Insuring Healthy Colonies: Exploring Beekeeper Participation in the Rainfall Index Apiculture Insurance Program

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Abstract

Honey bee colonies play an vital role in global agricultural by providing essential pollination services, in addition to producing honey and other hive products. Colony productivity and health can be adversely affected by weather. We examine the characteristics of beekeepers who participate in the Rainfall Index Apiculture Insurance Program (RI-API), a subsidized insurance program offered by the USDA Risk Management Agency. We find that large operations with more colonies and those deriving a greater share of household income from beekeeping are more likely to enroll in RI-API. We find regional variation in enrollment: beekeepers pollinating almonds in the Sacramento Valley region of California and beekeepers transporting colonies to almonds from the southwestern U.S. are less likely to enroll than their counterparts. We also find evidence that beekeepers who are more risk averse are less likely to enroll, counter to standard economic theory.

Introduction

Commercial beekeepers in the United States provide essential pollination services each year to $15 billion worth of crops (USDA, n.d.), while also providing over $350 million worth of honey production (USDA NASS, 2025). Honey production and colony health varies substantially from year to year based on numerous external factors, but especially weather (Mace, 1912; Switanek et al. 2017). Like the production of other agricultural products, the business of beekeeping is inherently risky, though unlike traditional crop operations, beekeeping operations have not had access to federally subsidized insurance programs in the United States. These safety nets are important in reducing financial stress on farm operations (Lee et al., 2024).

The first federally subsidized beekeeping insurance, the Rainfall Index Apiculture Insurance Program (RI-API), was piloted in a few states beginning in 2009, and was expanded to include all 48 contiguous states in July of 2017. RI-API is index insurance offered through the United States Department of Agriculture (USDA) Risk Management Agency (RMA) meant to insure beekeepers against below-average rainfall which could negatively affect beekeeping income sources, such as production of honey, wax, or breeding stock. Since 2017, enrollment in RI-API has expanded rapidly, increasing from less than 1 million colonies enrolled for the 2017 to over 3.7 million enrolled in 2025 (Figure 1).

While RI-API represents only around 1% of the total liabilities insured by USDA RMA in 2025, it provides an essential financial safety net for beekeeping operations which can stabilize the number of colonies the U.S. beekeeping industry is able to supply to crops that depend on managed pollination services. We are unaware of any research on the effectiveness of or participation patterns in the RI-API program. This is an important gap to be filled given many downstream specialty crop industries depend on the financial stability of the beekeeping sector for consistent supplies of pollination services. In this paper, we begin to address this gap by answering the following question: what are the characteristics of beekeeping operations that have chosen to enroll in RI-API? Relying on survey data collected from commercial beekeepers in 2021, we find that beekeepers with more colonies, a higher dependence on beekeeping for household income, and a tendency to use written pollination contracts are more likely to have enrolled in RI-API for the 2021 crop year. We find that a higher winter mortality rate over the 2019-2020 winter was associated with a lower likelihood of enrolling in RI-API. This might be related to larger operations tending to have lower winter mortality rates (Bruckner et al., 2023). We also find that as the beekeeper's stated willingness to take risks with their beekeeping operation increases, the likelihood of enrollment increases. While this contradicts traditional economic theory on the relationship between insurance and risk preferences, it aligns with research on a similar index insurance product, the Pasture, Rangeland, and Forage Rainfall Index Insurance (PRF-RI) program. Goodrich, Yu and Vandeveer (2020) find that the number of PRF-RI participants who exhibit low levels of risk aversion increases over time. Such findings indicate that as is, RI-API and PRF-RI policies may not be providing effective risk management as intended.

While extensive scientific research on the plight of the honey bees exists, few have examined the beekeeping operations dealing with the economic consequences of colony health issues. RI-API provides a tool to help financially assist beekeepers, and to our knowledge, this paper is the first to contribute to RI-API policy discussions. Fenton et al. (2024) show a high degree of concentration in the beekeeping industry; commercial beekeeping operations with at least 300 colonies represent two percent of operations, but operate 83% of colonies in the U.S. Thus, our finding that larger operations are more likely to enroll in RI-API means that RI-API has the potential to insure a large portion of colonies in the U.S., decreasing financial stress to these large operations who provide most pollination services and honey production. However, this finding also shows that outreach efforts by extension, USDA RMA, and/or crop insurance agents towards small and mid-sized operations could encourage additional participation from these smaller operations who will also benefit from income stabilization. The finding that participants in RI-API tended to exhibit very low levels of risk aversion suggests that future work should focus on how well this insurance product works for beekeeping risk management purposes.

RI-API Background

RI-API is a type of index insurance, meaning policies are not based on actual production or loss, rather payments are triggered by low precipitation relative to a chosen coverage level. Payments and coverage are based on a grid system, where grids cover an area of 0.25 degrees latitude by 0.25 degrees longitude (roughly 17 miles x 17 miles at the equator). An RI-API policy is based on the specific grid (or grids) in which colonies are located. Rainfall index values are calculated by a weighted average of nearby National Oceanic and Atmospheric Administration (NOAA) weather stations and are reported in relation to historical average rainfall in that grid. Each grid is associated with a base value which determines the baseline insured value of the RI-API policy. Base values are calculated using the 5-year rolling average state-level honey yield multiplied by the 5-year rolling average national honey price.

When enrolling in RI-API, beekeepers must make multiple decisions, including the coverage level (70-90%), a productivity factor (60-150%) to adjust the total insured value of the policy, and the number of colonies to insure. Participants also must allocate their coverage across at least two non-overlapping two-month intervals, allowing the participant to customize their policy to best protect their operation from below-average rainfall.

Figure 1 displays the number of colonies enrolled in RI-API since it first became available as a pilot program in 2009. While the program was being piloted during 2009-2016, the number of colonies enrolled increased moderately, but starting with the expansion of the program to the contiguous U.S. in 2017, the enrollment rapidly increased. In 2025, over 3.7 million colonies were enrolled in RI-API, which is substantially larger than USDA estimates for the total number of colonies in the U.S. as of April 1, 2024 (2.7 million colonies). This discrepancy could have multiple causes. The U.S. commercial beekeeping industry is migratory in nature, shipping colonies across the U.S. each year for pollination services and honey production (Bond et al., 2021; Goodrich et al., 2019). The migratory patterns, combined with the natural fluctuation in honey bee populations throughout the year, likely make it difficult for USDA to keep an accurate count of the number of honey bee colonies at any given point during the year. Additionally, while beekeepers are not supposed to enroll more than their total number of colonies across all RI-API policies, from conversations with industry members this may be happening, leading to more hives being insured than the total population. Likely a combination of these two issues is occurring and deserves to be investigated in further research.

