beekeepers earn revenue from the sale of non-honey hive products which include wax, propolis, pollen, or bee bread. These other hive products do not include the sale of bee stock such as queens, packages, or nucs, which are sold among beekeepers and not outside the beekeeping sector. For the beekeeping industry sales of queens, packages, and nucs are both a revenue and cost. Our 2022 tallow survey found that revenue from these other hive products was 3.9% of total beekeeper revenue on average. We use this share from out survey to calculate the revenues from non-honey hive products, which equals $5.2 million in 2022 for tallow colonies.

Figure 2 summarizes the results of the calculations in previous sections and illustrates the distribution of honey, pollination, and other hive product revenues of tallow colonies in 2022.

Figure 2: Summary of beekeeping revenues contributed by tallow in 2022.



Source: USDA aggregate date and data reported in the Tallow Appendix.

Table 6 lists the total revenue generated by colonies that forage on tallow by source. The total was $132.4 million in 2022. This total is the sum of honey $57.8 million, pollination $69.4

million, and other products $5.2 million. Table 6 also reports the corresponding revenue per colony of $291, which is very similar to with the weighted average of $281 indicated by our survey respondents (Tallow survey appendix).

Table 6: Summary of beekeeping revenues contributed by tallow colonies in 2022

Honey	**$ millions**	
- Tallow honey	34.8	
- Other honeys	23.0	
All honeys	**57.8**	
Other hive products (wax, propolis, etc.)	**5.2**	
Pollination		
- Pollination In tallow region	5.6	
- Pollination in West (including almonds)	60.4	
- Pollination in Northeast	3.4	
Pollination revenues total	**69.4**	
Total revenues	**132.4**	
Revenue per colony		$291

5) Beekeeper production costs, employment, and colony replacement

Beekeepers have many costs associated with operating honeybee colonies. These costs include those for physical hives, feed and supplements, pesticides, other purchased goods, forage access, facilities and equipment, and labor services. Measuring these costs are important for tracking the contribution of tallow as the patterns of costs reflect beekeeper purchases from other industries and beekeeping labor, measured in jobs or earnings. These cost-side or "upstream" economic impacts of beekeeping allow the "downstream" contributions of tallow captured by the revenues estimated in Section 4.

Data on beekeeping costs are scarce and beekeeping operations differ in their management and costs. We rely on our survey results for approximate estimates of total beekeeping costs. We compare our estimates to the limited information available from the USDA and other sources, especially for labor. Detailed cost accounting is beyond the scope of our tallow survey data collection and our economic impact estimates.

In 2022, tallow survey respondents reported an average cost of $210 per colony. This average cost is similar to published costs for California colonies, where costs per colony in this high-wage state were about $245 per colony (Champetier and Sumner, 2019).

Labor is a major input to beekeeping. Total labor by the beekeeper includes labor of the beekeeper/operator, potentially unpaid family labor, and hired labor. USDA estimates that there were 25,000 (paid and unpaid) apiary workers in the United States in 2022. This USDA estimate includes all workers not just "employees" and includes part-time and part-year workers. We do not know what definition of an "apiary worker" the beekeeper-respondents used in determining responses that led to this total.

With about 2.7 million U.S. colonies, 25,000 workers imply an average of only 107 colonies per worker.[19] Many very small beekeeping operations are included in the USDA survey data. Many of those survey respondents would appropriately list a single part-time worker even if they have very few hives. Thus, many respondents may list one or two part-time workers for fewer than 50 colonies.

Using the USDA average of 107 colonies per worker, and the total of 455,000 tallow colonies, we calculate that 4,260 workers, clearly mostly part-time, contributed to tallow-using beekeeping operations. Colony per worker relationships that were estimated with the data from our 2022 tallow survey were consistent with the common industry benchmark of about 500 colonies per full-time worker. Using this standard of 500 colonies per worker, we estimate that 909 full-time workers, including proprietors, work in the operations with colonies that used tallow forage in 2022.

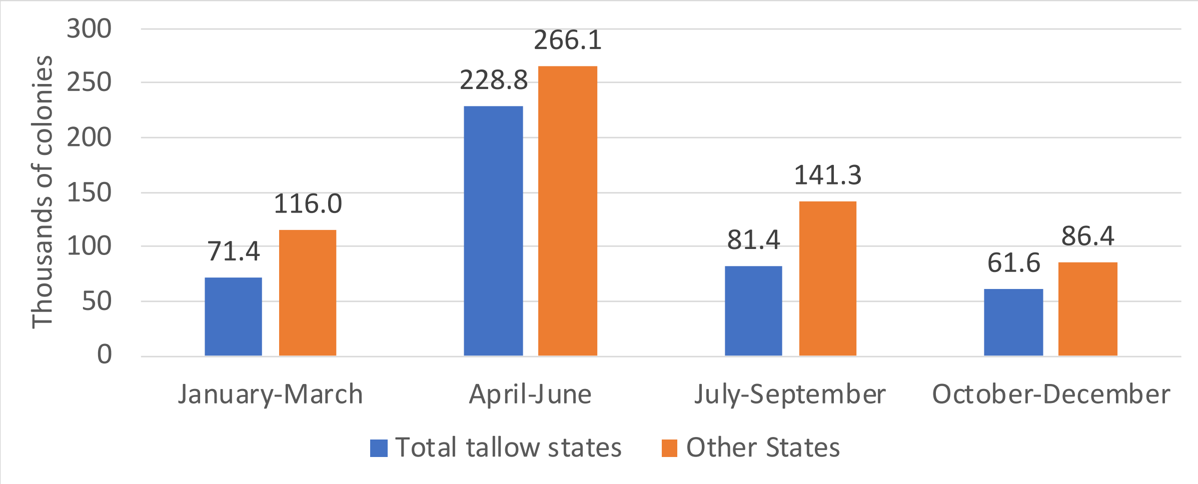
In addition to estimates of total costs and labor employed, our survey provides detailed evidence on the role of tallow as a forage. We find that tallow is an important forage seasonally. This is clear in the alternative feeding patterns of surveyed beekeepers (Tallow survey, appendix Figure 18). However, there is no available data to create a systematic inventory of forages and pollination opportunities for beekeepers in the Southern United States.[20] Tallow is accessed at relatively low costs by beekeepers who pay at most moderate fees for yards from which bees reach tallow (Tallow survey, appendix Table 8). Many beekeepers have access to tallow without incurring any costs other than the moving of bees.

The timing of tallow bloom makes it specifically important for colony stock management. In addition to revenues and costs, our tallow survey included questions on activities related to building colony strengths and colony replacement. Respondents indicated that they very often relied on tallow to build back stock to offset losses that occurred during the year and to prepare for honey production in the subsequent summer. This finding is consistent with recent USDA surveys on colony numbers. Figure 3 provides USDA data on colony renovation by quarter for tallow states and other parts of the United States that is consistent with the tallow survey data. Around 46% of colonies renovated in the country from April to June where located in tallow states.

[19] The "Honey" report for 2022 from the USDA covers honey-producing colonies and provides an inventory of 2.667 million colonies for the corresponding 25,000 workers.

[20] In Florida, citrus bloom varies by year, typically occurring in 2-3 waves of flowering any time from February through the end of March (Florida Department of Agriculture). That means the citrus pollination in Florida coincides with almond pollination in California and is complete before the tallow bloom begins.

Figure 3: Number of colonies renovated per quarter in 2022 (thousands)



Source:" Honey Bee Colonies" 2022, NASS-USDA

6) Economic contribution of tallow to beekeepers and the broader U.S. Economy

This section explains and calculates how the availability and extent of tallow forage contribute to the honeybee and honey industries directly and how those contributions generate broader ripple effects throughout the economy. We start with methods and then turn to results.

a) Methods for assessing the contribution of tallow to the broader economy.

Our approximation to determining the economywide implications of tallow forage availability follows several steps. In the previous sections, we determine the contribution of tallow to the economics of beekeeping in the affected region as indicated by the share of colonies that rely on tallow for forage. These calculations depend on USDA regional data and our tallow survey described in detail in the appendix. We then determine the beekeeper revenue by source and attribute a share of revenue to tallow availability. This assessment is described above in detail and an estimate of $132 million is provided.

In this section, we apply an economywide model and data set (IMPLAN) to our data on beekeeper revenue and employment. This model is used to calculate direct, indirect, and induced impacts on economy-wide revenues, economic value added, and numbers of workers that are attributable to honeybees and tallow. In the methodology, we modify the IMPLAN specification, building on our earlier honey industry report (Mathews and Sumner, 2019).

Some needed definitions and explanations are as follows:

(a) Economic V*alue added* measures the economic contribution of labor, capital, and management contributed by industry operations above the intermediate supplies, equipment, and services that they buy from other sectors of the economy. Economic value added is a measure of that part of revenue that removes any "double counting" from the calculation and is the economic value of each industry that is used in measures of economic activity and growth such as Gross Domestic Product (GDP).

(b) *Indirect effects* measure economic contributions to sectors that sell goods and services to an industry. That means indirect effects of beekeeping, for example, capture the impacts of expanded beekeeping revenue on revenue, economic value added, and jobs in the sectors that sell goods and services to beekeepers. Indirect effects measure one way that revenue in the sector of interest ripples throughout an economy.

(c) *Induced effects* measure economic contributions to sectors where those with direct or indirect income from an industry buy consumption goods and services. The induced effects of beekeeping, for example, capture the impacts of direct and indirect beekeeping revenue as it is spent on consumption goods and services. Induced effects measure the second way that revenue in the industry of interest ripples throughout an economy.

b) Estimated contribution of honeybee tallow forage to the broader economy.

In order to estimate the economic impact of tallow forage for honeybees on the rest of the economy we start with the tallow contribution to beekeeper revenue of $132 million as shown in the top left numerical entry in Table 7. Direct value added in the beekeeper industry is $71 million.[21] Recall value added represents the contribution of the labor, land, and capital after subtracting out goods and services that beekeepers buy from other industries. Those direct contributions of the dollar value of output and economic value-added lead to broader impacts economywide through the indirect and induced effects.

The indirect revenue includes upstream economic activity such as producers of feed, hive transportation, and other inputs used by beekeepers. Indirect revenue effects are $109 million as beekeeper purchases of inputs ripple through the economy. Similarly, the beekeeper activity generates value added for other industries throughout the economy.

The induced impacts indicate how the workers and operators in the honeybee industry also use their added incomes as consumers of goods and services. The total of $128 million in added revenue and $72 million of additional economic value added reflect the ripple effects from purchases from a wide array of industries.

Table 7: Economic contribution of tallow forage to economywide outcomes from beekeeping, excluding direct honey impacts

	Direct effects	Indirect effects	Induced effects	**Total**
Output Value ($ millions)	132	109	128	**369**
Value added ($ millions)	71	44	72	**186**
Jobs (Approximate FTEs)	909	503	790	**2,202**

Source: IMPLAN calculations based on revenue and jobs data presented above.

[21] The calculations on which table 7, 8 and 9 are built are multiplications with IMPLAN coefficients from Mathews and Sumner (2019) which are summarized for reference in the IMPLAN appendix of this report (page A1).

The jobs data presented in Table 7 are reported on a full-time equivalent basis. We do this using the direct jobs estimate of 500 colonies per job for beekeeping. The indirect and induced job effects are assumed to be primarily full-time equivalent jobs based on IMPLAN data on earnings per job and the nature of industries affected relative to beekeeping where a few hours per week and seasonal work is most common, especially for beekeepers with few colonies.

The totals in Table 7 are large and important. The $369 million in output revenue is contributed to the economy. The contribution to economic value added (similar to GDP) is $186 million, and tallow adds 2,202 FTE jobs to the economy.

Even these large contributions underestimate the full impacts because they fail to include the vital importance of tallow forage to the US honey-processing industry. Simply put, honey that is not produced by US beekeepers is not processed by the US honey industry. Therefore, honey production attributed to colonies using tallow as forage contributes to honey production by beekeepers, and honey processing has direct economic impacts that need to be included in our estimates.

Table 8 shows the direct honey market value, economic value added, and direct FTE jobs contributed by tallow in the honey processing industry The value of honey processing is $143 million on top of the value of the honey purchased from beekeepers. The direct value added of the honey processing industry is $46 million and 416 new jobs are directly attributable to the added honey processing.

