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White Paper: **Value of the California Commercial Beekeeping Industry and Related Challenges**

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This document provides a factual overview of the critical role that managed honey bees play in agriculture and human well-being, while addressing prevalent misconceptions related to honey bees and beekeeping. As a living resource, it is intended to serve as a foundation for evidence-based dialogue among policymakers, regulatory agencies, and the public, with the overarching objective of ensuring the long-term protection and sustainability of commercial beekeeping in California.

I. Honey bees overview

A wide variety of plant and animal species have been managed by humans for thousands of years for diverse purposes (Tauger 2010). Among the most charismatic managed insect species is the Western honey bee, *Apis mellifera*. The native range of the Western honey bee spans three continents: Africa, Asia, and Europe (Ruttner 1988). It is also important to note that North America was once home to a native honey bee species, *Apis nearctica*, which is now extinct (Engel et al. 2009). Due to its value to humans, *A. mellifera* has been introduced to nearly every continent except Antarctica (Hung et al. 2018). The Western honey bee is one of eight recognized honey bee species, although some literature cites a range of seven to eleven. *Apis mellifera* itself comprises over 30 distinct subspecies (Ilyasov et al. 2020; Johnson 2023). In the United States, managed populations are primarily composed of Italian, German, Carniolan, Caucasian, and Spanish honey bees, with traces of four additional subspecies recorded (Carpenter and Harpur 2021). Subspecies introductions began in 1622, when the first colonies were brought to Virginia by European settlers (Sheppard 1989). One of the most consequential introductions occurred in Brazil in the 1950s, when *Apis mellifera scutellata* (commonly referred to as Africanized honey bees, AHB) were accidentally released. Since then, AHB populations have spread northward throughout Central and North America and are now established across much of the southern United States (Marcelino et al. 2024). By the mid-1800s, aided by human transport, honey bees had spread to the West Coast.

The earliest records of beekeeping date to Ancient Egypt between 5000 and 3000 BCE (Crane 1999). Initially, honey bees were managed for honey production, which served both as a carbohydrate-rich food source and as a medicinal product. Over time, their use expanded to include pollination of crops consumed by humans. Beekeepers also began to utilize additional hive products such as royal jelly (glandular secretions used to feed developing bees), propolis (plant resins collected by bees), pollen, and bee venom for their nutritional and medicinal properties (Hristov et al. 2020). Today, the production of packaged bees and queen bees is a significant sector of the beekeeping industry, as these are essential resources for colony replacement given the challenges faced by beekeepers (USDA NASS, Bee and Honey Inquiry Survey and annual Honey Report). Modern beekeeping is primarily conducted using Langstroth hives, which are portable and easily moved to various locations, making them particularly well suited for both honey production and crop pollination (Connor and Caron 2013).

Global honey production reached has 1.9 million metric tons in 2023 (FAO 2023; https://www.fao.org/faostat/en/#data/QCL), and honey bees remain the primary managed pollinator for agricultural production worldwide. The current global market value of honey production is estimated at approximately $8 billion (Statista 2023; https://www.statista.com/topics/5090/honey-market-worldwide/#topicOverview). Pollination services add further economic value (Khalifa et al. 2021). Honey bees provide approximately 50 percent of pollination services to more than 130 crop species globally (Kleijn et al. 2015; Khalifa et al. 2021). Today, honey bee pollination services and honey production contribute an estimated $22 billion to the United States economy (Morse and Calderone 2000, adjusted for inflation). As generalist pollinators, they also play an important role in natural habitats, contributing to the reproduction of wild plants that provide food and habitat for numerous other species (Hung et al. 2018).

Despite their economic and ecological importance, U.S. beekeepers have faced widespread colony losses for several decades (VanEngelsdorp et al. 2008; VanEngelsdorp et al. 2009; Bruckner et al. 2023). Since the 1940s, colony numbers have declined from 5.9 million to approximately 2.8 million (vanEngelsdorp and Meixner 2010; USDA NASS, Bee and Honey Reports; https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Bee_and_Honey/). However, the 2022 Agricultural Census reported approximately 3.8 million colonies, an overestimate of about 1.2 million compared to the USDA NASS annual colony survey for the same period. This discrepancy raises questions about data collection methods and extrapolation, as earlier five-year comparisons did not display such inconsistencies. Regardless of the precise figures, the reality is that U.S. beekeepers have been losing up to 50 percent of their colonies annually (Giacobino et al. 2025), with commercial operations reporting losses as high as 62 percent in early 2025 (Nearman et al. 2025). To offset these losses, beekeepers are often forced to split colonies, which reduces productivity, or purchase replacement colonies at significant cost (in 2024, the national average cost was $109 for a nucleus colony and $89 for a package). Overwintering losses further exacerbate the problem, as they also represent lost pollination revenue (DeGrandi-Hoffman et al. 2019), making the enterprise increasingly unsustainable (Ferrier et al. 2018). Although the Emergency Assistance for Livestock, Honey Bees, and Farm-Raised Fish Program (ELAP) provides some financial relief, reimbursements generally cover less than half of total losses (Goodrich et al. 2019). Persistently high colony mortality and escalating replacement costs are pushing beekeeping toward economic unsustainability, which in turn carries broad societal implications, including rising costs of pollinated foods.

II. Managed honey bees and their contribution to California agriculture

California is home to the largest beekeeping industry in the United States, serving as the cornerstone of both state and national agricultural productivity. Managed honey bees provide essential pollination services for dozens of specialty crops, contribute significantly to honey and hive product production, and generate billions of dollars in economic value annually. At the same time, the industry faces complex challenges, including regulatory oversight, rising costs, colony losses, and increased risks associated with pollination services.