Figure 2 shows the average number of colonies per policy during 2009-2025. The number of colonies per policy was highest toward the beginning of the program, nearing 800 colonies per policy in 2009 and 2012. Over time this has decreased and stabilized to around 500 colonies per policy. This indicates that large commercial operations have been the primary users of this insurance product.

One way to assess insurance performance is by analyzing loss ratios, where the loss ratio is calculated by the indemnities paid out by the insurance divided by the premiums collected. If insurance is actuarily fair, the loss ratio over time would approximately equal one, or in other words, indemnities paid out approximately equal the premiums collected over time. USDA RMA is mandated to target a loss ratio over time of approximately 0.8, meaning for every $1 in premium, $0.80 is paid out in indemnities. This provides USDA RMA with a buffer in case of widespread crop losses in a given year. Figure 3 displays annual loss ratios for RI-API over 2009-2024, the average loss ratio over this time, and the USDA RMA target of 0.8. As expected, loss ratios fluctuate annually with precipitation variability. The average loss ratio over 2009-2024 is 1.02, which is close to actuarily fair, but well above the USDA RMA target of 0.8. This may indicate premium rating issues with the RI-API product.

Table 1 provides 2021 RI-API policy information by the U.S. regions depicted in Figure 4. The Pacific Northwest and Southeast regions had the most colonies enrolled, constituting 72% of the total colonies enrolled in 2021. The Plains and Southwest regions had the highest premiums per colony, likely reflecting the high value of honey production produced in many of those states, i.e., North Dakota, South Dakota, and Texas.

Methodology

To investigate commonalities among beekeeping operations that participated in RI-API, we estimate a probit model as follows:

$$Y^* = X\beta + \epsilon$$

$$Y = \begin{cases} 1 \; when \; Y^* > 0; \\ 0 \; when \; Y^* < 0; \end{cases}$$

where Y^* is the latent variable for enrollment in RI-API for the 2021 crop year, X represents independent variables related to the enrollment decision, and ϵ is the error term assumed to be distributed normally with a mean of 0 and standard deviation of 1. The RI-API enrollment and independent variables were collected from commercial beekeepers using a survey instrument. While there is little economic research related to enrollment in RI-API specifically, we can use prior literature on enrollment in the U.S. Federal Crop Insurance

Program (FCIP) to provide a lens through which to assess what might motivate beekeeping operations to enroll in insurance.

Variables related to enrollment in RI-API

From economic theory, the primary influences on a farm operation's decision to enroll in insurance are the operation's risk exposure and the operator's risk preferences. Other operator characteristics may also influence an operator's decision to enroll. Table 2 displays the definition of each variable we explore as being related to RI-API enrollment, and the expected relationship between the variable and enrollment in RI-API based on the previous literature. The variables are categorized by risk exposure, risk preferences, and farm and operator characteristics, discussed in the following subsections.

Risk exposure

Prior work relating a farm operation's level of risk exposure to traditional crop insurance uptake focuses on indicators of financial, production, and market risk exposure (Sherrick et al., 2004; Coble et al., 1996; Smith and Baquet, 1996; Jose and Valluru; 1997). Regarding financial risk exposure, Sherrick et al. find that operations with higher debt-to-asset ratios are more likely to be enrolled in yield, revenue or hail insurance. This supports earlier findings by Smith and Baquet indicating that operations with more debt are more likely to be enrolled in Multiple Peril Crop Insurance (MPCI). Other indicators related to financial risk include the amount of operated land a farm owns versus leases, and the proportion of farm income coming from a specific enterprise. Sherrick et al. find that operations that lease more land are more likely to purchase insurance. Jose and Valluru find that producers with more income coming from crop production (as opposed to livestock production) were more likely to purchase crop insurance. The larger a farm is in terms of acreage has been shown to be positively related to insurance uptake (Coble et al., 1996; Jose and Valluru, 1997; Sherrick et al., 2004), though Coble et al. find that a farm's net worth is negatively related to insurance enrollment. While these findings may seem contradictory, they are in alignment when considering the risk exposure perspective. More acreage is associated with higher yield and price risk exposure, increasing the likelihood a farmer may want to enroll in insurance. Higher net worth means more wealth and risk-bearing capacity, decreasing the financial risk exposure and need for insurance.

As a measure of production risk, Sherrick et al. (2004) and Smith and Baquet (1996) find that higher perceptions of yield variability are associated with more insurance uptake. Similarly, Smith and Baquet also find that a farm receiving disaster relief payments in the past is associated with higher rates of insurance. Coble et al. (1996) find higher variance in the market return was associated with more insurance enrollment.

More recently, studies have outlined factors associated with forage index insurance uptake amongst livestock producers in the U.S. and Canada (Roznik et al., 2019; Davidson and Goodrich, 2023; Goodrich and Davidson, 2024). The findings of these studies may be more relevant to RI-API uptake for multiple reasons. First, index insurance differs from traditional crop insurance in that index insurance indemnities are triggered purely by a calculated index, rather than based on reported on-farm outcomes. Index insurance has advantages due to reduced information asymmetry and implementation costs, however it can be less attractive to farmers due to its propensity for basis risk, i.e. the risk that on-farm outcomes do not perfectly correlate with the calculated index. Another reason for the relevance of the forage index insurance studies to RI-API enrollment is due to their focus on livestock producers who, like beekeepers, have traditionally been underserved when it comes to federally subsidized insurance policies, as opposed to traditional row crop producers who have had access to insurance since the 1980s.

Roznik et al. (2019) and Davidson and Goodrich (2023) find that a higher amount of feed reserves for livestock is associated with lower forage index insurance uptake, i.e., producers use feed reserves as a method of self-insurance against weather shocks. Similar to the traditional crop insurance studies with respect to production risks, Roznik et al. find that higher perceptions of drought and weather risks are associated with more insurance uptake. Like Sherrick et al. (2004), Goodrich and Davidson found that livestock operations renting out more land was associated with a higher likelihood of insurance uptake. Goodrich and Davidson find that full-time farmers were more likely to enroll in the forage index insurance. Like previous studies of traditional crop insurance, Davidson and Goodrich find that a higher proportion of farm income coming from livestock or hay production and past participation in livestock disaster programs was related to higher enrollment in the forage index insurance. Goodrich and Davidson included a measure of spatial basis risk in their analysis, and interestingly found no evidence that this was correlated with the farmer's enrollment decision.