Our economywide analysis recognizes that without US beekeeping, US honey processing would be impossible. Thus, for an accurate accounting, we must recognize and include the effects of tallow beekeeping on the size of the honey industry in the tallow states. Based on our earlier report for the National Honey Board, we estimate that each dollar of beekeeper honey revenue generates about $2.47 in wholesale revenue for honey processors, only part of which was counted as honeybee industry revenue. Therefore $58 million of honey revenue for beekeepers generates $143 million in wholesale revenue for the honey processing industry.

Table 8: Economic contribution of tallow to the honey processing industry.

	Direct effects
Honey processed value ($ millions)	143
Value added ($ millions)	46
Jobs (Approximate FTEs)	416

Source: IMPLAN data and data from Matthews and Sumner, 2019.

Much of the indirect and induced effects from honey processing are already counted in the direct, indirect, and induced beekeeper honey impacts. To avoid double counting, we therefore only count the direct effects in honey processing to recognize that honey processing often depends crucially on locally produced honey.

Table 9 is simply a sum of the estimates in Tables 7 and 8. Table 9 reflects our best current estimates, given available data, of the economywide implication of tallow forage availability. These results are $512 million of additional revenue in the economy, $232 million in contribution to economic value added, and 2,618 full-time equivalent jobs.

Table 9: Economic contribution of tallow to the beekeeping and honey processing industries

	Direct effects	Indirect effects	Induced effects	**Total**
Output value ($ millions)	275	109	128	**512**
Value added ($ millions)	117	44	72	**232**
Jobs (Approximate FTEs)	1,325	503	790	**2,618**

Source: Source: IMPLAN data and data from Matthews and Sumner, 2019.

In addition to honey, the other major revenue source for beekeepers is pollination, especially almond pollination. We do not incorporate the downstream impacts of tallow on the value of almond production for two reasons. First, colonies that forage on tallow are not crucial for almond production. Unlike honey production, almonds have alternatives to pollination derived from colonies that were in tallow. It would not be accurate to project substantially lower almond production, with little or no adaptation, if tallow colonies were unavailable. The IMPLAN model approach generally avoids downstream industry effects for just this reason.

Second, a much more comprehensive modeling approach could trace through all the economic relationships in almonds and other industries that use honeybee pollination. Such an approach would require estimating many supply, demand, and substitution parameters and far is beyond the scope of this report. We recognize that our estimates may miss some of the potential economic impact on revenue from pollination and the related pollination-dependent revenue, economic value added, and jobs.

7) Concluding remarks

Tallow that grows across a range of southern states provides abundant and crucial forage used by about half of all commercial honeybee colonies in the region. Forage from tallow allows these colonies to produce honey and generate honey revenue and other goods that would not otherwise be available. Tallow also allows beekeepers to build colony strength, split hives, and manage successful beekeeping operations that also generate revenue from pollination services both in the southern regions and nationwide.

Our analysis assesses the economic relationships and impacts of tallow and traces the influence of tallow forage through honey production and other markets to economywide impacts that are summarized in Table 9. The tallow survey appendix documents new data that confirms the crucial role of tallow in the economic well-being of commercial honeybee operations in the southern United States.

This report may underestimate the full impacts. First, we are not able to fully represent the activities and economic contributions of honeybee operations that have relatively few colonies. While our survey accounted for more than 30% of colonies in the region, only a small share of small beekeeping operations responded. Such an outcome is common in surveys, but it does mean that we were unable to analyze local impacts of tallow on such things as local direct retail honey sales in farmers' markets or similar venues. We also were unable to analyze empirically the benefits that these many beekeepers with relatively few colonies may garner from having a local source of abundant forage. We are also not able to capture the benefits that local businesses and retail consumers may gain from access to local honey produced on local forage. Without access to tallow, much of the direct retail sales of locally produced honey from small beekeeping operations in regions of the southern United States would not be possible.

Despite the limitations and others cited throughout the text, this report documents large positive economic impacts of tallow forage on the beekeeping industry and the broader economy.

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Appendix 1. IMPLAN multipliers and assumptions from Matthews and Sumner, 2019

Multipliers for the economic effects of the beekeeping sector

	Direct effects	Indirect effects	Induced effects	Total
Output Multipliers	1.000	0.821	0.967	2.787
Total Value Added Multipliers	0.532	0.335	0.540	1.408
Employment (jobs / $ million)	36.32	3.80	5.97	46.08

Multipliers for the economic effects of the honey processors sector

	Direct effects	Indirect effects	Induced effects	Total
Output Multipliers	1.000	1.118	0.877	2.995
Total Value Added Multipliers	0.323	0.505	0.490	1.318
Employment (jobs / $ million)	2.92	5.61	5.42	13.95

Prices and markups for the honey packing sector

Wholesale price of honey *($/lb)*	5.31
Quantity of wholesale honey made from US honey *(lbs million)*	147.6
Revenue at wholesale honey from US made honey *($ million)*	783.8
Value of honey sold by US beekeeper *($ million)*	318.0
Markup ratio	2.46

Source: Williams and Sumner (2019).

Appendix 2: Survey responses of beekeepers on tallow

Summary of Survey Findings

Our survey of beekeepers in the South of the United States was distributed between October 2022 and January 2023 to assess the use of tallow as a source of honeybee forage and contributor to honey production. This report provides a description of the survey and an analysis of the data collected. The findings from this survey support the calculation of contributions of tallow as forage to the regional and U.S. beekeeping industry and to the regional and U.S. economy.

The questionnaire circulated to Southern beekeepers, was completed by 95 respondents with more than 5 colonies. Two-thirds of the respondents were based in Texas, Louisiana, or Mississippi. Almost half of the respondents migrated across states (46%). Respondents had colony inventories from 5 to 30,000 colonies measured at their peak. Respondents operated a peak of 295,000 colonies in total.

Respondents placed 169,000 colonies (57.4% of their total inventory) on tallow, a clearly a vital source of forage. Some colonies did not forage on tallow because those blooms arrive in spring before the colony inventory peak. In addition, not all operations placed all of their colonies on tallow during tallow season. The survey indicated that the honey production from respondents totaled 20.9 million pounds per year, with 12.6 million pounds being derived from tallow (60.3%).

Tallow flow season was mostly reported in May. Some tallow flow started as early as March and some flow continued into August. Beekeepers reported paying access fees for 185,000 colonies placed on tallow. Tallow was relied upon for stock rebuild by 52% of respondents. Alternatives to tallow were limited during tallow flow and offered fewer options for rebuilding stock. Losses of colonies averaged 39.7% for both winter and summer and 89% of replacements were made from splits from own stock.

Respondents averaged one full time equivalent worker for each 534 colonies. Respondents reported an average of $46 in feed costs per colony. Feeding was most frequent in late winter, late summer and fall with variations across states. Total direct expenditures on beekeeping operations averaged $210 per colony per year.

Across all respondents, average annual revenue per colony was $281. Tallow honey represented 40% of average beekeeping revenues per colony. Other honey represented 25% of revenues and pollination 22%. Other sources of revenue where a quite small share of total revenues for all respondents except for few specialized operations. Hence tallow plays a central role in beekeeper economic activity and viability in the region.

Overview and context of the survey

This survey appendix describes our survey of Southern beekeepers. We first explain survey design and administration. Then we turn to the main findings from survey responses. These responses describe the activities of the beekeeping operations and their use of tallow. We cover size and location, revenues, costs, and stock replacement. In each section describing results, we provide key tables of data and the context for interpreting the data.[22] The source for all tables and charts in this appendix is our tallow survey.

Introduction to the survey itself

The survey was designed and administered to gather detailed objective information from a large sample of Southern beekeeping operations that provided data confidentially. The survey was advertised to beekeepers by the American Honey Producers Association (AHPA) and Honey Board via emails and at professional meetings. Beekeepers also encouraged their colleagues to participate through informal means.

The goal of the survey was to gather new information that would allow us to better characterize the contribution of tallow to beekeeping in the Southern United States. Tallow forage is used for the production of honey directly and the build-up of the strength and numbers of colonies. Therefore, the survey devoted attention to colony feeding practices, honey production, and stock management practices. The questionnaire was designed to characterize the beekeeping operations run by the respondents by gathering information on colony numbers (operation size) and migration. Most questions sought specific numerical responses. A few open-ended questions were included to elicit general feedback about tallow use. The survey questionnaire is provided in another appendix.

Questionnaire design

The draft survey questionnaire was reviewed by beekeepers and sponsors. Comments and suggestions were received from the AHPA and Honey Board. Feedback from beekeepers helped improve clarity and avoid ambiguity in terminology. This round of revision resulted in small but useful edits to the questionnaire. The initial draft version is available upon request. The questionnaire was made available online as a Google Form from September 27, 2022, until January 15, 2023, It could be filled anonymously. Respondents were given the option to provide their email for follow-up questions and 58 opted to do so.

The questionnaire is divided into two sections. The first 14 questions are designed to characterize the operation of the respondent in terms of size, output (for example, honey, pollination services,

[22] Our survey and analysis were funded by the American Honey Producers Association and the National Honey Board. All findings are our own and not attributable to any organization including our home institutions, or any funding organizations for any of our research, including the USDA or the organization listed above.

and other products), and stock management practices (splitting and replacement of colonies). The second set of questions (15 to 30) focuses on feeding practices and the use of tallow for forage.

Data collection and cleaning

To ease respondent burden and increase response rates, respondents were allowed to use their preferred units as well as shares as an alternative to magnitudes whenever questions allowed (for example, revenue from honey sales in dollars, or as a share of total revenue). In addition, respondents provided numerical or text answers for some questions (for instance 0 for none or all for 100%). The original responses were therefore converted to standard units and formats that could be compared across respondents. When respondents provided a range rather than a single number, the midpoint was calculated and used in the analysis. Responses from individual respondents that were far outside the plausible range of responses were assumed to be mistaken and not included in the statistical analysis.

The terms “hobbyist”, “side-liner” and “commercial” are often used to describe beekeeping operations in terms of “size” or the number of colonies operated. However, the cutoffs between categories are not distinct and may be subject to variation across purposes and regions. For this report, the range of colonies operated was simply broken into 6 intervals as shown in Table 1. Table 1 includes operation with 5 or more colonies to be comparable to national agricultural statistics reported by USDA, which also provide data collected from operations with 5 or more colonies. We use “size of operations” as a shorthand for “number of colonies in inventory.” We indicate a specific date or average over a period wherever we refer to colony numbers (for example, peak inventory versus average inventory).

The numbers and placement of colonies in a beekeeping operation vary over seasons. A complete description of the stock management and migratory patterns of operations was beyond the scope of this survey. The survey asked only about peak and minimum numbers of colonies. The survey also investigated locations associated with tallow forage.

Number of colonies and base of operations

Table 1 shows the distribution of operations in the seven categories of inventory sizes, using peak inventory (the largest number of colonies at any time during a typical year). The survey respondents covered the full range of colony counts or operation “sizes”. A total of 95 questionnaires contained sufficient information to be deemed useful about operations with 5 colonies. These operations reported that, at their maximum in 2022, they had a total of 294,925 colonies. The 38 operations with more than 1,000 colonies represented 96.4% of colony inventory.

Table 1: Number of operations and colonies in each category of colony counts (Questions 2 and 3)

Inventory bracket	Number of operations	Number of colonies	Average colonies per operation
5 to 49	27	605	22
250 to 499	5	1,800	360
50 to 249	17	2,220	131
500 to 999	8	5,950	744
1,000 to 4,999	15	33,650	2,243
Over 5,000	23	250,700	10,900
Total	95	294,925	3,072

Table 2 reports the breakdown of the number of operations by categories the number of colonies at the annual maximum for each operation and the self-reported "base" state.