Scale of Beekeeping in California

California beekeeping spans multiple levels of operation. The state supports approximately 600,000 colonies managed by commercial beekeepers (more than 500 colonies) and sideliner operations (50–500 colonies). In addition, California hosts a dynamic community of backyard beekeepers whose numbers fluctuate with changing public interest and the pressures of colony losses. Nationally, surveys estimate 115,000–125,000 beekeepers in the United States (Honey Industry Facts from Bee Culture Magazine, 2012), with California accounting for roughly 10,000 of them.

These figures shift over time due to two main factors: the accessibility of hobbyist beekeeping and the high mortality rates that often discourage new entrants. Despite this volatility, California remains the epicenter of American beekeeping due to its agricultural reliance on managed pollination services, particularly in almonds.

Regulatory Framework

Beekeeping in California is governed primarily under the Apiary Protection Act**,** California Food and Agricultural Code, Division 13, Chapter 1, Sections 29000–29322 (https://www.cdfa.ca.gov/plant/pollinators/ApiaryProtection.html). This framework grants the California Department of Food and Agriculture (CDFA) authority to regulate apiary health and operations to protect both the beekeeping industry and agricultural crops dependent on pollination.

Key provisions include:

- **Registration:** All beekeepers operating colonies in California must register annually with their local County Agricultural Commissioner's office, including out-of-state beekeepers bringing colonies for pollination (https://www.cdfa.ca.gov/plant/pollinators/ApiaryProtection.html). Registration supports oversight, enables communication regarding pesticide applications, and contributes to disease and pest monitoring. Registration is facilitated through the BeeWhere portal (https://beewhere.calagpermits.org/).
- **Inspection and Enforcement:** A State Apiary Inspector is appointed by CDFA, and most counties employ local inspectors. Incoming colonies, particularly those entering from out-of-state, undergo inspections at border protection stations and often receive more detailed inspections upon arrival at their final destinations (https://www.cdfa.ca.gov/plant/pollinators/inspections.html).
- **Advisory Board:** The Apiary Board functions as CDFA's advisory body, comprising six commercial beekeepers and one (optional) public member. This body advises on issues affecting the industry and makes recommendations regarding research, regulatory priorities, and apiary health (https://www.cdfa.ca.gov/plant/pollinators/ApiaryProtection.html).
- **Local Associations:** California also benefits from a robust network of regional and local beekeeping associations, alongside the California State Beekeepers Association (CSBA). These organizations provide training, education, and advocacy for beekeepers of all scales.

Through this regulatory system, California maintains a high level of oversight and coordination intended to balance the needs of beekeepers, growers, and the broader public.

Economic Value

The economic contribution of honey bees in California is immense. Nationwide, managed honey bees provide an estimated $22 billion in value to agriculture through pollination and honey production (Morse and Calderone 2000, inflation-adjusted). In California, apiary-related production ranked #15 among the state's agricultural commodities in 2022, with a reported value of $851.9 million (CDFA 2022–2023 California

Agricultural Statistics Review, https://www.cdfa.ca.gov/Statistics/PDFs/2022-2023_california_agricultural_statistics_review.pdf; see also Figure 1 and Table 1).

Beyond this direct commodity value, honey bees support a wide array of specialty crops classified by USDA as fruits, tree nuts, vegetables, herbs, spices, and horticultural products (https://www.ams.usda.gov/). Many of these crops are exported globally, linking California beekeeping directly to international markets.

Almond Pollination

Almond pollination represents the most significant annual pollination event for U.S. beekeeping. California's almond industry requires the services of nearly 70% of the nation's managed honey bee colonies each year (Goodrich et al. 2019). Bloom typically lasts six weeks, beginning in February, and marks the start of the annual production cycle for beekeepers.

Because almonds are almost entirely dependent on honey bee pollination, expansion of almond acreage over the past two decades has driven unprecedented demand for colonies. Concurrently, annual colony losses and the early-season timing of almond bloom have increased costs for beekeepers. Colonies must be strong, averaging eight frames of bees, to meet pollination standards, requiring intensive investment in feed, pest and disease treatments, labor, and transport before bloom begins (Goodrich and Goodhue 2020).

The cost of hive rental has risen steadily, with the CSBA's 2023 pollination survey reporting an average rental fee of $196.30 per colony, ranging from $170–245. Most growers rent two colonies per acre, making almond pollination the single largest pollination market in the world.

To meet this demand, migratory beekeepers truck colonies into California from across the country as early as October of the previous year. Colonies are inspected at border protection stations and again upon arrival. Increasingly, beekeepers use controlled-environment storage facilities to overwinter colonies, a practice shown to reduce losses and improve early-season colony strength (Bahrein and Currie 2010; Suresh and Currie 2016; DeGrandi-Hoffman et al. 2019; Hopkins et al. 2021, 2023).

After almond bloom, beekeepers shift to other crops, honey production, or live bee and queen production. Thus, almonds anchor the annual cycle of beekeeping in California, influencing management decisions and financial outcomes across the industry.

Honey Production

California consistently ranks among the top honey-producing states. In 2024, U.S. honey production was valued at $361.5 million. California produced 13.3 million pounds of honey from 310,000 colonies, valued at $32.8 million, with an average yield of 43 pounds per colony (USDA-NASS, 2024).

Honey yields vary annually depending on climate, colony health, forage availability, and market dynamics. Drought and reduced floral diversity often lower production. The California Food and Agricultural Code regulates honey labeling, classification, and container standards (https://www.cdfa.ca.gov/plant/pollinators/docs/Laws-Bee-Management.pdf). Honey varieties reflect local floral sources, ranging from wildflower blends to distinctive monofloral honeys such as orange blossom, lavender, yellow starthistle, and sage.