To measure risk exposure in the commercial beekeeping context we utilize the following variables: the number of colonies rented for almond pollination (*Colonies),* the percentage of household income coming from the beekeeping operation (*Perc HH Income),* and the colony mortality rate over the 2019-2020 winter (*Winter Mortality)*, the annual household income (*HH Income),* and the percentage of beekeeping income derived from pollination services (*Prop Pollin of Beek Income)*. We expect that an increase in *Colonies, Perc HH Income,* and *Winter Mortality* will increase the beekeeping operation's risk exposure, and thus have a positive relationship with RI-API enrollment. We expect that an increase in the household income is likely correlated with an increase in household wealth, so *HH Income* will be negatively related to enrollment in RI-API. While *Prop Pollin of Beek Income* likely affects the level of risk exposure of an operation, we do not have specific expectations regarding how it will relate to the RI-API enrollment decision. Because RI-API is posed primarily as a product insuring against lost honey production, less dependence on pollination income (consequently more dependence on honey production income) might be associated with higher levels of RI-API enrollment. However, more dependence on pollination income likely means a higher dependence on colonies surviving the winter to have more colonies for almond pollination. Adequate rainfall during the months preceding pollination is important for colony health (Switanek et al. 2017), making RI-API enrollment important for operations focusing on pollination services as the primary income source.

Risk preferences

Numerous studies have investigated the relationship between farmer risk preferences and the decision to enroll in insurance, and there is no overall consensus on the direction of such a relationship. Just, Calvin and Quiggin (1999) and Goodwin (1993) find no relationship between the farmer's level of risk aversion and insurance decisions, while Petrolia, Landry, and Coble (2013), Condliffe and Fiorentino (2014), Jin, Wang, and Wang (2016), and Menapace, Colson, and Raffaelli (2016) find that as risk aversion increases, farmers are more likely to purchase insurance.

Regarding forage index insurance, results are similarly mixed. Davidson and Goodrich (2023) and Shrum and Travis (2022) suggest a positive relationship between risk aversion and insurance uptake. Though Goodrich and Davidson (2024) find no relationship between risk aversion and forage index insurance enrollment. The forage index insurance studies have investigated revealed preferences for risk aversion, i.e., attitudes towards forage index insurance (Roznik et al., 2019), drought risk management strategies (Greene et al., 2022) and previous enrollment in other livestock revenue insurance programs (Goodrich and Davidson), finding positive relationships that would suggest increased risk aversion would be associated with increased insurance uptake.

To measure a beekeeper's risk preferences, we use a combination of stated and revealed preference variables. The stated risk preference variable is the response to a Likert scale question asking participants how willing they are to take risks with their beekeeping operation, with 0 meaning they are not willing to take risks and 5 representing being very willing to take risks (*Stated RA).*[1] We expect the less risk averse a participant is, the less likely they would be to enroll in RI-API. We use four variables to represent revealed risk preferences from the participant's answers to questions related to their almond pollination

[1] Petrolia (2016) showed that stated Likert-scale risk preferences often perform equally as well (or better) than Holt and Laury (2002) risk preference elicitation measures. To simplify our survey and reduce respondent burden we chose to use the Likert-scale method.

contracts. The use of a written contract (*Written Contract)*, receiving advanced payment from an almond grower or broker for almond pollination (*Advanced Payment),* and the use of pesticide clause(s) to reduce risk of colony pesticide exposure (*Pesticide Clause)* are all assumed to be associated with greater risk aversion as each of these reduces the beekeeper's risk in their almond pollination agreements. Thus, we expect these variables to be positively related to RI-API enrollment. We also include a variable for the percentage of colonies that were contracted in advance of 2021 almond bloom (*Percent Col Advanced Contract)* as a measure of revealed risk preference. However, this variable is not as straightforward of a relationship as the previously described. Contracting a large proportion of colonies may increase the risk of a beekeeper having to default on a contract if they experience large winter loss rates. However, contracting a small proportion of colonies lowers the risk of default from high losses, but increases price risk and/or the risk that they may not be able to contract the remainder of colonies. Thus, in the regressions we include a squared variable to account for such nonlinearities in the relationship of this variable and risk preferences.

Farm Operation and Operator Characteristics

Previous studies offer mixed evidence on various farm operation and operator characteristics. With respect to age, evidence is mixed, with enrollment sometimes having no association with age (Jose and Valluru, 1997), but also positive (Sherrick et al., 2004) and negative associations (Roznik et al., 2019). Relatedly, Davidson and Goodrich (2023) found no relationship between the number of years a participant had been farming and their decision to enroll in forage index insurance.

Accordingly, we do not have specific expectations for how the farm and operator characteristics will related to the RI-API decision. We explore two characteristics of the operator: the number of years beekeeping (*Years Beekeeping)* and the participant's age (*Age)*. While it is unclear the direction of the impact of these variables on the RI-API enrollment decision, it is intuitive that they could impact the decision through a number of mechanisms, including age and/or experience related risk perceptions, the networks through which beekeeper's gather information, the willingness to participate in government programs, among others.

We include two characteristics of the beekeeping operation: the region(s) of California in which the operation pollinates almonds (*Sacramento (Sac) Valley*, *North San Joaquin Valley (SJV) and South SJV,* see Figure 5*)* and the U.S. region the participant's colonies came from immediately prior to almond pollination (see Figure 4). These regions may not have a direct relationship with the RI-API decision but can help identify types of operations. For example, the Sacramento Valley is home to many queen breeding operations (Schiff and

Sheppard, 1996) that may not be focused on maximizing honey production, thus, RI-API may not be well suited as an insurance product for such an operation. Similarly, the regions colonies came from prior to almond pollination may tell us about the beekeeper's typical honey and pollination circuit, indicating different operation types that may be more or less suited to RI-API as a risk management option. Also, as seen in Table 1, different regions will have different premium and liability rates based on rainfall variability and honey production, which could influence the RI-API decision.

An important finding of Goodrich and Davidson (2024) was that awareness of new insurance products, like RI-API, plays a role in whether a potential participant enrolls in insurance, i.e., a producer unaware that an insurance product exists does not enroll but does not consciously make an enrollment decision. Thus, without accounting for awareness in enrollment decisions, one might falsely conclude a type of producer chooses not to enroll in the product, when that group may have been less likely to be aware of the product. We do not account for awareness in our regressions, and as such some of the interpretations might be due to lack of awareness rather than an active choice on behalf of the beekeeper. However, our sample population likely suffers much less from lack of awareness than livestock and forage producers in the Goodrich and Davidson sample. For one, the population of livestock and forage producers that Goodrich and Davidson sampled from was over 138,000, distributed across the northeast and southeast. We were targeting commercial beekeeping operations that transport colonies to almond pollination. Fitting this criterion, there were roughly 1,200 beekeepers operating 300 or more colonies according to the 2017 USDA agricultural census. Commercial beekeeping operations tend to attend a similar rotation of beekeeping conferences each year: for national meetings, either (or both) the American Honey Producer's Association or the American Beekeeping Federation, and likely their local state association meetings. There is one insurance company, Beekeeping Insurance Services (BIS), that does most of the book of business writing RI-API policies for beekeepers.[2] This insurance company is an annual meeting sponsor of both major national organizations, as well as most of the major beekeeping state organizations, and has been regularly sponsoring such events since before 2019.[3] Thus, it seems likely that commercial beekeepers would have been well aware that this insurance product existed due to these marketing efforts, and so this lack of awareness bias is likely a minimal issue in our sample.