Table 2: Operations by state and colony-count categories (Questions 1, 2 and 3)

'Base' State	5 to 49	50 to 249	250 to 499	500 to 999	1,000 to 4,999	Over 5,000	Total
Texas	7	8	0	2	5	12	34
Louisiana	13	4	0	0	1	3	21
Mississippi	3	1	3	1	5	3	16
Florida	0	1	0	3	0	1	5
Georgia	0	1	0	2	0	2	5
Alabama	0	2	1	0	1	0	4
South Carolina	1	0	1	0	0	0	2
Arkansas	1	0	0	0	0	0	1
Other states	2	0	0	0	3	2	7

Table 2 shows that the highest number of operations was in Texas, which also had the largest number of operations in the 5,000 or more inventory category. Many of the smaller operations also had their base in Texas. We also received many responses from Louisiana and Mississippi. As detailed below, a limitation of the survey is comes from the fact that responses from Florida and Georgia were low relative to the beekeeping activity of those states reported by USDA data. Alabama, South Carolina, and Georgia have small beekeeping industries and relatively fewer responses.

Table 2 lists as "other states," respondents with a reported home base in California, Iowa, Minnesota, Nebraska, North Dakota, and Wisconsin. These operations with a home base elsewhere have colonies that spend time in the south.

Number of colonies using tallow by state

Table 3 reports the number of respondent beekeeping operations and colonies by the state.

Table 3: Number of colonies placed on tallow by state (Question 18)

State	Number of colonies on tallow	Number of operations	Number of colonies in operations (max. inventory)	Share of colonies in tallow
Texas	104,885	30	136,449	76.9%
Louisiana	32,666	17	45,740	71.4%
Mississippi	22,506	16	40,672	55.3%
Florida	3,725	5	17,100	21.8%
Alabama	1,850	4	2,625	70.5%
Other*	1,820	17	37,589	4.8%
Georgia	1,630	5	14,450	11.3%
South Carolina	150	1	300	50.0%
Total	**169,232**	**95**	**294,925**	**57.4%**

Note: * includes respondents who did not indicate a state where tallow was used.

Seasonal migration

The survey did not include an explicit question about the migration of beekeeping operations or colonies. However, information about interstate migration may be derived by comparing the reported home-base state with other states listed in responses about pollination contracts and alternatives to tallow as a source of forage. The implied estimate of the prevalence and extent of colony migration is conservative. We find that at least 44 out of the 95 operations shift some of their colonies across state lines. Migratory operations tend to be larger than average. These 44 operations managed 143,114 colonies, implying an average of 4,933 colonies per operation. All but three operations with 3,000 colonies or more were migratory. The average inventory for the 51 non-migratory operations is 593 colonies, but falls to 145 colonies without these three large operations.

Revenues

The survey requested information about the source of beekeeping revenues (question 7) including honey, pollination, and other products. For honey revenue respondents provided quantity and revenue for honey produced from tallow forage and other forage. For pollination, respondents provide revenue from almond pollination and other pollination. For other products, they provided the source among many potential products. Respondents could choose to respond with shares or dollar amounts. Dollar amounts were converted to shares based on totals provided for those that provided total beekeeping revenue.

Honey Production

The total amount of honey produced by all 95 respondents in a typical year was 20.9 million pounds, of which 12.6 million pounds were tallow honey (60.3%).

Figure 1 shows the cumulative distribution of honey production among operations starting with the largest honey producers. The largest 15 producers supply around 15 million pounds, or about three-quarters of all honey production, among respondents. In Figure 1, the color indicator (red, green, or blue) shows that for 6 of these top producers, tallow is less than half of their honey. For most of the other top producers, tallow is more than 75% of the honey output. It is likely that these top honey producers migrate out of the region for honey production in places such as North Dakota.

Figure 1: Cumulative honey production ranking operations by amount of honey produced.

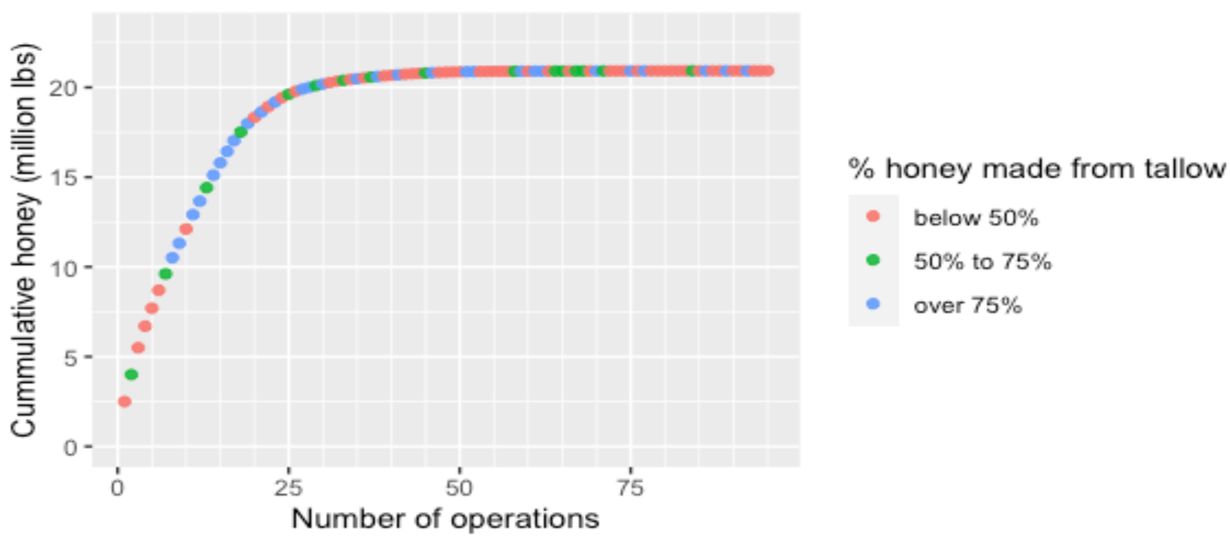


Figure 2 shows cumulative tallow honey sorting operations as in Figure 1, but now with color indication of their home base state. The top 15 producers of tallow honey supply 10 million out of the 12.6 million and most of them are located in Texas.

Figure 2: Cumulative tallow honey production ranking operations by amount of honey produced.

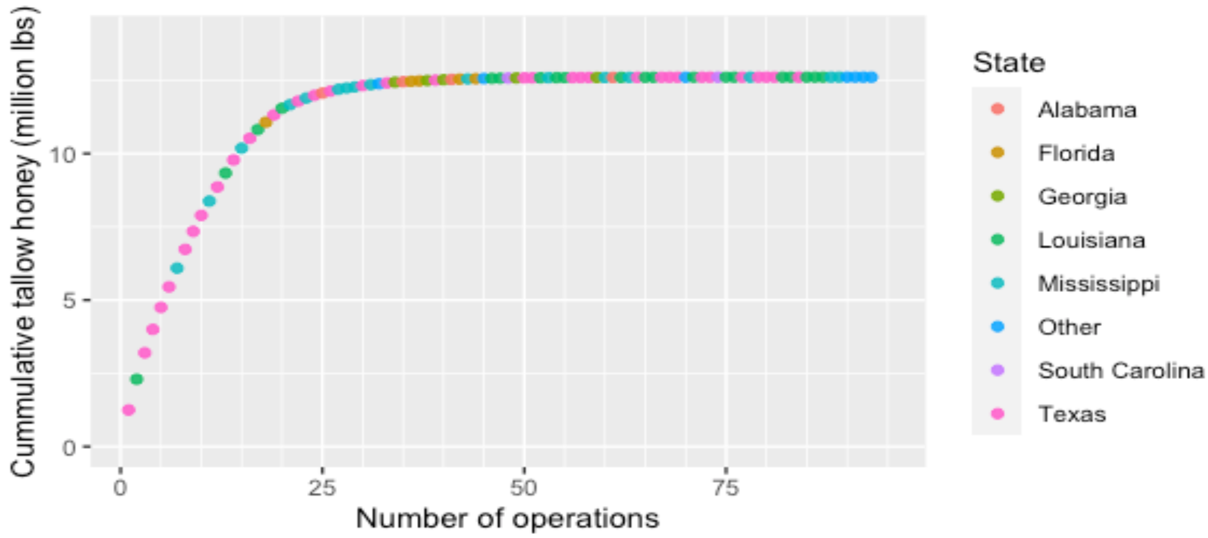


Figure 3 shows the distribution of average honey yields in pounds per colony per year. This yield is calculated by dividing the total honey produced on the operation by the number of colonies at peak inventory and is therefore an average yield that also includes for instance colonies that are used for pollination and from which no or little honey is extracted.

For this figure as for all the other similar histograms in the rest of this analysis, two means are indicated on the figure. For the blue dashed line is the mean (or average) including all responses to that honey per colony question where each response, and therefore each operation, has the same weight in the calculation. The red solid line shows the mean weighted by colony count (at average inventory, not peak). This weighted mean gives equal importance to all colonies in the sample (instead of equal importance to all operations, which is the un-weighted average of survey responses). The weighted mean is 71.3 pounds indicating that operations with more colonies tend to have higher yields of honey per colony. To understand the aggregate economic implications of the beekeeping industry and tallow as a forage the means weighted by colonies is the most useful statistic. The higher honey per colony for operations with more colonies shown Figure 3 is consistent with those operations being more likely to migrate for a longer honey-producing season.

Figure 3: Histogram of annual yield per colony for all honey (Question 4)

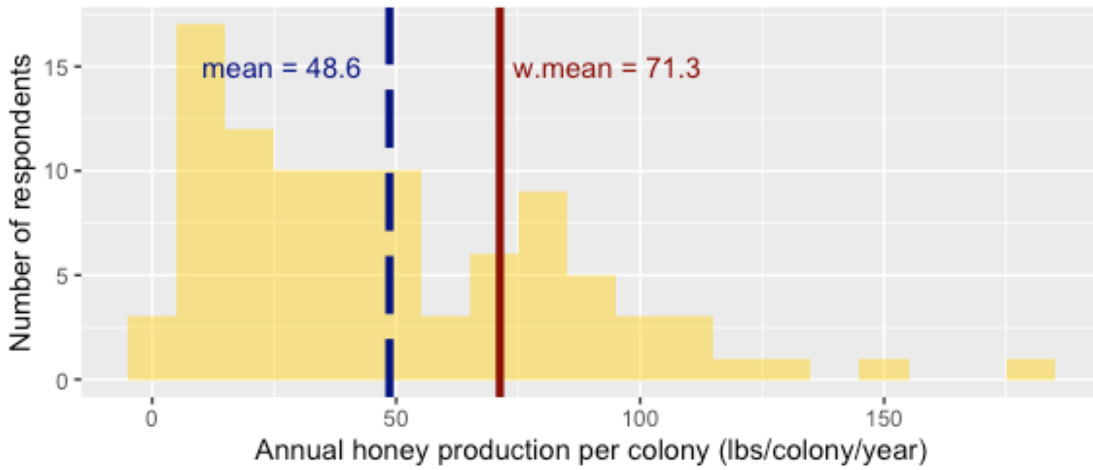


Figure 4 shows the distribution of yields per colony for tallow honey. Note that this figure must be compared with the previous with care as the numbers come from a question directly asking beekeepers to estimate how much tallow honey they obtain on average from a colony placed on tallow. Thus, this yield estimate excludes colonies that are not producing honey. There is no important difference between the mean and weighted mean, which indicates that the number of colonies in the operation does not affect the yield of tallow honey per colony among survey respondents.