Beyond serving as a food product, honey demonstrates antibacterial and medicinal properties, with applications in wound healing (Tashkandi 2021), cough suppression (Paul et al. 2007), and potential anti-allergenic uses (Yong et al. 2021). The American Honey Producers Association advocates for honey quality standards and works to prevent adulterated imports from entering U.S. markets (https://ahpanet.com/).

Live Bee and Queen Production

California is also a national leader in producing live bees and queens. Each spring, beekeepers harness natural colony reproduction to create packages and nucleus colonies for sale. Packaged bees, typically sold in two- or three-pound lots with or without queens, average $89 per package, while nucleus colonies sell for about $109 (USDA-NASS, 2024). This market provides essential replacement stock for beekeepers nationwide facing high overwintering losses.

Northern California is particularly important for queen production, with an estimated one million queens produced annually for shipment across the U.S. and Canada (Cobey et al. 2012). Current average price of a queen is $18 (USDA NASS 2024). Queen production not only sustains colony replacement but also reduces nuisance swarming by directing reproductive behaviors into managed outputs.

Additional hive products, including pollen, propolis, royal jelly, and beeswax, contribute to industry value, though their economic impact is less thoroughly quantified.

Supporting Industry Stability

The concentration of colonies in California during almond bloom underscores the state's pivotal role in the national beekeeping economy. What happens in California reverberates across the country, shaping beekeeper profitability, colony availability, and pollination pricing. Recognizing this, the Almond Board of California, in partnership with industry groups and researchers, has developed Honey Bee Best Management Practices to protect colonies during pollination (https://www.almonds.com/almond-industry/orchard-management/honey-bee-best-management-practices).

Collaborative efforts extend beyond almonds. The Honey Bee Health Coalition (https://honeybeehealthcoalition.org/) brings together beekeepers, growers, researchers, and private entities to develop solutions addressing pests, diseases, forage, and pesticide risks. These partnerships highlight the importance of shared responsibility in sustaining pollinator health.

The California beekeeping industry is both vast and indispensable, anchoring the national pollination economy and producing significant honey and live bee outputs. Almond pollination defines the industry's scale and timing, while honey and queen production diversify its economic contributions. Yet high colony losses, rising costs, forage scarcity, and regulatory pressures challenge long-term sustainability.

By strengthening regulatory frameworks, supporting beekeeper–grower cooperation, expanding forage opportunities, and investing in research on bee health, California can continue to lead the way in sustaining both its own agriculture and the national beekeeping industry.

I. III. Honey bee colony stressors

Honey bee colonies in the United States and worldwide face persistent, multifactorial threats that contribute to unsustainable annual losses. In 2006, the phenomenon later named Colony Collapse Disorder (CCD) brought this issue to widespread public attention, as beekeepers reported sudden disappearances of adult bees from hives (Cox-Foster et al. 2007; VanEngelsdorp et al. 2009). Although CCD is no longer considered a major cause of mortality, it underscored the vulnerability of honey bees to multiple stressors acting in combination (Figure 2). Today, colony losses remain troublingly high, often exceeding 40–50 percent annually, with commercial losses recently reported as high as 62 percent (VanEngelsdorp et al. 2008, 2010; Spleen et al. 2013; Seitz et al. 2022; Giacobino et al. 2025; Nearman et al. 2025). These losses reflect the combined effects of parasites, pathogens, pesticides, nutrition, climate, and even human-related threats such as theft.

Varroa Mites and Associated Viruses

The ectoparasitic mite *Varroa destructor* is universally recognized as the most significant biological threat to managed honey bees. Originally a parasite of the Eastern honey bee (*Apis cerana*), *Varroa* shifted hosts to the Western honey bee (*Apis mellifera*) in the mid-20th century and has since spread nearly worldwide.

Varroa mites feed on the fat body tissue of developing and adult bees, organs vital for nutrient storage, immune response, and detoxification (Ramsey et al. 2019; Ramsey et al. 2022). Infested bees suffer reduced lifespans, weakened immune systems, and greater susceptibility to other stressors (Morfin et al. 2023; Warner et al. 2024). Colonies with uncontrolled infestations inevitably collapse within a year.

The mite's role as a viral vector compounds its impact. More than 20 viruses are associated with honey bees, and *Varroa* transmission has increased their prevalence and virulence (Chen and Siede 2007; McMenamin and Genersch 2015; Grozinger and Flenniken 2019). Deformed Wing Virus (DWV), for example, causes wing deformities that prevent bees from foraging, leading to rapid colony decline (Dainat et al. 2012; Lamas et al. 2025).

Control of *Varroa* has relied heavily on miticides such as amitraz, fluvalinate, and coumaphos. However, resistance has developed in many populations, reducing their efficacy. Miticide residues can also accumulate in wax, raising concerns about long-term contamination. Researchers and beekeepers are pursuing alternatives, including new miticides, temperature-based treatments (Porporato et al. 2022), breeding for resistance traits such as Varroa Sensitive Hygiene (Danka et al. 2011), and experimental biological controls. Despite these efforts, sustainable management of *Varroa* remains one of the greatest challenges in apiculture.

Other Pests

Honey bee colonies are also vulnerable to additional pests, which exploit weakened hives. The small hive beetle (*Aethina tumida*) lays eggs in colonies; larvae consume pollen, honey, and brood, leaving frames slimed and unusable (Neumann and Elzen 2004). Beetles use behavioral mimicry to evade bee defenses and can even solicit feeding from workers (Ellis et al. 2002). Wax moths (*Galleria mellonella* and *Achroia grisella*) similarly infest stressed colonies. Their larvae burrow through comb, destroying brood and honey stores while leaving behind silken tunnels that cause permanent equipment damage (Kwadha et al. 2017). Individually, strong colonies can usually suppress these pests, but when combined with other stressors, infestations contribute to economic losses from unrecoverable honey and comb.