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[2] This is provided by anecdotal evidence as well as a statement on the BIS website that says "We write 88% of the USDA rainfall program in the U.S."

[3] Current sponsorships are listed on the BIS website (https://beekeepingins.com/insurance-offerings/) while historical sponsorship information was acquired from personal communications with the California State Beekeeper's Association and American Honey Producer's Association personnel.

Survey Data

In Spring 2021, we conducted a survey of commercial beekeeping operations using the Qualtrics platform. We advertised the survey to beekeepers via individual email and through social media and email lists of industry groups, including the American Honey Producers Association, Bee Culture Magazine, Project Apis m., Bee Informed Partnership, and the California State Beekeepers Association.

The survey began with a short screening section to ensure respondents were part of the intended population, i.e. commercial beekeepers active in the 2021 almond pollination services market. Those who passed the screening proceeded to answer questions about their almond pollination contracts, operational characteristics (e.g., income levels and the proportion of revenue from honey production versus pollination services), and past involvement in the almond pollination services market. A Discrete Choice Experiment was also part of the survey, though it is analyzed separately in another study. We piloted the survey with beekeepers and pollination brokers and received feedback to ensure the accuracy and relevance of the questions.

We advertised the survey from mid-February through late April 2021 aligning with the downtime during the almond pollination season, i.e., after colonies had been placed in almond orchards but prior to beekeepers needing to move colonies out of the orchards. Beekeepers who completed the survey received a $20 gift card. They were also invited to answer follow-up questions in exchange for either an additional $10 gift card or a donation of the same amount to a beekeeping organization. Specific to this study, the survey asked whether the beekeeper had enrolled in RI-API for the 2021 crop year, in addition to information regarding risk exposure, stated and revealed risk preferences, and other operator and operation characteristics. The list of relevant questions can be found in the Appendix.

Table 3 shows summary statistics from the sample. The sample represents roughly 463,000 hives, which is 16% of the total number of honey bee colonies in the U.S. on January 1, 2021. Only counting hives for beekeeper who stated they enrolled in RI-API, the number of enrolled hives is approximately 359,000, or 16% of the total hives enrolled in 2021 (Figure 1). Our survey sample represented a larger proportion of the total population of U.S. colonies than either of the 2020-21 and 2021-22 Bee Informed Partnership (BIP) surveys (Aurell et al., 2024), results of which are often used and cited widely by industry participants. Thus, our survey seems to be representative of the intended population.

Results

Table 4 displays the results of the probit regressions of enrollment in RI-API on the variables representing risk exposure, risk preferences, and other characteristics. Three different regressions are run excluding certain variables due to the propensity for low response rates to specific questions, i.e., *Percent Col Advanced Contract, Pesticide Clause,* and *HH Income*.

Two risk exposure variables are statistically significant in at least one of the regressions and have the expected sign: *Colonies* and *Prop HH Income*. Thus, as the number of colonies a beekeeper rents out for almond pollination increases, the likelihood of RI-API enrollment increases. This aligns with USDA RMA Summary of Business data that shows RI-API policies are on average fairly large (Figure 2). Additionally, the more a beekeeper's household relies on beekeeping for its annual income, the more likely the beekeeper is enrolled in RI-API indicating that beekeepers use RI-API at least partially to smooth household income. An unexpected finding across all three regressions was that as the mortality rate over the 2019-2020 winter increased, the beekeeper was less likely to have enrolled in RI-API. Historically, large commercial operations have consistently had lower winter mortality rates compared with smaller sideline or hobby beekeepers (Bruckner et al., 2023). Thus, this finding with respect to winter mortality rates could be partially reflecting the difference between smaller and larger more efficient operations.

For risk preferences, only one variable stood out with a statistically significant and expected relationship with enrollment in RI-API. The revealed preference variable representing whether or not a beekeeper used at least one written contract for almond pollination, *Written Contract,* was positively related to the RI-API enrollment decision and statistically significant across all three regressions. The stated risk preference variable (*Stated RA)* and the revealed preference variable *Pesticide Clause* were statistically significant in at least one regression but suggested the opposite relationship between risk aversion and RI-API enrollment: as risk aversion increases, enrollment decreases. While this is counterintuitive with respect to economic theory, the finding is not completely without merit in the context of rainfall index insurance in the U.S. Goodrich, Yu and Vandeveer (2019) find that participation patterns in a similar rainfall index insurance for livestock producers, PRF-RI, tend to move away from risk averse patterns towards risk neutral and even risk increasing patterns of enrollment. These findings across both PRF-RI and RI-API suggest that producers view these rainfall index insurance products less as insurance and more as mechanisms to take advantage of subsidies.

We do not find any statistically significant relationships between RI-API enrollment and the age of the beekeeper, nor the number of years they have been keeping bees.[4] Beekeepers pollinating almonds in Northern California are less likely to enroll in RI-API. As discuss previously, these might represent queen breeders for which RI-API does not seem as applicable. Of the regions beekeepers provided bees from immediately prior to almond pollination, only the southwestern U.S. showed any relationship, and this was negative. This is somewhat surprising given that Texas is often one of the largest honey producing states. However, the southwest has one of the highest premium rates per colony (Table 1), thus, this may indicate a reduction in enrollment due to a price impact.

Discussion and Conclusions

In this paper, we investigate the characteristics of beekeeping operations that enroll in a relatively new, federally subsidized insurance product, the Rainfall Index Apiculture Insurance Program (RI-API). We focus on variables collected in a 2021 survey of U.S. commercial beekeepers. While we provide a first look into the types of beekeepers participating in RI-API, there is much room for future work in this area. Other research has shown that federally subsidized crop insurance reduces financial stress in other industries (Lee et al., 2024), thus, RI-API or other insurance products could play an important role in stabilizing beekeeping incomes at a time when honey bee colony health is highly variable (Aurell et al, 2024; Bruckner et al., 2023).