Figure 4: Histogram of annual yield per colony for tallow honey (Question 20)

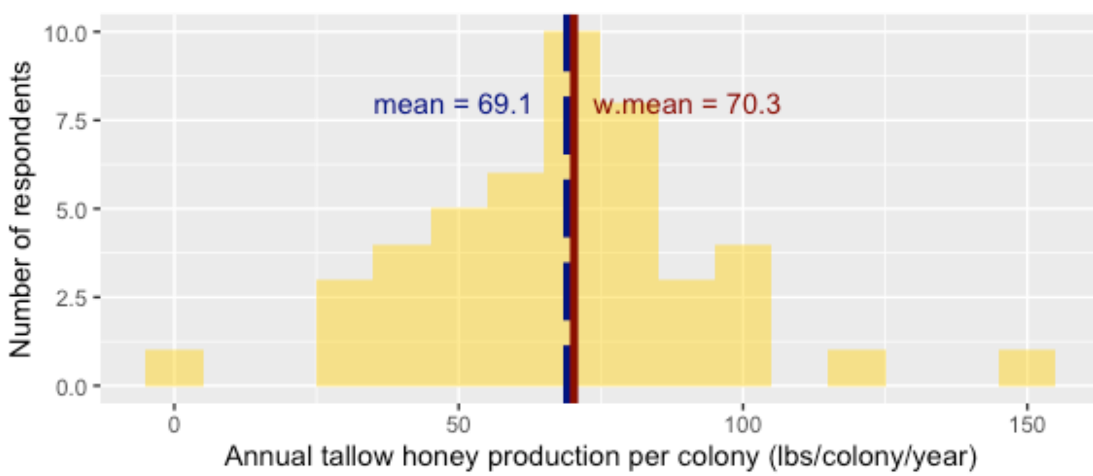
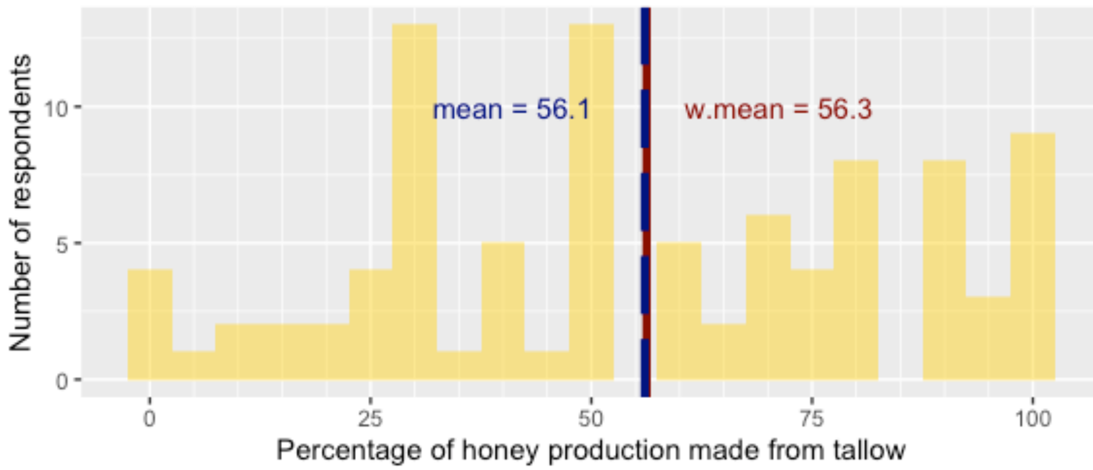


Figure 5 shows the share of tallow honey in all honey produced by respondents. This share varies greatly across operations with 20 operations producing 90% or more of their honey in tallow. At the other end of the distribution, a dozen operations make less than 25% of their honey in tallow.

Figure 5: Histogram of percentage of honey made from tallow (Question 5)



Honey revenues

Honey revenues reflect the patterns of honey production with tallow honey and other honey ranging in share of total revenues from 0 to 100%. The mean share of tallow revenue was 59.9% while the weighted mean was 42.9% indicating that larger operations tend to have more revenue from other sources, such as pollination fees.

Figure 6: Histogram of share of tallow honey sales in total beekeeping revenue (Question 7a)

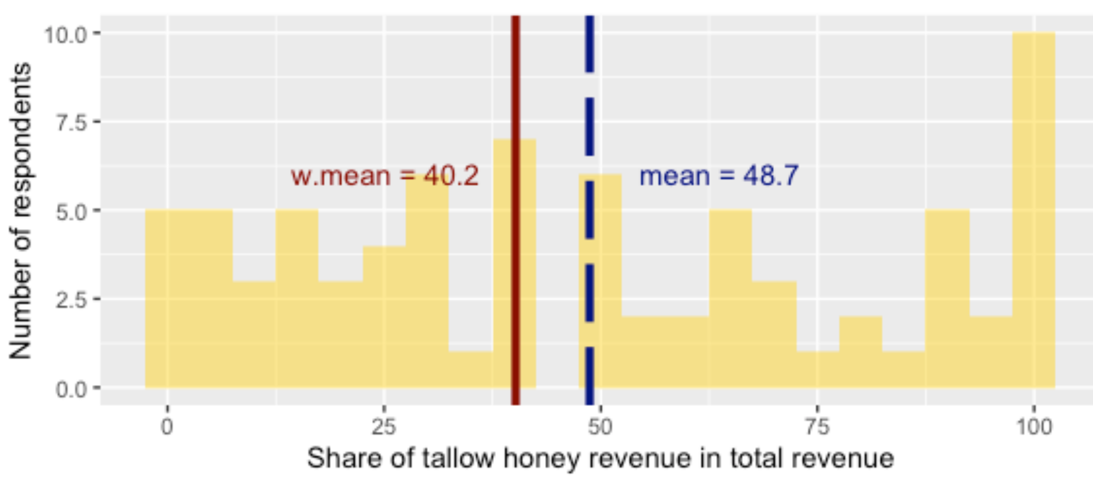
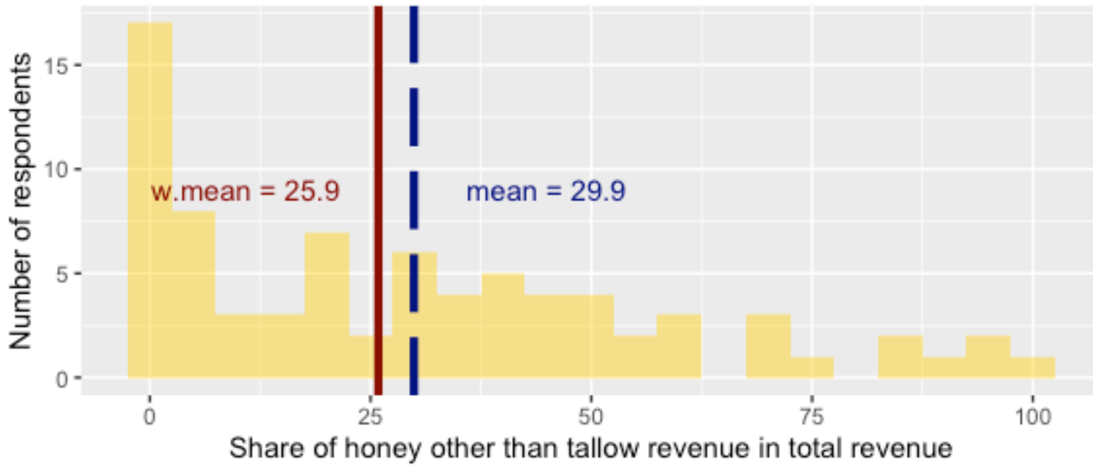


Figure 7 shows the distribution of shares of non-tallow honey which also range widely. The mean share of non-tallow honey in beekeeping revenues was 31.3% and the mean weighted by operation count was 26.7%, indicating that non-tallow honey was a smaller source of revenue than tallow honey as well as again that larger operations tended to have larger other revenue sources than honey sales.

Figure 7: Histogram of share of non-tallow honey sales in total beekeeping revenue (Question 7a)



Pollination revenues

Pollination revenues are separated into pollination of almonds and all other crops. Figure 8 shows the distribution of shares of almond pollination revenue in total revenue. About half of all respondents reported zero almond pollination revenue. For operations that did report almond pollination revenue, it represented 5% to 50% of total revenue, except for one operation that derived nearly all of its revenue from almond pollination.

In total respondents reported using 99,768 colonies to pollinate almonds. The weighted mean share was 21.8%. Larger operations are much more likely to pollinate almonds.

Figure 8: Histogram of share of almond pollination fees in total beekeeping revenue (Question 7c)

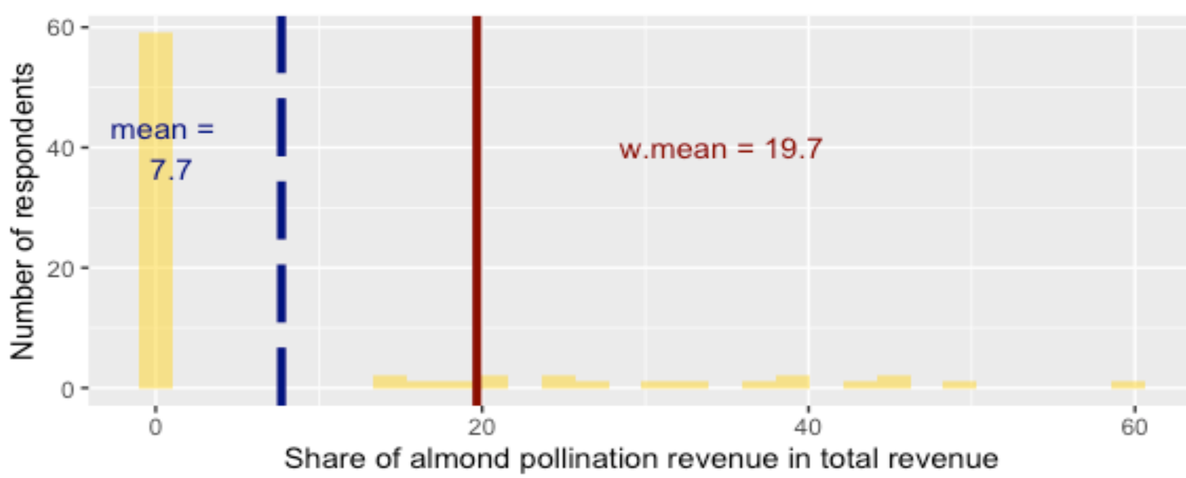
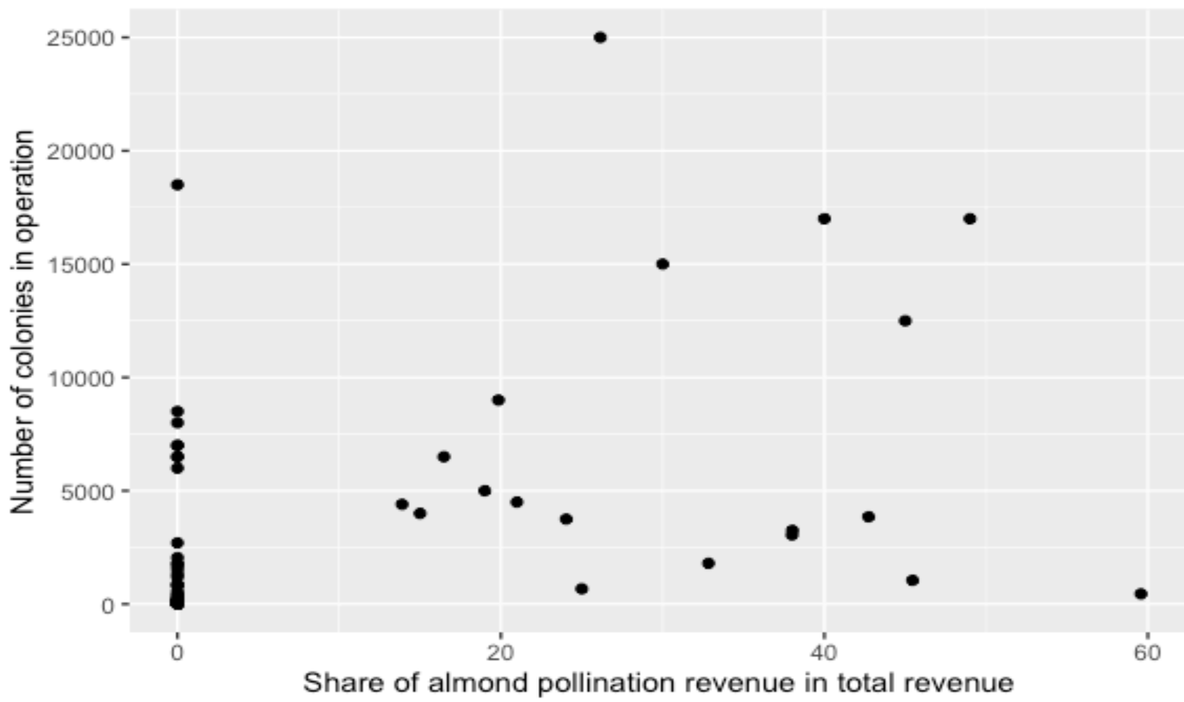