Pathogens

Honey bees host a wide array of pathogens, including viruses, bacteria, microsporidia, and fungi. Among viruses, DWV is most damaging, but others such as Acute Bee Paralysis Virus and Black Queen Cell Virus also contribute to colony decline (McMenamin and Flenniken 2018). Viral infections often act synergistically with *Varroa* infestations, intensifying impacts at the colony level.

Bacterial diseases remain critical concerns. American foulbrood (AFB), caused by *Paenibacillus larvae*, produces highly resistant spores that persist for decades. Because of this, AFB is a regulated disease in California and most of the United States, requiring destruction of symptomatic colonies and destruction and sterilization of equipment (Stephan et al. 2020; Matović et al. 2023). European foulbrood (EFB), caused by *Melissococcus plutonius*, has risen in prevalence and exhibits variant strains that complicate diagnosis and treatment (Forsgren et al. 2018; Ponce de León-Door et al. 2020). Since 2018, antibiotics for foulbrood require a veterinary feed directive (VFD), creating challenges for timely management due to the limited number of veterinarians trained in apiculture (http://www.usfarad.org/vfd-and-rx-for-bees.html; https://www.hbvc.org/; https://www.wifss.ucdavis.edu/beevets/).

Microsporidian infections such as *Nosema* (*Vairimorpha*) species damage gut cells, impair nutrient absorption, and reduce colony longevity (Goblrisch 2018; Grupe and Quandt 2020). While recent surveys suggest low prevalence in California (UC Davis Bee Health Hub, unpub. data), broader monitoring is needed. Fungal diseases like chalkbrood (*Ascosphaera apis*) thrive under stressful conditions such as high humidity and poor nutrition, leading to brood mortality (Castagnino et al. 2020). Beekeepers often manage chalkbrood by re-queening with hygienic stock that better detects and removes infected brood.

However, the prevalence and intensity seem to be on the rise.

Emerging Threats

The globalization of trade and bee movement increases the risk of new pests reaching the United States. Tropilaelaps mites, currently found in Asia, Africa, Papua New Guinea, and recently Russia, are considered one of the most serious emerging threats (Chantawannakul et al. 2018; Brandorf et al. 2025). Like *Varroa*, they reproduce within brood cells and cause severe colony damage. Without preemptive action, their introduction could devastate North American apiculture. USDA-APHIS currently conducts annual national surveys to monitor for such threats (https://www.aphis.usda.gov/plant-pests-diseases/honey-bee-surveys), and scientists are performing crucial research in the region of origin to prepare for an inevitable arrival.

Pesticide Exposure

Chemical exposure remains a major abiotic stressor. More than 120 pesticides and metabolites have been identified in hive products (Mullin et al. 2010; Johnson et al. 2010). Neonicotinoid insecticides have been particularly controversial due to their persistence and sublethal effects on bees. Their provisional ban in the United Kingdom has prompted reevaluation by the U.S. Environmental Protection Agency (EPA; https://www.epa.gov/pollinator-protection/schedule-review-neonicotinoid-pesticides) and regulatory measures by the California Department of Pesticide Regulation (CDPR; https://www.cdpr.ca.gov/docs/enforce/neonicotinoid/neonicotinoid_regulations.htm).

Pesticide exposure can reduce foraging efficiency, impair navigation, and increase susceptibility to disease. However, understanding of synergistic effects between pesticides and other stressors remains limited (Zhao et al. 2022). To mitigate risks, EPA has updated its risk assessment framework (https://www.epa.gov/pollinator-protection/how-we-assess-risks-pollinators), and CDPR has issued a comprehensive Pollinator Protection Plan (2018) with stakeholder-specific guidelines (https://www.cdpr.ca.gov/docs/enforce/pollinators/index.htm).

Practical tools also exist for beekeepers and growers. The University of California Bee Precaution Pesticide Ratings database (https://ipm.ucanr.edu/bee-precaution-pesticide-ratings/) helps identify less harmful products. Apiary registration with county agricultural offices ensures that pesticide applicators notify beekeepers of upcoming applications classified as toxic to bees, allowing protective measures.

Predation and Theft

Beekeepers face additional challenges from both wildlife and human activity. Bears represent a persistent predator in regions of California and beyond, tearing apart hives in search of food. Climate-driven drought has reduced natural forage in higher elevations, pushing bears into agricultural areas where they devastate apiaries despite fencing and deterrent efforts (Clark et al. 2005; Otto and Roloff 2015).

Hive theft has also escalated, particularly during almond pollination when hive rental prices peak. Over the past decade, more than 10,000 hives valued at $3.5 million have been reported stolen in California (https://www.kcra.com/article/california-beehive-thefts-farmers-lose-thousands/46824351). Thieves may place stolen hives under fraudulent pollination contracts, collect payments, and abandon the colonies. High-profile cases, such as the theft of hundreds of hives in Sutter County in 2017, highlight the seriousness of the issue.

To counter theft, beekeepers brand equipment and increasingly use GPS trackers hidden in hives. Growers are encouraged to verify beekeeper credentials, confirm branding consistency, and be alert to unusually low rental offers. Suspicious activity should be reported to law enforcement to improve recovery rates and deter future incidents.