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Tables

Table 1. 2021 RI-API Policy Information by Region

Region	Premium	Premium Subsidy	Colonies	Liability	Premium $/Colony	Producer Premium $/Colony	Liability $/Colony	$ Liability per $1 Producer Premium
Mountainous	5,985,116	3,088,161	166,588	26,281,592	35.93	17.39	157.76	9.07
North Central	2,128,796	1,089,219	79,605	13,457,305	26.74	13.06	169.05	12.94
Northeast	274,409	139,742	17,600	2,400,540	15.59	7.65	136.39	17.83
Pacific NW	35,562,706	18,454,672	1,017,421	116,337,366	34.95	16.82	114.35	6.80
Plains	7,613,846	3,922,111	198,751	38,071,435	38.31	18.57	191.55	10.31
Southeast	14,253,498	7,288,418	556,615	80,389,617	25.61	12.51	144.43	11.54
Southwest	5,982,554	3,094,129	159,660	27,637,069	37.47	18.09	173.10	9.57
Total	71,742,699	37,045,885	2,194,559	304,381,619	32.69	15.81	138.70	8.77

Source: USDA RMA Summary of Business

Note: Sums across regions do not add up to total because colonies and policies can be split across regions.

Table 2. Beekeeping Survey Data Variable Descriptions and Expected Relationships with Enrollment in RI-API

Variable	Values	Expected Sign
Enrolled in RI-API	Dependent variable, indicator variable equal to 1 if the participant had enrolled in RI-API for the 2021 crop year, 0 otherwise	
<u>Risk Exposure</u>		
Colonies (1000s)	Total colonies rented for almond pollination in 2021	+
Perc HH Income	Integer ranging from 1 to 4, representing the percentage of annual household income expected from beekeeping activities. 1) 1-10% 2) 11-50% 3) 51-90% 4) Over 90%	+
Winter Mortality	Integer ranging from 1 to 6 representing the operation's colony mortality rate over 2019-2020 winter 1) 0-10% 2)11-20% 3)21-30% 4)31-40% 5)41-50% 6) Over 50%	+
Perc Pollin of Beek Income	Percentage of beekeeping income derived from pollination services	+/-
HH income	Integer ranging from 1 to 6 representing the participant's pre-tax household income 1) <$35k 2) 35-49.9 3) 50k-74.9 4)75k-99.9 5) 100k-150k 6) Over 150k	-
<u>Risk Preference</u>		
Stated RA	Stated willingness to take risks in beekeeping operation, 0 (not willing to take risks)-5 (very willing to take risks)	-
Advanced Payment	Indicator variable equal to 1 if the participant receives advance payment from grower or pollination broker for almond pollination services, 0 otherwise	+
Pesticide clause	Indicator variable equal to 1 if the participant has a clause in at least one of their almond pollination agreements intended to reduce risk of pesticide exposure during almond pollination, 0 otherwise	+
Percent Col Advanced contract	Percentage of colonies that were contracted in advance of the 2021 almond bloom	?
Written contract	Indicator variable equal to 1 if the participant had at least one of their almond pollination agreements as a written contract, 0 otherwise	+
<u>Farm and Operator Characteristics</u>		
CA Regions Pollinated	Indicator variables for the region(s) in which the participant supplied colonies for almond pollination (Sacramento Valley, Northern San Joaquin Valley (SJV), Southern SJV as outlined in Figure 5)	?
Years beekeeping	Integer ranging from 1 to 4 representing the number of years the participant has been keeping bees 1) 1-5 years 2) 6-10 years 3) 11-20 years 4) Over 20 years	?
Regions prior	Indicator variables for region(s) in which a participant's colonies came from prior to almond pollination (Southeast, Southwest, Northeast, North Central, Plains, Mountainous, Pacific Northwest as outlined in Figure 4)	?
Age	Integer ranging from 1 to 4 representing the participant's age 1) 18-34 2) 35-49 3) 50-64 4) Over 64	?

Table 3. Summary Statistics

Variable	N	Mean	St. Dev.	Min	Max
Enrolled in RI-API	79	0.39	0.49	0	1
Colonies (1000s)	81	5.71	14.48	0.05	120
Perc HH Income	79	3.16	1.04	1	4
Perc Pollin of Beek Income	80	56.62	22.22	10	100
Winter Mortality	79	3.05	1.40	1	6
HH Income	72	4.76	1.25	1	6
Stated RA	81	2.05	1.37	0	5
Advanced Payment	81	0.44	0.50	0	1
Written Contract	81	0.52	0.50	0	1
Pesticide Clause	73	0.49	0.50	0	1
Percent Col Advanced Contract	61	66.97	33.85	0	100
Age	81	2.57	0.99	1	4
Sac Valley	81	0.20	0.40	0	1
North SJV	81	0.41	0.49	0	1
South SJV	81	0.62	0.49	0	1
Southwest	81	0.14	0.34	0	1
Southeast	81	0.19	0.39	0	1
Northeast	81	0.00	0.00	0	0
North Central	81	0.14	0.34	0	1
Plains	81	0.14	0.34	0	1
Mountainous	81	0.20	0.40	0	1
Pacific Northwest	81	0.36	0.48	0	1
Years Beekeeping	81	3.32	0.85	1	4