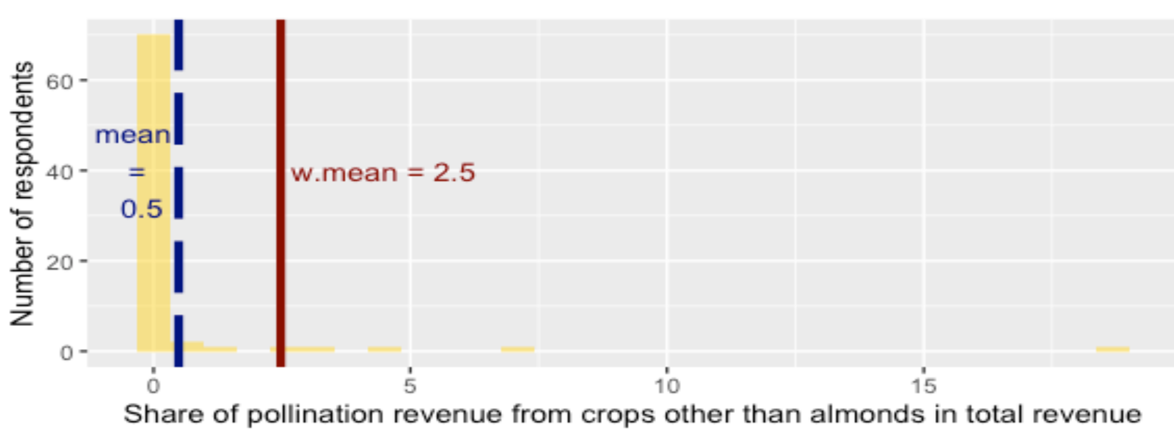
Figure 9 shows positive relationships between revenue share from almond pollination and operation size. It also shows a few operations with several hundred colonies that supply almond pollination (the smallest with 400 colonies). Operations with thousands of colonies were the majority of those supplying almond pollination and several of those received more than 25% of revenue from almond pollination.

Figure 9: Share of almond pollination in revenue in relation to operation size



Crops other than almonds, such as watermelons or blueberries, also offer opportunities for pollination revenues. Figure 10 shows that pollination revenue from crops other than almonds is a very small share of revenue. The weighted mean was 2.5%, with one large operation (at 18%) pulling up the weighted average.

Figure 10: Histogram of share of pollination revenues for crops other than almonds in total beekeeping revenue (Question 7c)



Other revenues

Beekeeping revenues other than honey and pollination, include sales of wax and other hive products (propolis and pollen among others). This “other category also includes sales of queens, bee packages, nuclei, and full colonies. These revenue sources are small compared to honey and pollination except for specialized operations, that may, for instance, specialize in queen production.

Figure 11 shows that a dozen operations indicated a revenue share of 10% or more from wax and other products. The weighted mean was just 4.2%, and about half the respondents reported zero revenue from other products.

Figure 11: Histogram of share of wax and other hive product sales in total beekeeping revenue (Question 7b)

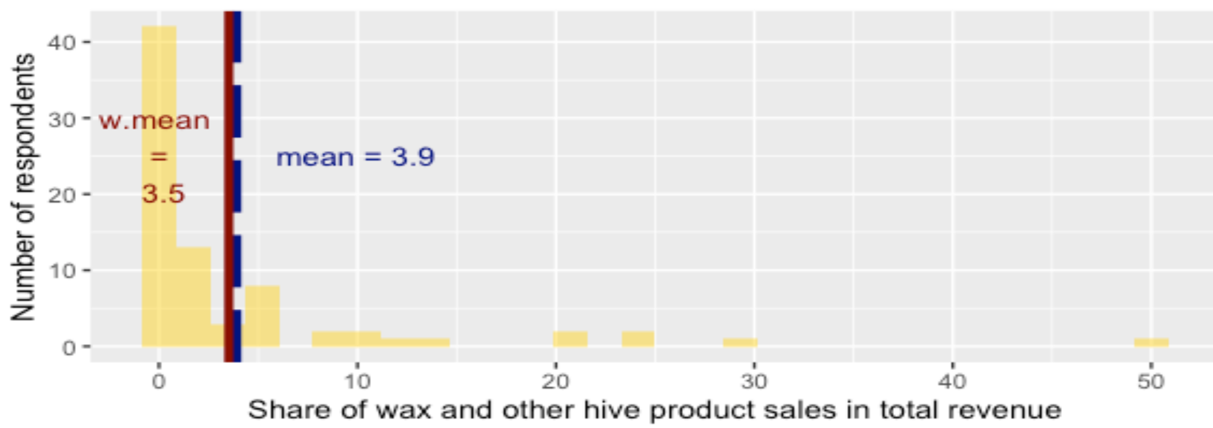


Figure 12 provides a similar pattern for revenues from queen sales with a handful of operations showing some specialized queen production activity and most operations with no queen sales. For nuc sales (Figure 13) the weighted average was 3.1% of total revenue. The weighted mean from hive or package revenue (Figure 14) share was 3.2%.

Figure 12: Histogram of share of queens sales in total beekeeping revenue (Question 7d)

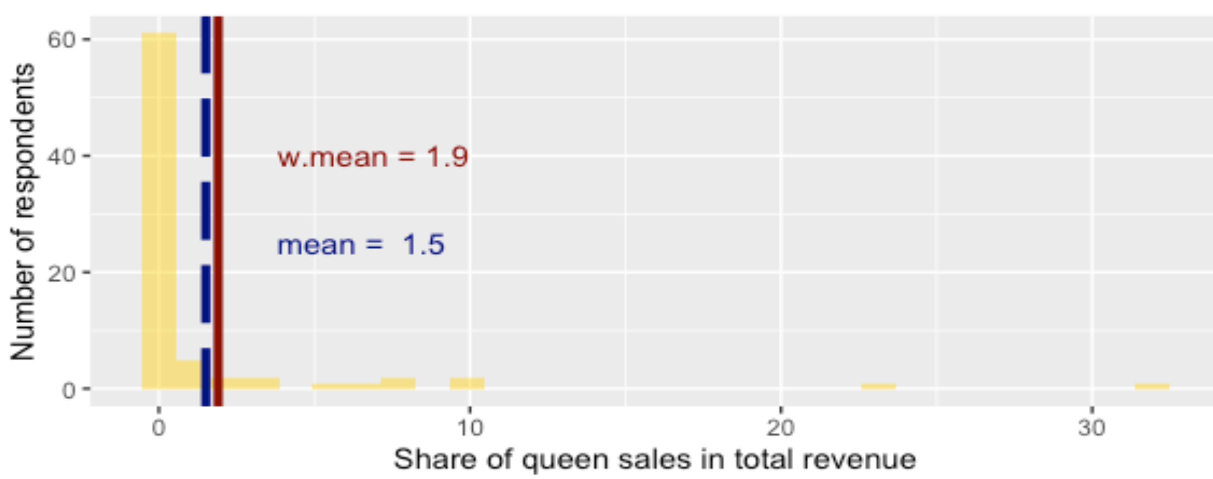


Figure 13: Histogram of share of nuc sales in total beekeeping revenue (Question 7d)

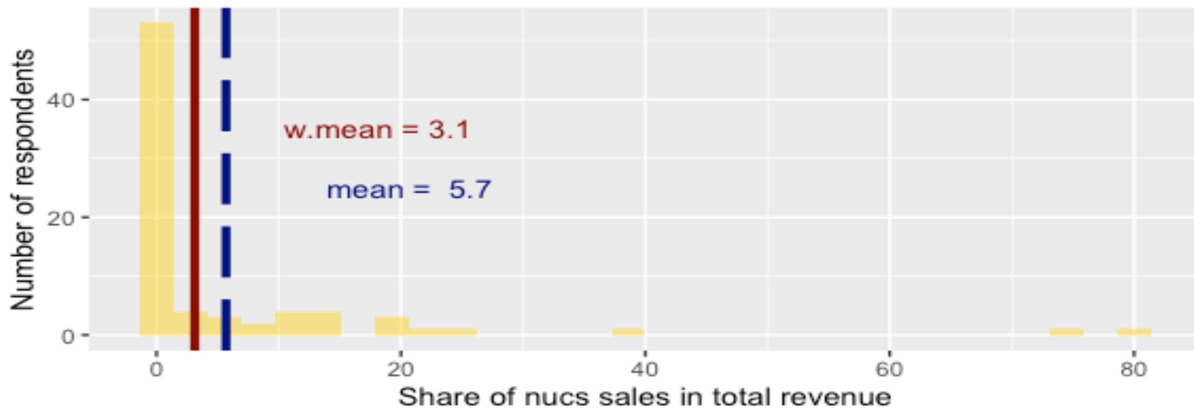
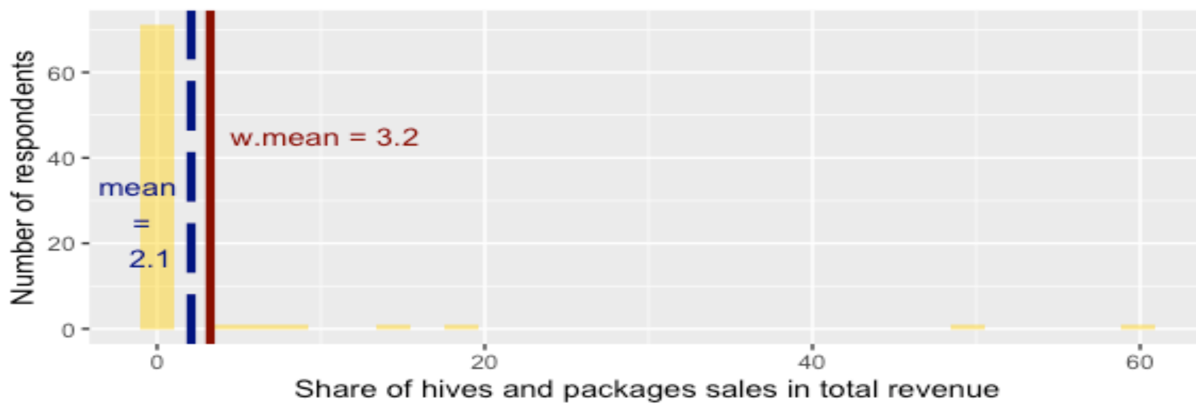


Figure 14: Histogram of share of hives or package sales in total beekeeping revenue (Question 7d)



Summary of revenues

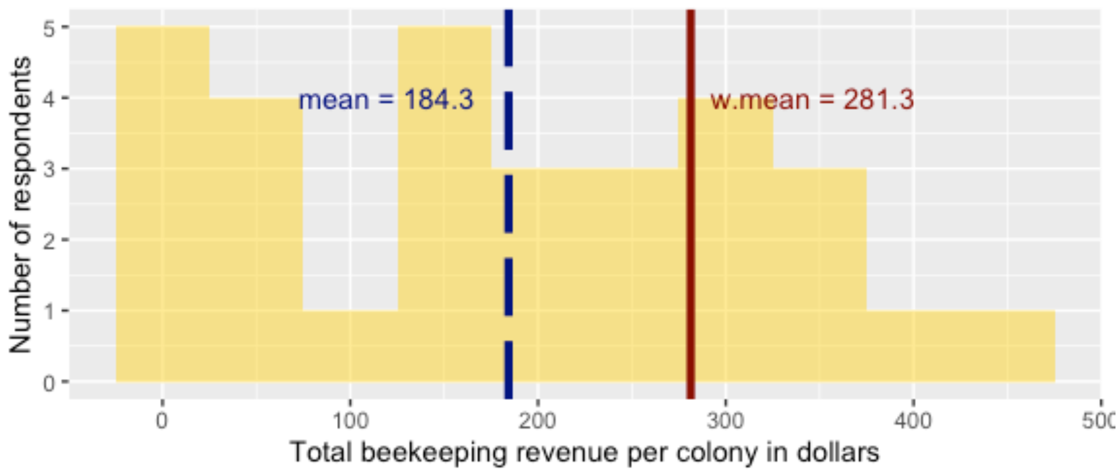
Table 4 gathers the means and weighted means for the eight sources of revenue presented in this section.