The stressors impacting honey bee colonies are numerous, interrelated, and persistent. Parasites such as *Varroa destructor* and emerging threats like

Tropilaelaps mites weaken colonies directly while amplifying the effects of viruses and pathogens. Bacterial, fungal, and microsporidian diseases further reduce colony health, while pesticide exposure continues to pose significant sublethal risks. Added to these biological and chemical stressors are predation by wildlife and theft, both of which impose direct economic losses on beekeepers.

The cumulative effect of these stressors makes beekeeping increasingly difficult to sustain without substantial economic and management inputs. Addressing them requires coordinated strategies: investment in research on sustainable *Varroa* control and emerging threats; regulatory frameworks for pesticide risk reduction; improved communication between growers and beekeepers; expansion of hygienic and resistant bee stocks; and practical measures to protect colonies from predation and theft. Without such interventions, the economic viability of beekeeping, and the pollination services essential to California agriculture and global food security, will remain under threat.

IV. Forage and Nutrition

Nutrition is one of the most critical determinants of honey bee colony health and productivity. Just as humans require balanced diets to maintain immune function and overall well-being, honey bees rely on adequate and diverse nutritional resources to survive, reproduce, and provide pollination services. Colonies obtain their nutrition primarily from pollen and nectar collected from flowering plants. Pollen supplies proteins, lipids, and micronutrients, while nectar provides carbohydrates in the form of sugars. Together, these resources form the foundation of colony growth and resilience.

In recent years, growing evidence has shown that many of the stressors undermining honey bee health, parasites, pathogens, pesticides, and climate-driven challenges, are exacerbated when colonies face nutritional stress (Bernklau and Arathi 2023; Chakrabarti et al. 2020; Tsuruda 2021). Adequate forage helps bees detoxify pesticides, strengthens their immune systems, and enhances cognitive functions such as learning and memory (DeGrandi-Hoffman et al. 2015; Arien et al. 2015; Schmehl et al. 2014). By contrast, malnourished colonies are more vulnerable to disease outbreaks, perform less efficiently as pollinators, and are more likely to experience collapse.

Importance of Nutrition

While pollen primarily supplies protein, its composition varies widely depending on plant species. Some pollens are rich in essential amino acids, sterols, and lipids, while others are nutritionally incomplete. Nectar, though primarily a carbohydrate source, also contains phytochemicals and trace minerals that support bee physiology (Chakrabarti et al. 2020). Together, diverse floral resources allow bees to balance their diets in ways no single crop or supplement can fully replicate.

Access to diverse forage supports many major aspects of bee health, for example:

1. **Immune pathways:** Well-nourished bees mount stronger immune responses against pathogens (DeGrandi-Hoffman et al. 2015).
2. **Cognitive performance:** Adequate nutrition enhances learning and memory, both of which are critical for effective foraging (Arien et al. 2015).
3. **Detoxification capacity:** Nutritional inputs fuel detoxification enzymes, allowing bees to process pesticide exposures more effectively (Schmehl et al. 2014).

For these reasons, loss of natural forage has become one of the most impactful stressors threatening honey bee health. Habitat conversion, monoculture farming, urbanization, and climate change have all reduced the abundance and diversity of floral resources available to bees.

Almond Pollination and Early-Season Nutrition

Almonds provide the first major bloom of the year in California, typically beginning in early to mid-February. This bloom coincides with the critical period of early-season colony buildup.

Almond pollen is highly nutritious, offering bees a dense source of proteins and lipids. However, studies have shown that even during almond bloom, bees benefit from access to additional floral resources. Colonies with supplemental forage demonstrate stronger brood production and higher foraging activity, benefits that persist well beyond the almond pollination period (Eckert et al. 1994; Carroll et al. 2018; Mayack et al. 2025).

A common concern among almond growers is that providing supplemental forage within orchards might distract bees from pollinating almond flowers. Research, however, indicates that this is not the case. Supplemental plantings complement rather than compete with almond pollination, while providing long-term benefits to colony strength (Lundin et al. 2017). Recognizing this, organizations such as Project Apis m promote the planting of forage in almond orchards through initiatives like the "Seeds for Bees" program, which incentivizes growers to establish pollinator-friendly plantings (https://www.projectapism.org/). The Almond Board of California has also developed resources and best management practices for integrating cover crops and supplemental forage into orchard systems (https://www.almonds.com/sites/default/files/2021-07/Cover%20Crops%20Best%20Management%20Practices%20BMPs_0.pdf).

The benefits of supplemental forage extend beyond almonds. In other specialty crops, including fruits, vegetables, and seed crops, providing floral diversity improves pollination outcomes, strengthens colonies, and supports broader pollinator communities.

Supplemental Forage Beyond Orchards

Forage scarcity is not limited to almond orchards. Throughout the year, colonies often experience "dearth periods" when natural bloom is absent. Climate change, prolonged drought, wildfires, and restricted access to public lands exacerbate health issues (Mayack et al 2023) and nutritional gaps. Beekeepers increasingly depend on supplemental forage plantings or alternative land-use strategies to sustain colonies.

Landscape-level interventions include establishing hedgerows, wildflower strips, and rotational cover crops to provide forage during off-peak periods. Such plantings not only benefit honey bees, but also support native pollinators and other beneficial insects, contributing to ecosystem resilience. Research continues to refine which species provide the greatest nutritional value across different seasons and regions, aiming to build forage portfolios that complement major crop blooms (Chakrabarti et a. 2024).

Supplemental Diets

When natural forage is unavailable or insufficient, beekeepers turn to supplemental diets. These include protein patties, sugar syrup, and proprietary feed formulations. Protein patties often contain brewer's yeast, soy flour, or other protein sources, while carbohydrate supplements are usually sucrose or corn syrup. Many commercial products also include vitamins, lipids, and proprietary additives.