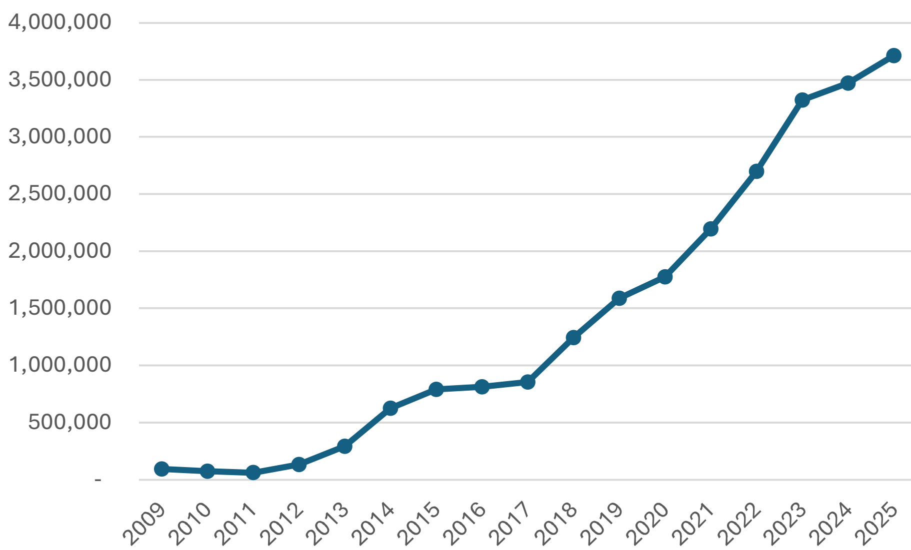
Table 4. Probit Regression Results

	Dependent variable:		
	Enrolled in RI-API		
	(1)	(2)	(3)
Colonies (1000s)	0.04 (0.11)	0.12 (0.09)	0.14* (0.08)
Perc HH Income	0.70 (0.52)	0.98** (0.46)	0.71** (0.32)
Perc Pollin of Beek Income	-0.01 (0.02)	-0.003 (0.01)	0.005 (0.01)
Winter Mortality	-0.59* (0.36)	-0.60** (0.28)	-0.40* (0.24)
HH Income	0.12 (0.27)	0.08 (0.22)	
Stated RA	0.32 (0.31)	0.52* (0.28)	0.48** (0.23)
Advanced Payment	0.32 (0.71)	0.59 (0.60)	0.60 (0.50)
Written Contract	2.07* (1.14)	1.09* (0.64)	0.82* (0.50)
Pesticide Clause	-2.51** (1.21)	-1.04 (0.76)	
Percent Col Advanced Contract	-0.01 (0.05)		
Percent Col Adv Contract.Sq	0.0002 (0.001)		
Age	-0.90 (0.58)	-0.18 (0.41)	-0.04 (0.35)
Sac Valley	-1.62 (1.44)	-2.99* (1.69)	-3.29** (1.47)
North SJV	0.50 (1.36)	0.91 (0.87)	0.53 (0.64)
South SJV	-1.08 (1.17)	-0.42 (0.80)	-0.44 (0.67)
Southwest	-1.53 (1.74)	-2.63* (1.47)	-2.38* (1.26)
Southeast	0.16 (1.74)	0.46 (1.28)	0.61 (0.98)
North Central	1.10 (2.19)	-0.25 (1.52)	-0.39 (1.11)
Plains	3.02 (2.62)	2.21 (1.99)	1.96 (1.36)
Mountainous	-1.69 (2.67)	-2.17 (1.86)	-1.66 (1.44)
Pacific Northwest	1.84 (2.22)	0.91 (1.44)	0.49 (1.14)
Years Beekeeping	0.55 (0.86)	-0.28 (0.54)	0.01 (0.45)
Constant	-1.26 (3.47)	-2.23 (2.79)	-3.50 (2.22)
Observations	48	62	75
Log Likelihood	-14.71	-20.06	-25.95
Akaike Inf. Crit.	75.41	82.11	89.90

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors in parentheses.

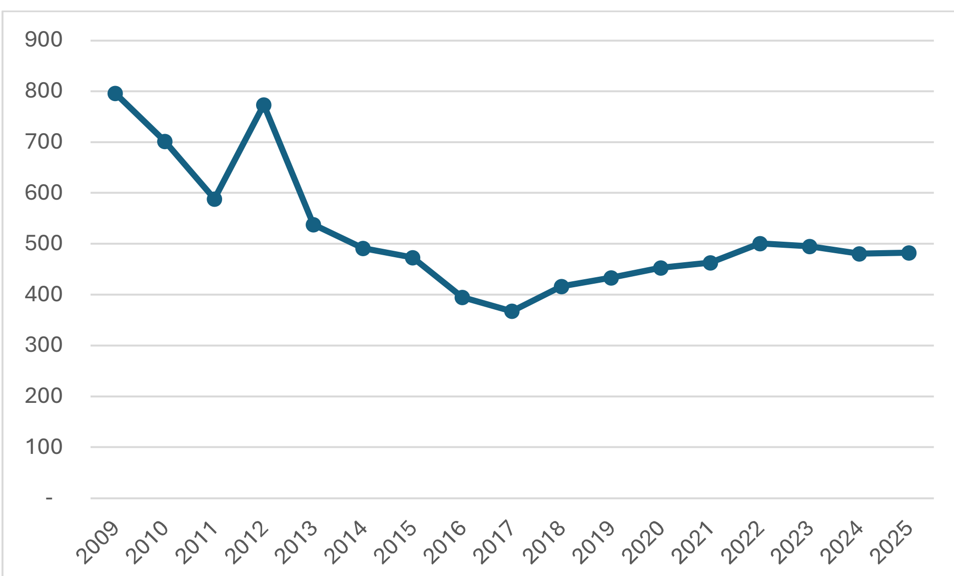
Figures

Figure 1. Colonies enrolled in RI-API, 2009-2025



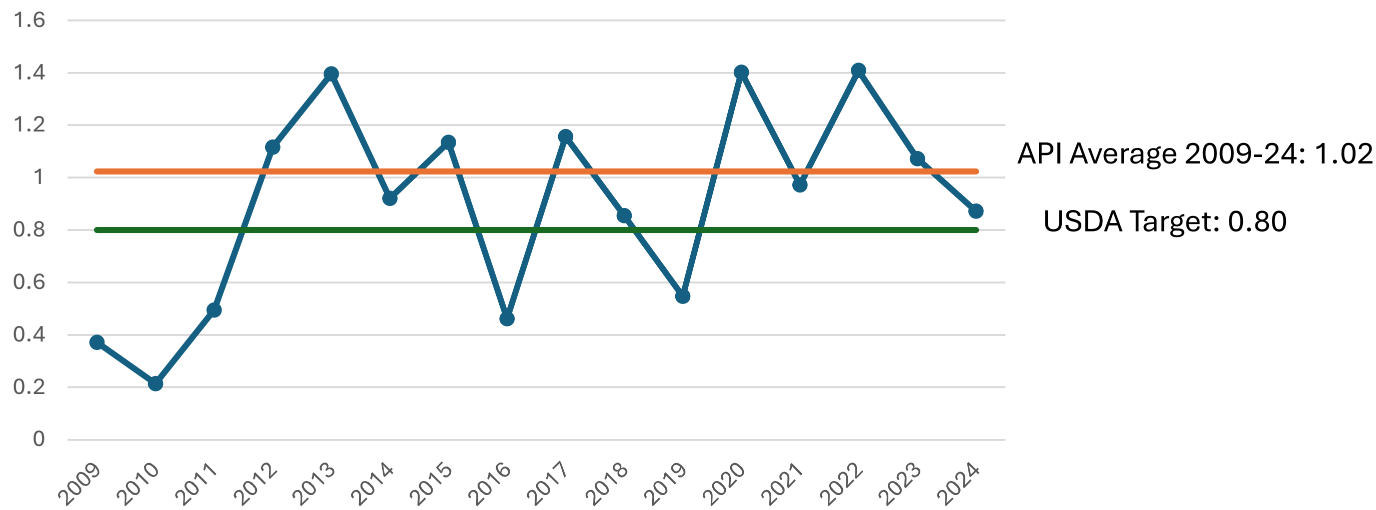
Source: USDA RMA Summary of Business Data