Table 4: Summary of shares of beekeeping revenues

Revenue source	Mean	Weighted mean
Tallow honey	48.7	40.2
Other honey	29.9	25.9
Almond pollination	7.7	19.7
Other pollination	0.5	2.5
Wax and other hive products	3.9	3.5
Queens	1.5	1.9
Nucs	5.7	3.1
Hives and packages	2.1	3.2
Total	100.0	100.0

Figure 15 provides the distribution of revenue per colony for the 26 operations that reported revenue by source in dollars rather than shares. The weighted average revenue for these operations was $281 per colony.

Figure 15: Histogram of total beekeeping revenue per colony in dollars (Question 7)

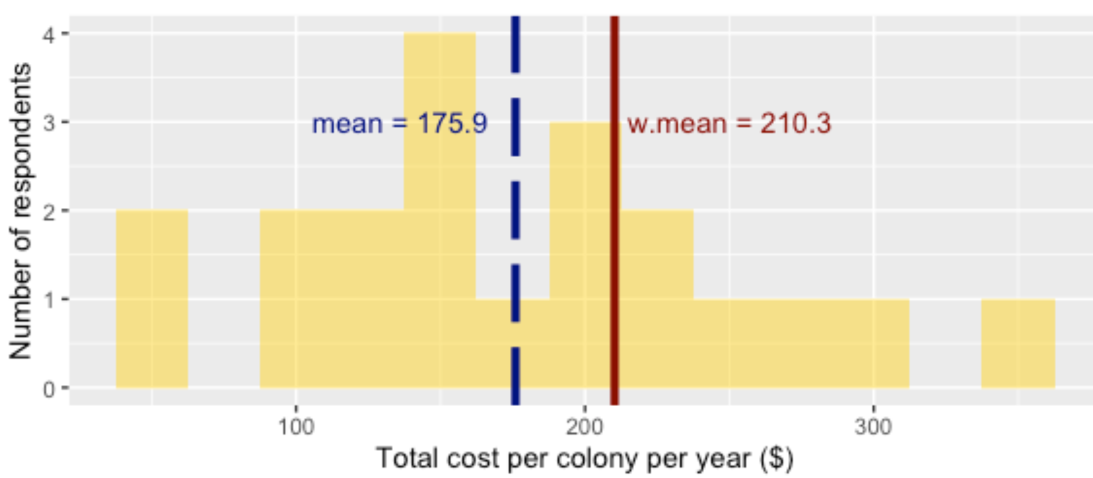


Costs

Because of our focus on the contribution of tallow as a honeybee forage, this section reports data on the cost of bee feeding and access to forage, as well as bee stock replacement.

Figure 16 describes the distribution of total annual costs per colony for the 21 operations that provided total costs. The weighted mean of the total cost was $210 per colony per year. Cost data provided by operators may not include compensation for the time and labor of the beekeeper or family members. These data are nonetheless useful to confirm that revenue data and other cost data are broadly consistent.

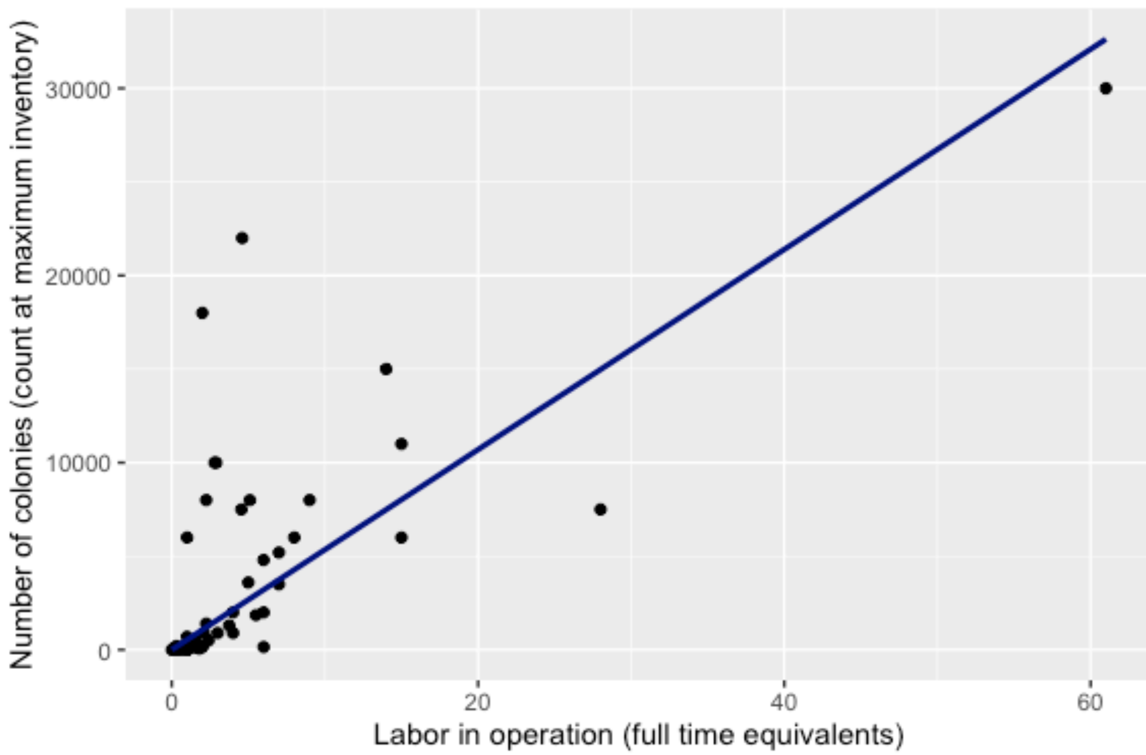
Figure 16: Histogram of total cost per colony per year (Question 9)



Labor

Labor is an important input and concern in beekeeping (see Appendix table A1). Figure 17 shows the relationship between colony inventory and full-time equivalents (FTEs) workers. A linear regression through the data points is shown in blue.

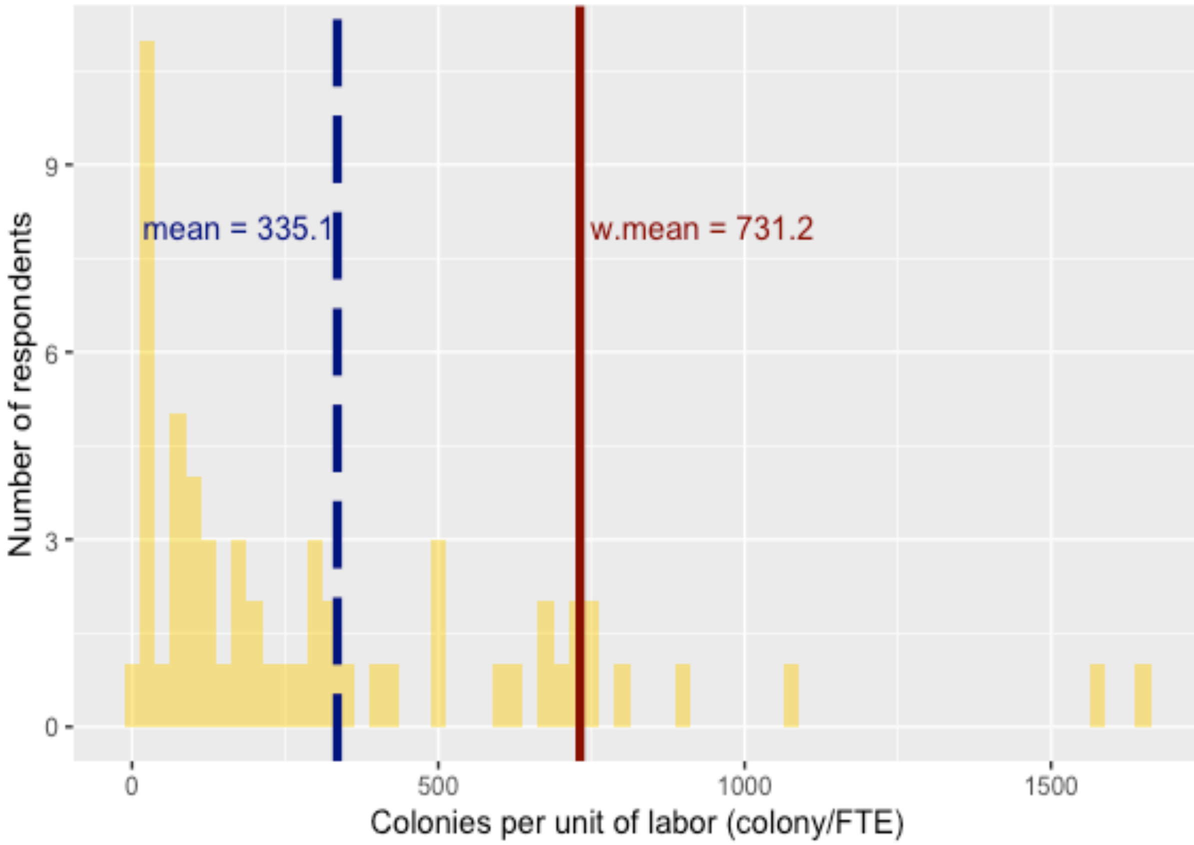
Figure 17: Relationship between colonies inventory and labor on operation (Question 8)



The coefficient of labor FTE on the number of colonies in the operation is 534 (the slope of the blue line). The coefficient is influenced by the largest operation with about 30,000 colonies and 60 FTE workers. The slope of 534 colonies per work is close to the often-cited average of 500 hives per beekeeper. The data shown by the black dots in Figure 17 indicate that several large operations report more than 500 colonies per worker. This may be because operator and family labor is underreported, or that some activities, such as management and office tasks are underreported. Responses of two operation with around 20,000 colonies and five or fewer workers may not be plausible.

Figure 18 shows a histogram of colonies per FTE with a mean of 335 colonies per FTE and a weighted mean of 731 colonies per FTE. The responses show a wide range. Small operations with less than 500 colonies and less than one FTE likely find it difficult to report labor time precisely. Some very small operations may also report many hours for a few colonies, especially if it is partly a form of recreation. In addition, the concerns raised about data in Figure 17 arise for interpreting some of the responses reporting more than 1,500 colonies per FTE.

Figure 18: Histogram of colonies per FTE among respondents (Question 2,3 and 8)

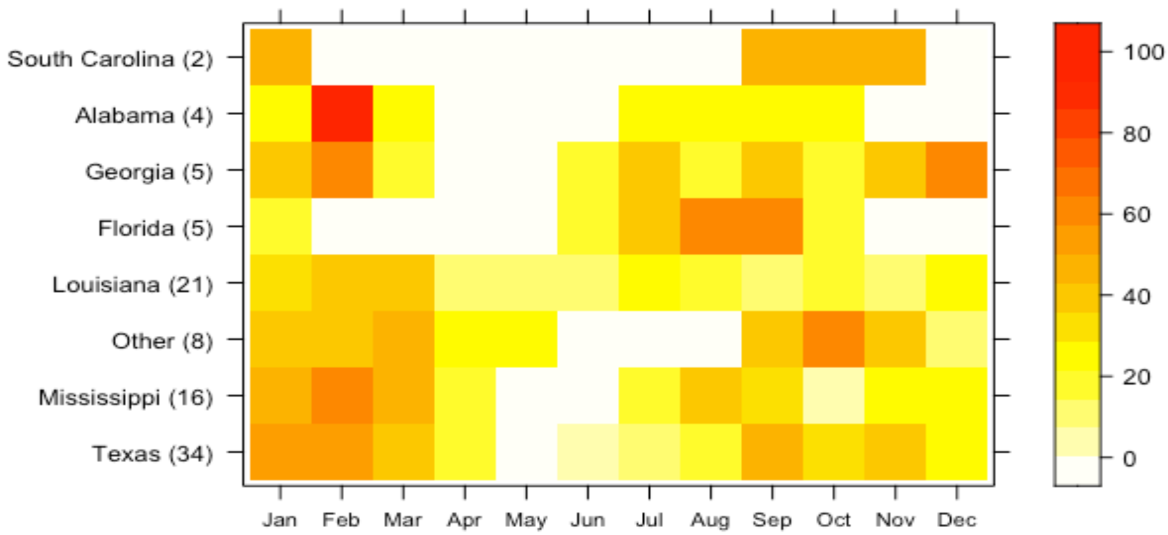


Colony feeding

In this section, honeybee feeding means supplemental nutrition for the colony above what is gathered through forage.