While supplements sustain colonies during forage dearth, they remain imperfect substitutes for natural pollen and nectar. One challenge is replicating the full spectrum of micronutrients, such as sterols and phytochemicals, that bees obtain from diverse plants (Chakrabarti et al. 2024). Another is the variability of colony needs across seasons: protein is most critical during brood-rearing periods, while carbohydrates are vital for overwinter survival (DeGrandi-Hoffman et al. 2018; Wright et al. 2018).

Scientific research is increasingly focused on developing more complete supplemental diets. Some progress has been made in creating balanced formulations, but most supplements still fall short of natural forage in terms of nutritional completeness and colony outcomes. Innovative approaches, including the use of novel, sustainable protein sources such as microalgae and yeast-derived feeds, are being tested with promising results (Ricigliano 2020; Moore et al. 2025).

Challenges and Knowledge Gaps

Despite advancements, several challenges remain:

- **Nutrient complexity:** It is still unclear which micronutrients are essential and in

what combinations. Many plant-derived compounds appear to have synergistic effects that are difficult to replicate artificially.
- **Regional variation:** Colonies in different geographic areas face distinct forage gaps depending on local crops, climate, and bloom cycles. One-size-fits-all diets are unlikely to be optimal.
- **Economic considerations:** Supplemental feeding represents a significant cost for beekeepers, especially in years with widespread forage shortages. Balancing cost and nutritional adequacy is a persistent challenge.
- **Climate impacts:** Drought, wildfires, and shifting weather patterns reduce natural forage and complicate predictions of when supplements will be needed.

Addressing these gaps requires both continued basic research on bee nutritional biology and applied work on the design of supplemental diets that are affordable, sustainable, and nutritionally complete. Efforts to address honey bee nutrition should take a two-pronged approach:

1. **Expanding forage opportunities:** Policies and programs that incentivize planting pollinator-friendly vegetation on farmland, public lands, and rights-of-way can dramatically increase forage availability. Given that nutritional resources benefit all pollinators, such efforts also strengthen broader biodiversity.
2. **Developing advanced supplemental diets:** Investments in nutritional research should aim to replicate the complexity of natural forage, tailoring formulations to seasonal and regional colony needs. Incorporating sustainable protein sources and refining delivery methods will be central to future solutions.

Nutrition underpins every aspect of honey bee health, from immune defense to foraging efficiency. While almonds and other specialty crops provide critical seasonal resources, they are not sufficient to sustain colonies year-round. Declines in natural forage, driven by habitat loss and environmental change, have made supplemental plantings and diets increasingly necessary. However, supplements are not perfect substitutes, and both research and policy should prioritize long-term solutions that restore forage landscapes while advancing the science of supplemental feeding.

Sustaining honey bee populations will require coordinated efforts among beekeepers, growers, researchers, and policymakers. By ensuring adequate and diverse nutrition, the beekeeping industry can strengthen colonies, mitigate the impacts of other stressors, and continue to provide essential pollination services that underpin California agriculture and global food security.

II. Coexistence of honey bees and native bees

The coexistence of managed honey bees (*Apis mellifera*) and native bee species is a subject of ongoing research and debate, reflecting both ecological complexities and management challenges. While honey bees are critical for global agricultural production, native bees provide indispensable ecosystem services that sustain biodiversity, natural habitats, and long-term agricultural resilience (Goulson et al. 2015). Both groups face similar pressures, including parasites, pathogens, pesticides, climate change, and habitat loss. Understanding how these two groups interact is essential for balancing agricultural demands with biodiversity conservation.

Competition for Floral Resources

Honey bees and native bees often overlap in their use of floral resources, particularly in agricultural landscapes where nectar and pollen availability can be limited. Increased honey bee abundance has been linked to reduced floral resources for native species, altering their foraging patterns and visitation rates (e.g., Goulson 2003; Page and Williams 2023a,b). For example, studies in California's Central Valley and montane meadows demonstrated that honey bee competition reduced nectar and pollen availability, resulting in greater niche overlap with native bees (Page and Williams 2023). However, native species responded and adapted by shifting their foraging strategies - some became more specialized on particular flowers, while others broadened their diet to include less-utilized resources. These findings suggest that competition is not uniform but varies depending on floral diversity, seasonal availability, and the species involved.

Other studies echo these patterns. Cunningham et al. (2013) reported that honey bees often dominate resource-rich areas, yet certain native species, such as bumblebees (*Bombus* spp.) and sweat bees (*Halictidae*), demonstrated behavioral flexibility by exploiting resources honey bees avoided. Such adaptations may allow coexistence in some habitats, though the ecological cost to native populations remains uncertain.

Neutral and Positive Interactions

Although competition is a documented concern, evidence also suggests neutral or even positive effects of honey bee presence on native bees and plant communities. Reviews indicate that approximately half of studies find negative impacts of honey bees on native bees, while the remainder show neutral or mixed outcomes (Mallinger et al. 2017). In some cases, honey bees contribute positively to plant reproduction, particularly where native pollinators are scarce or absent.

For example, Chamberlain and Schlising (2014) examined pollination of *Triteleia laxa* (Ithuriel's spear), a native California wildflower, and found that honey bee visitation had no negative effect on pollen transfer compared to native bees. Moreover, honey bee activity was associated with increased seed production. Similarly, in semi-natural environments (Batra et al. 1999) and agricultural systems (Tepedino et al. 2007), managed honey bees often coexisted with native bees without reducing visitation rates.