Figure 2. Average RI-API Policy Size (Colonies Per Policy), 2009-2025



Source: USDA RMA Summary of Business Data

Figure 3. RI-API Loss Ratios, 2009-2024



Source: USDA Summary of Business Data

Loss ratio=Indemnities/Premiums

Figure 4. U.S. Regions

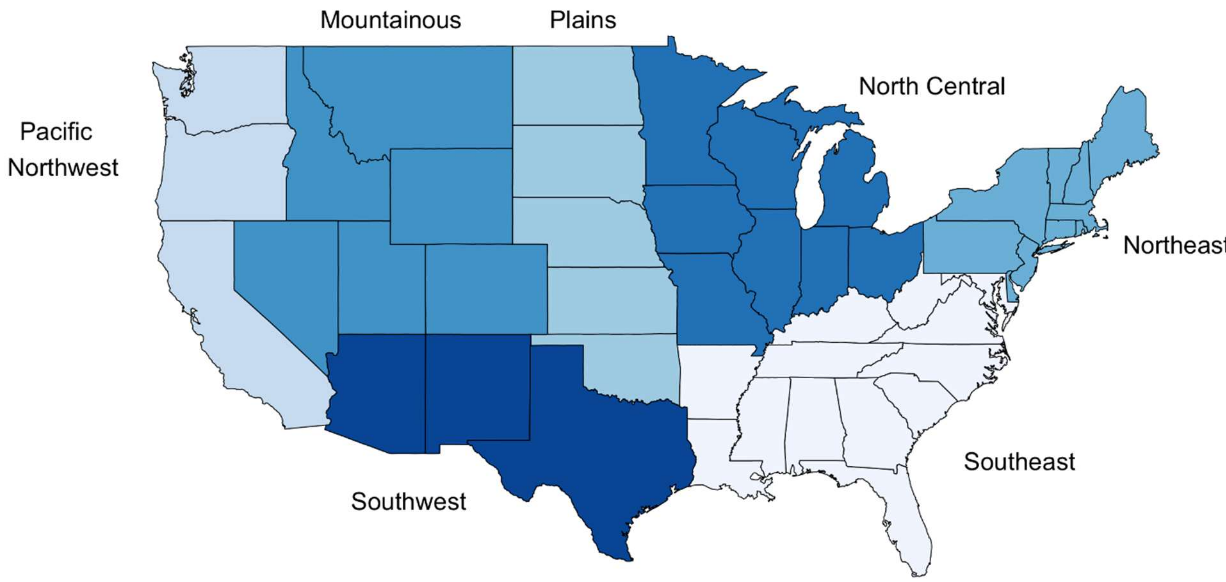
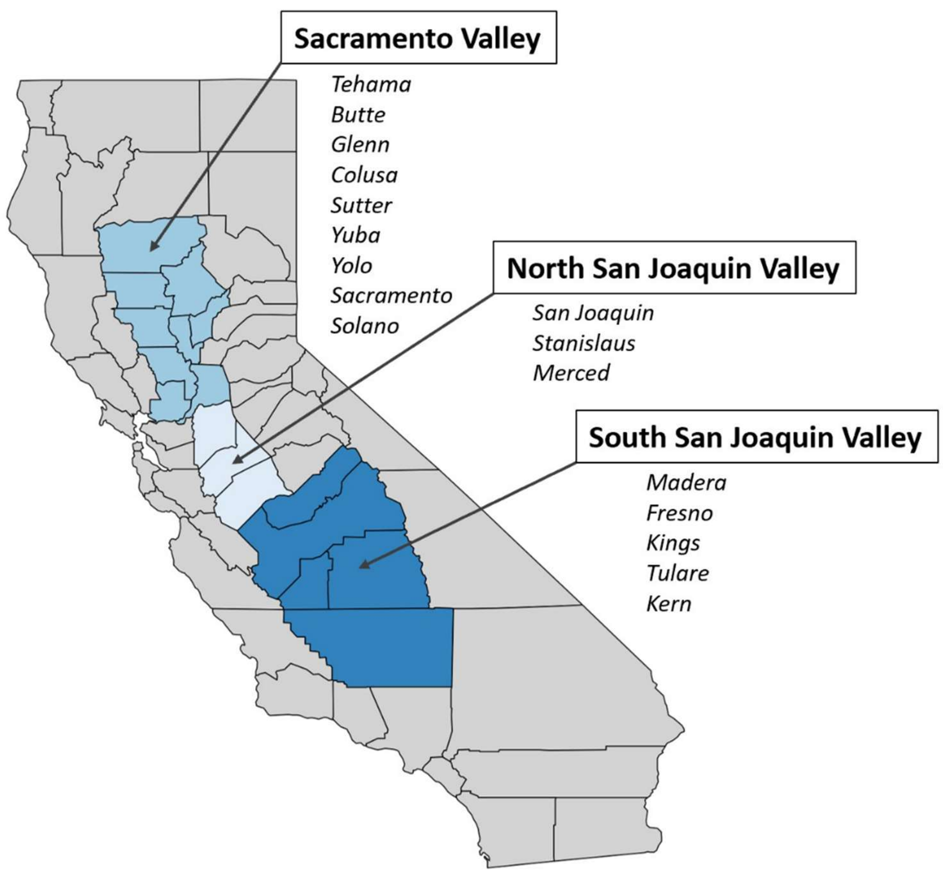


Figure 5. California Almond Pollination Regions



Appendix

Abridged Survey Questions

Did your beekeeping operation supply colonies to California almond orchards for the 2021 bloom?

- ○ Yes
- ○ No

Which of the following best describes your role(s) as a pollination service provider:

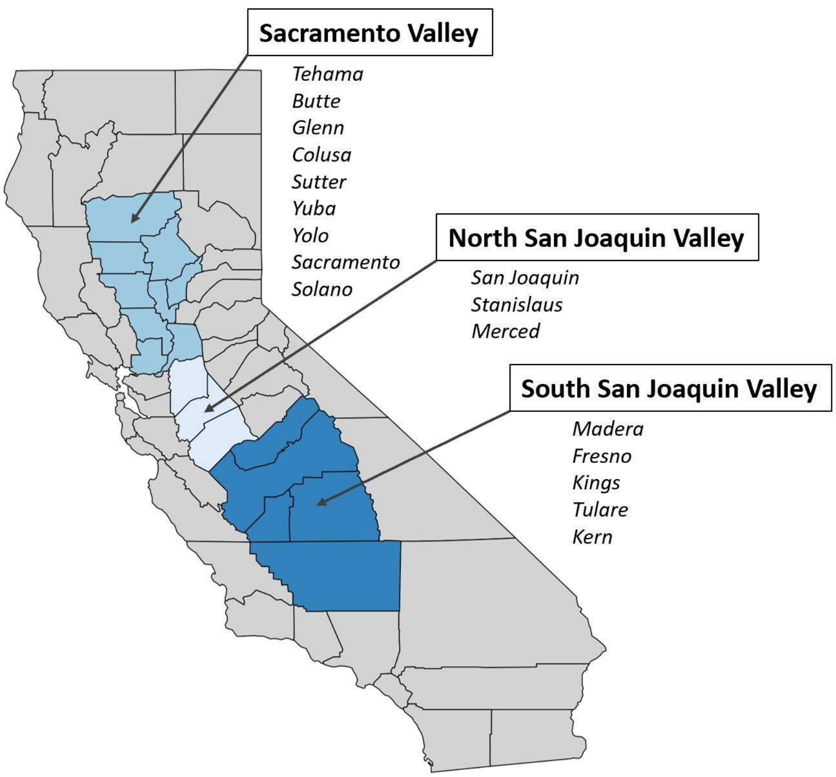
- ○ Beekeeper (You own/manage honey bee colonies)
- ○ Pollination Broker (You act as a middleman between beekeeper and grower for pollination services rentals, but do not own/manage honey bee colonies)
- ○ Beekeeper and Pollination Broker

Section 1: 2021 Almond Pollination Agreements

In this first section, we will ask about your exisiting pollination rental agreements for 2021.