Figure 19 provides an overview of when feeding is practiced throughout the year across states. The color scale represents the share of respondents who reported feeding their colonies in a given month in each state, with the number of responses by state shown along the vertical axis.

Figure 19: Percentage of responding operations indicating feeding during each month of the year (Question 17)



The spring and early summer months of April, May, and June generally involved less feeding. More intensive feeding occurred from mid-summer to fall and again in January through March. The extent of the period without feeding varied across states. For reference, the data used to generate Figure 19 are reported in Appendix Table A2.

The distribution of feeding costs per colony and per year are represented in Figure 20. These data are for feed alone and do not include labor. The weighted mean of annual feeding cost per colony was $46.3. Larger operations tend to invest more resources in feeding per colony.

Figure 20: Histogram of feeding cost per colony per year (Questions 15 and 16)

Figures 21 and 22 provide the distribution of two feed costs among respondents in dollars per colony and per year.

Figure 21: Histogram of sugar feeding cost per colony per year (Question 15)

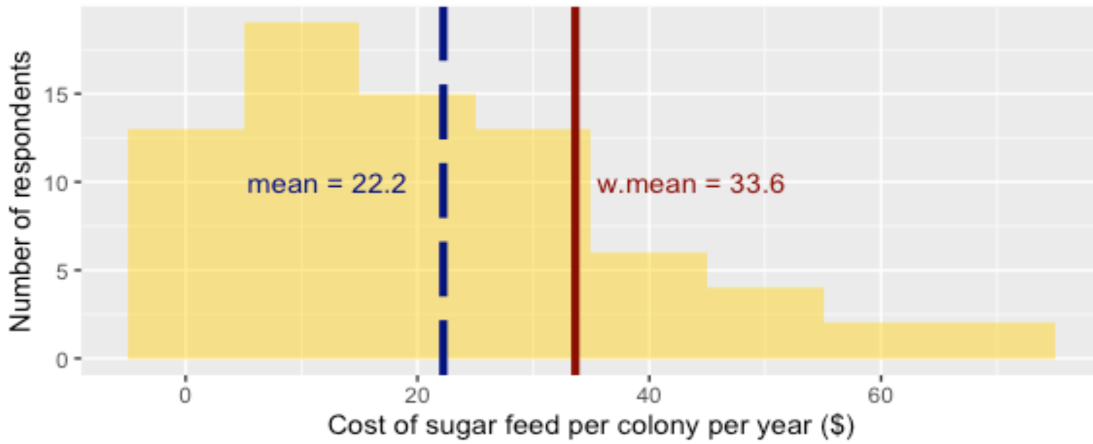


Figure 22: Histogram of protein feeding cost per colony per year (Question 16)

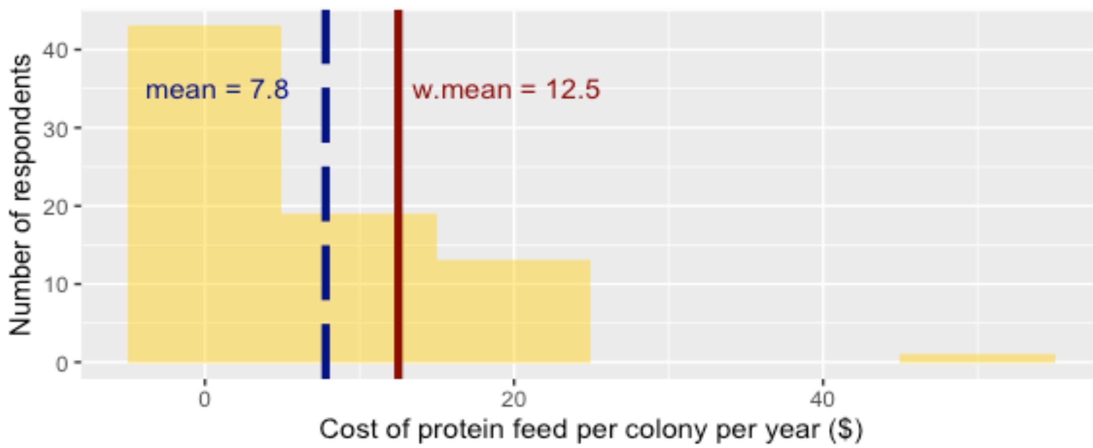
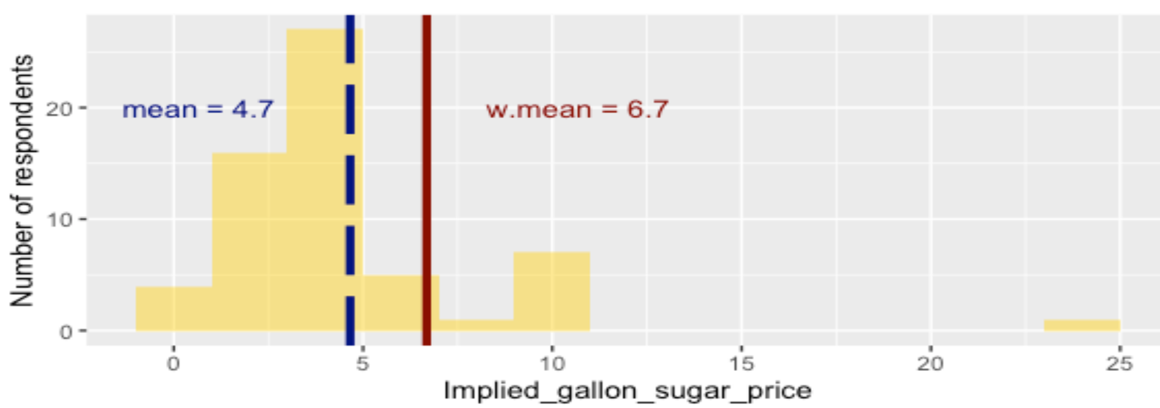


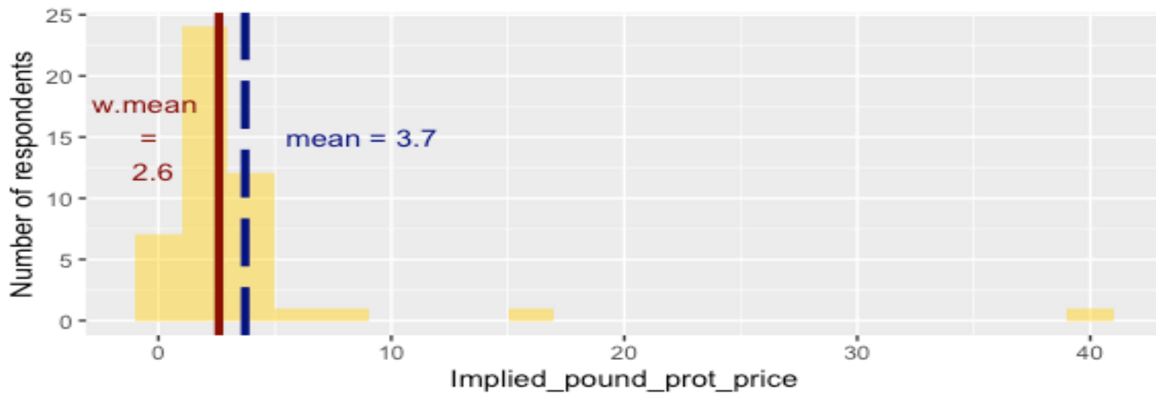
Figure 23 indicates a weighted average of $6.7 per gallon of sugar syrup.

Figure 23: Histogram of implied cost of a gallon of sugar syrup (Question 15)



The weighted mean cost of protein feed was $3.7 per pound.

Figure 24: Histogram of implied cost of protein per pound (Question 16)



The means and weighted means for the feeding costs and factors are gathered in table 5.

Table 5: Summary statistics for feeding cost and its factors (Question 15 and 16)

	Min	Max	Mean	Weighted mean
Syrup (gallons per colony per year)	0.0	20.0	5.7	6.5
Cost of syrup ($ per colony per year)	0.0	75.0	22.2	33.6
Protein (lbs per colony per year)	0.0	10.0	2.5	5.1
Cost of protein ($ per colony per year)	0.0	50.0	7.8	12.5
Total feeding costs ($ per colony per year)	0.0	85.0	28.8	46.3
Implied cost of sugar ($ per gallon)	0.2	23.2	4.7	6.7
Implied cost of protein ($ per lbs)	0.2	40.0	3.7	2.6

Tallow forage

Table 6 provides a summary of the dates of the start and end of tallow flow in each state as indicated by respondents. The mean date is calculated as the mean across respondents. The states are ordered from the earliest to the latest mean start date. May and June are the most common months of tallow flow across respondents and states. In some areas of Texas, tallow flow starts in early March. Respondents reported tallow flow as late as August in areas of Georgia.

Table 6: Dates of tallow bloom across states e (Question 19)

State	Earliest start	Mean start	Latest start	Earliest end	Mean end	Latest end
Louisiana	03-20	04-23	05-10	04-30	06-25	07-30
Texas	03-01	04-27	05-15	05-30	06-16	07-30
Mississippi	04-01	05-09	06-01	06-10	06-30	07-30
Florida	05-05	05-21	06-01	06-15	06-26	07-15
Georgia	05-20	05-27	06-01	06-15	07-11	08-15
South Carolina	06-01	06-01	06-01	06-25	06-25	06-25
Alabama	05-20	06-02	06-20	06-30	07-20	07-30

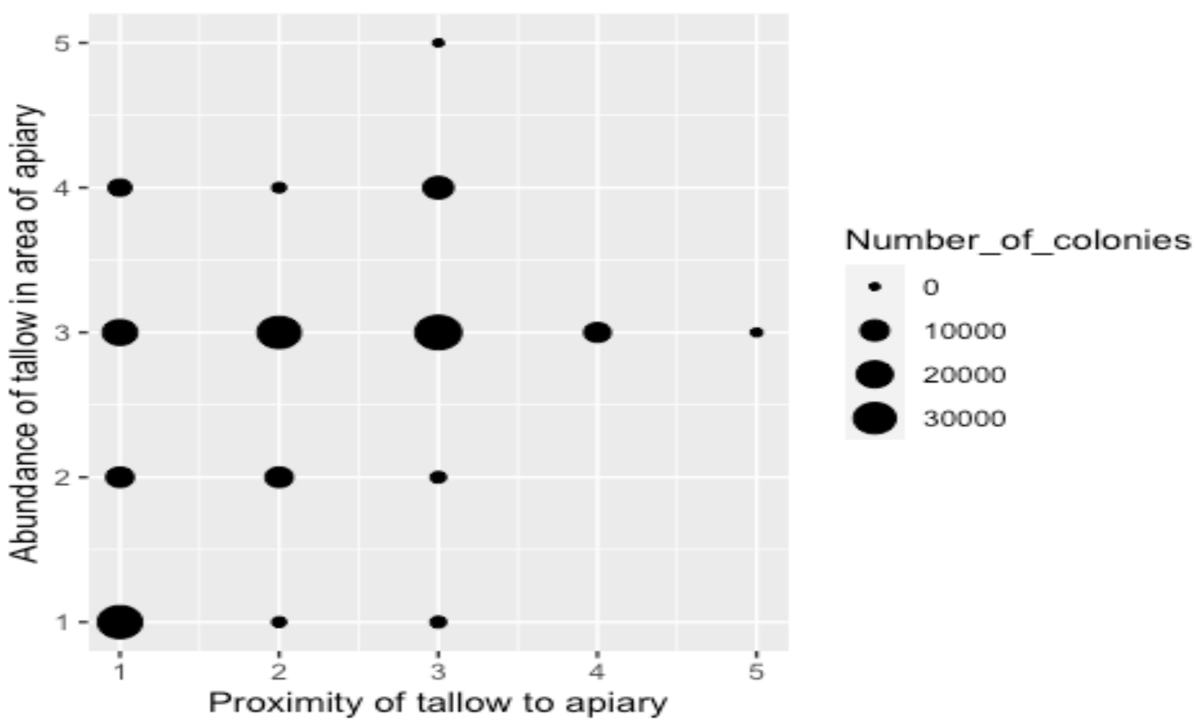
Respondent beekeepers were asked to rate the abundance of tallow in their area and the proximity to their base of operation of the tallow their colonies foraged on during tallow season. They rated these characteristics on scales from 1 to 5. A rating of 1 represented the most abundant source and the closest source. Table 7 reports the percentage of responses in each rating of proximity and abundance. Although the relative scale does not provide a metric such as distance or density of tallow, Table 7 shows that many beekeepers were able to find locations that they rates as at least moderately abundant and relatively close to their base of operation.