At broader scales, honey bees can provide "insurance" for pollination services. When environmental pressures or habitat fragmentation reduce native bee populations, honey bees can stabilize crop pollination and, in some cases, sustain pollination for native plant species. This functional redundancy may be particularly important as climate change and land-use change threaten pollinator diversity (Mallinger et al. 2017).

Variation Across Ecosystems

The impact of honey bees on native bees is highly context-dependent. Prendergast et al. (2021), studying urban and semi-natural areas in southwestern Australia, found that relationships between honey bee abundance and native bee richness shifted across years and locations. In the first year, native bee richness was positively correlated with honey bee abundance, while in the second year it was negatively correlated. Larger-bodied native bees, which shared more dietary overlap with honey bees, were more likely to be negatively affected. Smaller species, by contrast, demonstrated greater adaptability. These findings underscore the importance of considering traits such as body size, diet breadth, and nesting requirements when evaluating competition.

Other research demonstrates that native bees may respond differently based on ecological context. For example, in resource-rich environments, honey bees may dominate without significantly displacing native species, while in resource-poor landscapes, competition may intensify (Paini 2004; Paini et al. 2005; Ruso 2016). These differences complicate generalizations and point to the need for location-specific assessments of pollinator interactions.

Management Approaches to Reduce Conflict

Given the variability of outcomes, management strategies should focus on creating conditions that support both honey bees and native bees. Habitat restoration is among the most effective approaches. Increasing floral diversity, planting wildflower strips, and maintaining semi-natural habitats within agricultural landscapes provide additional resources that can reduce competition (e.g., Herbertsson et al. 2016; Schoch et al. 2022). These practices benefit not only bees but broader pollinator communities and biodiversity.

Adjusting hive densities in sensitive habitats is another tool. Lowering the number of managed colonies in areas with limited floral resources reduces competitive pressure on native species. Similarly, spatial planning, such as avoiding high-density apiaries near conservation areas, can help balance agricultural pollination needs with conservation goals.

Integrated pest management (IPM) strategies also play an indirect role. By reducing disease transmission and pesticide exposure in managed colonies, IPM helps prevent spillover effects that could harm native populations. Efforts to minimize pesticide use, or to select products less harmful to bees, further support pollinator coexistence (Potts et al. 2016).

Broader Conservation Context

The dynamics between honey bees and native bees mirror patterns observed with other introduced pollinators. Non-native pollinator introductions can sometimes displace native species, yet in other cases they fill ecological roles without significant disruption (Ruso 2016). This variability highlights the need for long-term, landscape-level research that accounts for differences in species traits, habitats, and resource availability.

While honey bees can outcompete native species under certain conditions (Cane and Tepedino 2017), they can also complement native pollinators, enhancing overall pollination efficiency when resource overlap is limited (Klein et al. 2007; Brittain et al. 2013; Evans et al. 2018). Ensuring diverse and abundant floral resources remains the most reliable strategy for supporting both groups, as well as working towards more balanced regulatory frameworks (Beaurepaire et al. 2025).

The coexistence of honey bees and native bees is not defined by a single outcome but instead reflects a spectrum of interactions ranging from competition to complementarity. Outcomes depend on multiple factors, including floral diversity, resource availability, nesting opportunities, and the traits of native bee communities. Where floral resources are limited and overlap is high, competition may reduce native bee abundance and diversity. In more diverse landscapes, however, honey bees and native bees can coexist and even enhance one another's pollination contributions.

Balancing agricultural reliance on managed honey bees with conservation of native bees requires context-specific approaches. Expanding floral resources, managing hive densities, reducing pesticide exposure, and restoring habitats are practical steps that support coexistence. Continued research, particularly long-term and geographically diverse studies, is essential to refine these strategies. Ultimately, sustaining both honey bees and native bees is vital to securing agricultural productivity, ecosystem resilience, and biodiversity.

III. V. New technologies

Rising labor costs, persistent colony losses, and the increasing demand for pollination services have spurred researchers, beekeepers, and growers to explore new technologies to improve the sustainability of beekeeping. Collectively, these innovations are shaping the field of precision beekeeping, which applies tools such as sensors, robotics, artificial intelligence (AI), and feed-based enhancements to reduce costs, improve efficiency, and safeguard colony health.

Monitoring Tools

In-hive sensors capable of recording temperature, humidity, gas concentrations, and sound provide continuous data on colony conditions (Meikle et al. 2015, 2017, 2018, 2022). These tools allow early detection of stress, enabling preemptive management without frequent intrusive inspections. Hive cameras (e.g., Eyesonhives) and bee counters (e.g., HiveGenie) further extend monitoring by tracking flight activity and foraging effort. Such data can benefit both beekeepers and growers by providing verifiable evidence of pollination activity.

Robotics and Automation

Prototypes of robotic hive systems have been designed to house multiple colonies while automating tasks such as supplemental feeding or pest control (e.g. BeeWise). These systems, though still in development, have the potential to reduce labor demands in large-scale operations and support more precise management strategies.

Feedants and Therapeutics

Feed-based technologies are being tested to improve pollination performance and colony resilience. Products developed by Beeflow, for example, enhance bee foraging under cooler conditions and increase attraction to target crops (Cavigliasso et al. 2021). Research also explores using feedants as delivery systems for therapeutics, such as antiviral or antiparasitic compounds, providing a scalable alternative to labor-intensive treatments (Ricigliano et al. 2024).

Artificial Intelligence

Advances in AI and machine learning offer rapid diagnostic potential. Algorithms trained on hive images, video, or acoustic data can help identify parasites, pathogens, or colony-level disturbances with speed and accuracy (Hossain et al. 2025). Automated diagnostics would reduce the time between the onset of problems and beekeeper intervention, improving survival rates and lowering management costs.