For the 2021 season, how many colonies did you agree to supply in each of the following regions to pollinate almonds? If county not listed, use your best estimate of the closest region.

Northern California-Sacramento Valley	0
Central California-Northern San Joaquin Valley	0
Southern California-Southern San Joaquin Valley	0
Total	0



Please move the slider to select the approximate percentage of your total colonies that were **not** contracted in advance for 2021 almond pollination (ex: reserve in case of unexpected losses, etc.).

0	25	50	75	100

Percentage of total colonies not contracted in advance

How many of each type of rental agreements did you engage in with growers, independent brokers or other beekeepers for almond pollination in 2021?

	0	1	2	3+
Written contract(s)	○	○	○	○
Handshake/verbal agreement(s)	○	○	○	○

Please select the features that were included in **at least one** of your 2021 almond pollination agreements.

- Portion of pollination fee paid in advance
- Per-frame bonus incentives for high strength colonies
- Compensation from the grower/broker if your colonies are stolen while in the orchard

Did any of your 2021 almond pollination agreements contain any of the following details regarding pesticide exposure?

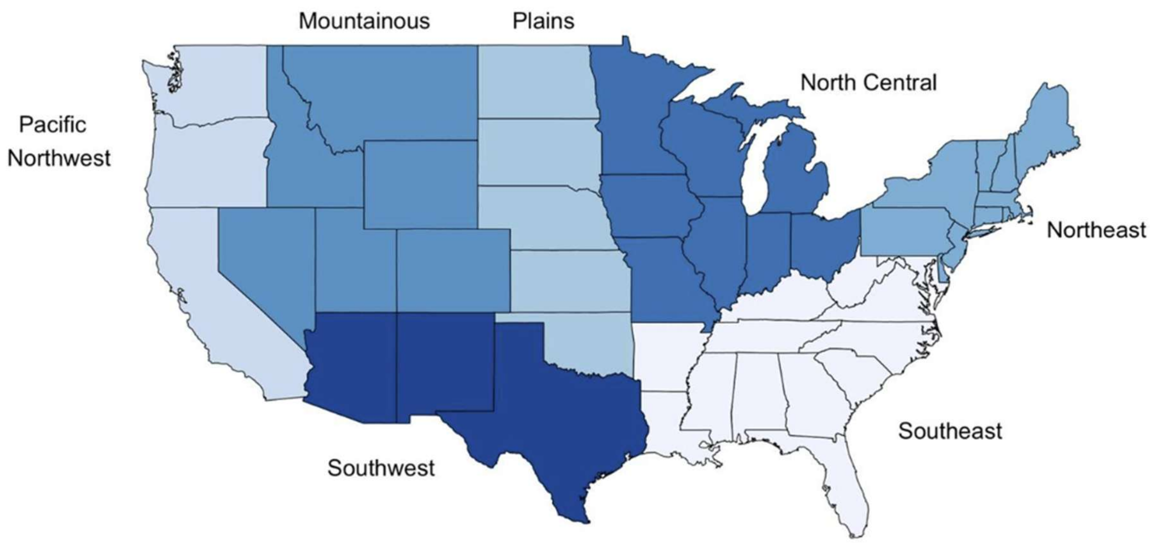
In at least one of my 2021 almond pollination agreements, the grower agrees to...

- None of my agreements contained details regarding pesticide exposure
- Pay extra fees if colonies must move due to pesticide application
- Pay damages for colony losses due to pesticide exposure
- Minimum notification time before applying pesticides (e.g. 48, 72 hours)
- Apply pesticides only during inactive foraging times (e.g. evening, night)
- Not tank-mix multiple pesticides
- Not apply specific chemicals
- Other (please specify)

Section 3: Additional Almond Pollination Questions

Almost there! This section asks a few more questions about almond pollination, then you'll enter the final section.

For the 2021 almond pollination season, which region(s) did your colonies come from immediately prior to entering California? Select all that apply. Do not include colonies brokered for other beekeepers.



- Pacific Northwest
- Mountainous
- Plains
- North Central
- Northeast
- Southeast
- Southwest

Section 4: Beekeeping Operation and Demographics

Final section! Here we ask you a few questions about your beekeeping operation and yourself.

What were your mortality rates this winter and last winter?

	0-10%	11-20%	21-30%	31-40%	41-50%	> 50%
This winter (Oct 1, 2020-today)	○	○	○	○	○	○
Last winter (Oct 1, 2019- April 1, 2020)	○	○	○	○	○	○

Did you enroll in the Apiculture Rainfall Index Insurance Program offered by USDA Risk Management Agency for 2021? (Note: the enrollment deadline for 2021 was November 15, 2020.)

Yes

No

Unsure

How would you rate your willingness to take risks in the following areas?

	Not willing to take risks 0	1	2	3	4	Very willing to take risks 5
...while driving	○	○	○	○	○	○
...with investments	○	○	○	○	○	○
...with your beekeeping operation	○	○	○	○	○	○
...with your health	○	○	○	○	○	○

How many years have you

	1-5 years	6-10 years	11-20 years	21+ years
Kept bees	○	○	○	○
Supplied bees for almond pollination	○	○	○	○

Please indicate the range that best represents total yearly income, before taxes, of all immediate family living in your household.

- <35,000
- 35,000-49,999
- 50,000-74,999
- 75,000-99,999
- 100,000-149,000
- 150,000+

- I don’t know

What percentage of your household annual income do you expect to derive from your beekeeping activities?

- 0%
- 1-10 %
- 11-50%
- 51-90%
- Over 90%
- I don't know

What percentage of your beekeeping income comes from pollination services?

0 10 20 30 40 50 60 70 80 90 100

Pollination services

What is your age group?

- 18-34
- 35-49
- 50-64
- 65+