Table 7: Percentage of responses for rating of tallow location from best to worst (Questions 23 and 24)

Indicator	Proximity	Abundance
1	42.1	25.3
2	20.0	20.0
3	23.2	32.6
4	2.1	10.5
5	1.1	2.1
NA	11.6	9.5

Figure 25 shows the distribution of colonies placed on tallow in terms of proximity and abundance. This figure indicates that while around 30 thousand colonies are in locations judged to be as near as possible to as abundant as possible tallow, many more colonies are in locations with both average location and average proximity. A large share of colonies of survey respondents were relatively near to adequate tallow flow.

Figure 25: Distribution of colonies along gradient of tallow proximity and abundance (Questions 23 and 24)



Access to good forage locations may require payment of fees to land owners in addition to the cost of moving colonies. Table 8 reports the number of respondents and corresponding colonies for each type of payment for access. Fees per location have most colonies (96,700). Fees averaged $273 and ranged from $100 to $500 per location. Almost half the respondents, with 69,971 colonies, accessed tallow forage for free. Fees per hive averaged $4 and ranged from $1 to $10 per colony. The ratios of colonies to the number of respondents by category indicate that free access was more frequent among smaller operations.

Table 8: Forms of payment and amount for access to tallow locations (Question 22)

Payment form	Number of respondents	Colonies	Mean	Minimum	Maximum
Fee for location	14	96,700	273	100	500
Fee per hive	8	88,350	4	1	10
Free	46	69,971	0	0	0
NA	22	30,854	NA	NA	NA
Payment in honey	3	6,800	NA	NA	NA
Sharecrop	1	2,000	NA	NA	NA
In exchange for pollination	1	250	NA	NA	NA

Respondents used tallow forage for rebuilding 97,527 colonies during 2022, which is equivalent to 57.6% of all colonies placed on tallow. Slightly more than half of respondents reported relying on tallow to rebuild their stock.

To assess alternatives to tallow available to beekeepers during tallow flow, questions 26, 27, and 28 collected indicators describing alternative forage sources on which colonies could be placed. Each alternative was characterized by the plant, state, honey production, pollination fees, feeding costs, and the possibility of stock rebuilding. Table 9 summarizes the characteristics of all the alternatives reported by respondents. The last column, labeled "N" (for number) indicates how many respondents cited that alternative. Many respondents indicated that there were no alternatives in their state, and some indicated not moving their hives. These negative responses are not included in Table 9.

Most of the averages in Table 9 rely on information from a single respondent and a few are outside the expected range. The honey yields of 250 pounds per colony attributed to citrus and clover in Louisiana are more than four times the average annual USDA honey yield per colony in Louisiana.[23]

[23] Louisiana Honey report, March 12, 2022, available at: https://www.nass.usda.gov/Statistics_by_State/Louisiana/Publications/Livestock_Releases/Bee_Honey/2021/lahoney21.pdf

Table 9: Honey, pollination, and other characteristics of non-tallow locations (Question 26, 27 and 28)

Crop	States	Avg. fee*	Avg. honey yield**	Avg. feeding costs*	Rebuild possible	No rebuild possible	N
none indicated	many	45	28	11	4	13	23
wildflowers	LA, TX, MS	0	53	18	2	2	5
brush	TX, MS	0	6	25	1	1	2
soybeans	IA, MS	0	81	21	0	2	2
citrus	LA	0	250	10	0	1	1
clover	LA	0	250	10	0	1	1
cotton	MS	0	42	2	0	1	1
orange	FL	50	27	0	1	0	1
privet	TX	0	20	0	1	0	1
watermelons	SC	50	27	0	1	0	1

Notes: *Dollars per colony; ** Pounds per colony"

Stock replacement

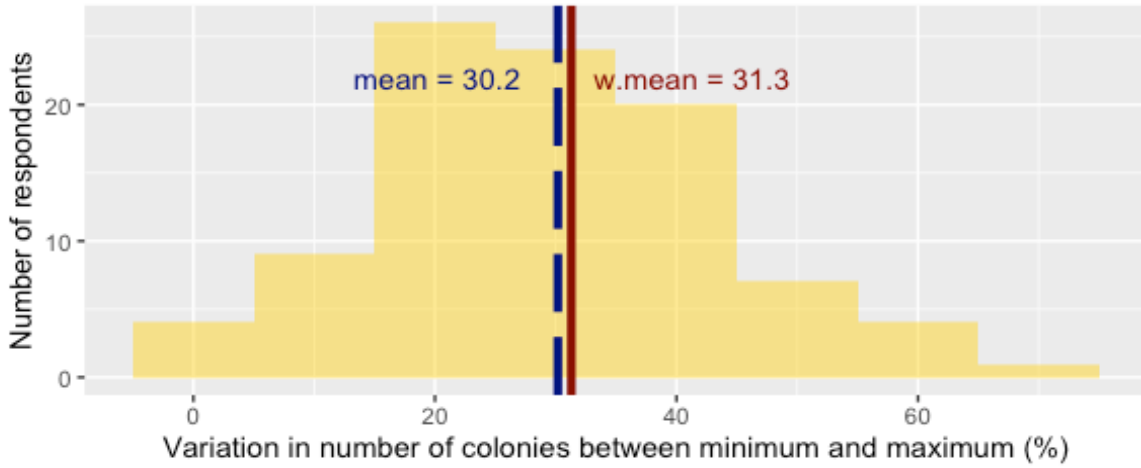
The difference between the highest number of colonies during the year and the lowest number is related to losses of colonies. This difference indicates the number of replacements required to maintain a stable number of colonies from year to year. In addition to colony losses, sometimes the number of colonies is reduced by the beekeeper to reduce the number of colonies when feeding is necessary and revenue opportunities are limited. Respondents list tallow as an important resource for bee stock replacement.

The sum of colonies across all respondents was 294,925 at peak inventory and 200,524 at the lowest point of the year.

The variation in colony inventory between maximum and minimum for all respondents combined was calculated to be about 32%.

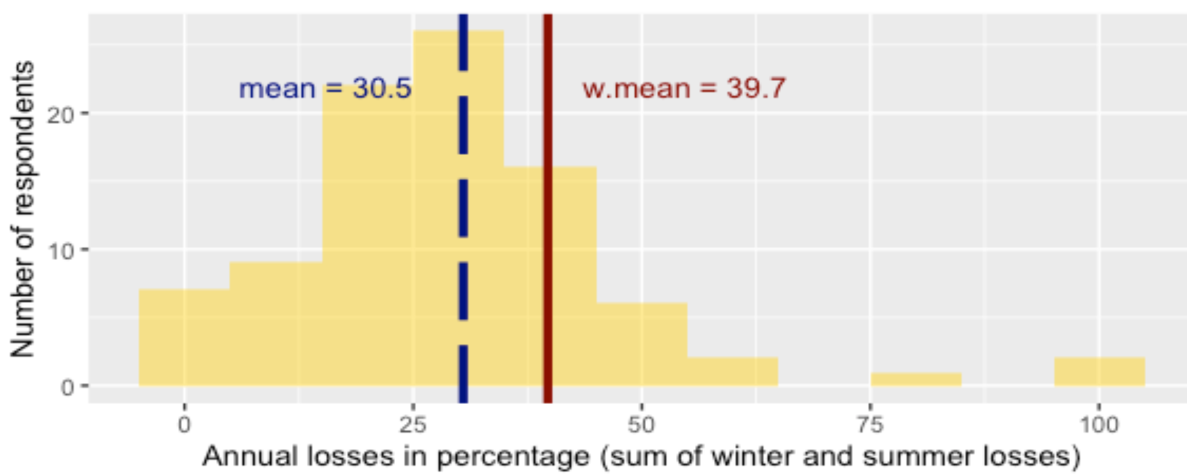
Figure 26 shows that the yearly variation percentage in colony numbers differs greatly across operations. In Figure 26, the weighted mean uses average colony inventory (and not peak inventory) to be consistent with the other figures in this report, which explains why the percentage variation reported is 31.3% and not 32.0%.

Figure 26: Histogram of percentage change in colony count per operation between high and low counts during the year (Questions 2 and 3)



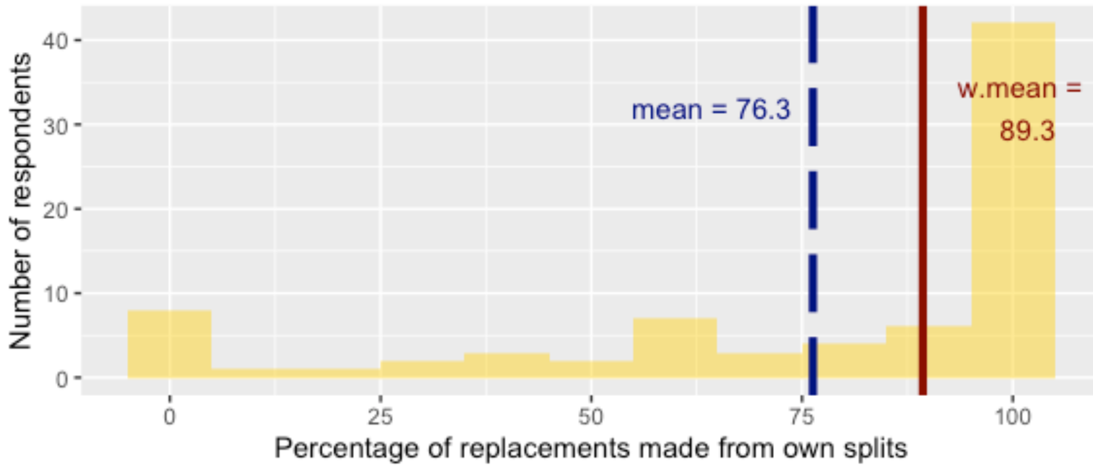
As expected, losses of colonies were commensurate with reported variations in colony numbers. Figure 27 shows the distribution of annual losses in percentage for winter and summer combined with a weighted mean of 39.7%. Because summer losses occur while replacement may still be possible, total yearly losses can exceed the variation in colony numbers. Winter losses had a weighted mean of 17.4% and summer losses a weighted mean of 22.2%.

Figure 27: Histogram of total colony losses in percentage (Questions 2 and 3)



Splitting of own colonies was the dominant method of replacing stock as illustrated in figure 28.

Figure 28: Histogram of percentage of colony replacements made from own splits (Questions 12)



Supplemental tables for survey analysis

Table A1: Frequency of words in the responses to question 14 on factors of colonies in operation

Word	Number of times found in responses
time	28
labor	17
nectar	5
flow	3
forage	3
hired	3
honey	3
location	3
profit	3
resources	3
tallow	3
weather	3

Table A2: Percentage of responding operations indicating feeding during each month of the year (Question 17)

	Responding_ operations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Texas	34	56	56	38	15	0	3	12	21	44	35	38	26
Mississippi	16	50	62	50	19	0	0	19	38	31	6	25	25
Other	8	38	38	50	25	25	0	0	0	38	62	38	12
Louisiana	21	33	38	38	10	10	10	24	19	14	19	14	24
Florida	5	20	0	0	0	0	20	40	60	60	20	0	0
Georgia	5	40	60	20	0	0	20	40	20	40	20	40	60
Alabama	4	25	100	25	0	0	0	25	25	25	25	0	0
South Carolina	2	50	0	0	0	0	0	0	0	50	50	50	0