While challenges remain, including cost, regulatory approval, and integration into everyday practice, technological innovation holds promise for improving beekeeping efficiency and resilience. In the near future, integrated platforms combining robotics, sensors, feedants, and AI diagnostics could form the basis of more sustainable pollination systems, providing economic benefits to beekeepers while ensuring reliable pollination for growers.

VI. Working towards solutions

Securing a stable and sustainable supply of healthy honey bee colonies is critical for U.S. agriculture, food security, and ecosystem stability. Despite the resilience and adaptability of commercial beekeeping, mounting pressures from biotic and abiotic stressors, combined with unsustainable economic losses, underscore the need for practical, immediate, and long-term solutions. This section highlights key areas where targeted action can support beekeepers, mitigate risks, and strengthen pollination services that underpin agriculture and natural systems alike.

Forage and Nutrition

Optimal nutrition remains a cornerstone of honey bee health. A diverse and abundant diet improves immune function, resilience to pathogens and pesticides, and overall colony productivity (Dolezal and Toth 2018; Tsuruda et al. 2021; Mayack et al. 2025). Conversely, inadequate or monotonous forage undermines bee immunity, weakens colonies, and reduces pollination efficiency.
Unfortunately, continued habitat degradation from urbanization, intensified agriculture, and climate change reduces the diversity and abundance of floral resources (Naug 2009; Landaverde et al. 2023). Droughts, wildfires, and land-use restrictions have further limited beekeepers' access to high-quality forage throughout the year. This nutritional stress exacerbates losses from other biotic and abiotic stressors, creating a feedback loop that makes colonies more vulnerable to pests, pathogens, and pesticide exposure.

In response, federal, state, and local governments have promoted supplemental plantings in agricultural and urban landscapes to improve pollinator health. Initiatives such as the 2015 White House Pollinator Health Task Force called for expanding pollinator-friendly habitat, and nonprofits including Project Apis m and Pollinator Partnership have since partnered with landowners and growers to enhance thousands of acres with high-value forage. Project Apis m's "Seeds for Bees" program (https://www.projectapism.org/sfb-home), for example, provides growers with seed mixes designed to provide supplemental forage before and after crop bloom, benefiting honey bees and wild pollinators alike.

While such programs are impactful, broader action is needed. Expanding forage plantings onto federal and state lands would provide substantial benefits, particularly in regions like California where drought and land conversion have constrained habitat. Equally important is expanded access to public lands, and incentivizing private landowners to participate through tax breaks, cost-share programs, or direct payments. Similar models already exist for conservation programs targeting soil health and water quality; extending them to pollinator habitat would generate immediate gains for honey bee and native pollinator communities (Fenton et al. 2025).

Pest and Disease Management

Among the many threats to colony health, *Varroa destructor* remains the most urgent. This parasite weakens bees by feeding on their fat bodies and vectors multiple viruses, including Deformed Wing Virus, which is strongly associated with colony collapse (Ramsey et al. 2019; Morfin et al. 2023). *Varroa* infestations have been increasing despite heavy reliance on miticides, as resistance to existing compounds spreads. Recent reports highlight increasing resistance to amitraz, one of the last effective chemical controls (Lamas et al. 2025).

Currently, the U.S. Environmental Protection Agency (EPA) has federally registered 17 miticide products containing 11 active ingredients (Table 2). However, in California, only 11 products with eight active ingredients are registered for use, excluding miticides such as oxalic acid-based treatments, sucrose octanoate, and l-glutamic acid (Table 2). While products like Amiflex and oxalic acid formulations are under review by the California Department of Pesticide Regulation (CDPR), the approval process is slow, leaving beekeepers with limited tools. A novel RNAi-based product, Norroa (vadescana), is under EPA and CDPR review, offering a promising addition once approved (GreenLight Biosciences 2025).

Expediting the regulatory review of new active ingredients and biologically based treatments is essential. The current pace of product registration cannot keep up with the rapid development of *Varroa* resistance. In addition, research on safe adjuvants to enhance miticide effectiveness is showing promise (Shannon et al. 2025) and should be prioritized.

Beyond *Varroa*, other diseases and pests also require attention. The bacterial disease American foulbrood (AFB), caused by *Paenibacillus larvae*, remains a regulated threat. Recently, Dalan Animal Health developed the world's first honey bee vaccine, which, when fed to queens, passes immunity to their offspring (Dickel et al. 2022). Early studies indicate the vaccine not only protects against AFB but may also reduce viral loads, particularly of Deformed Wing Virus strain B (Weinberg et al. 2024). Expediting review and approval of innovative tools like this is critical for disease management.

Monitoring and Preparedness

As global trade and human movement increase so too does the risk of new honey bee pests and pathogens entering the United States. Vigilant monitoring and early detection are the best defenses against potentially devastating invasions. The USDA National Honey Bee Survey is a cornerstone of national surveillance, tracking the prevalence of parasites, pathogens, and pesticide residues across commercial colonies. Importantly, this program provides the only coordinated effort to detect and respond to emerging threats such as *Tropilaelaps* spp. mites or invasive bee species like *Apis cerana*. Recent detections of *Tropilaelaps* in Papua New Guinea and Russia highlight how quickly these parasites can spread beyond their native ranges (Brandorf et al. 2025). If introduced, *Tropilaelaps* could cause colony losses even more severe than those inflicted by *Varroa*.

To prepare, the United States must increase investment in monitoring, early detection technologies, and rapid-response protocols. Research into the biology, dispersal, and control of emerging pests is also urgently needed, along with development of international partnerships to share surveillance data and management strategies.

Research and Innovation

Continued funding for honey bee research is essential to support practical solutions. Federal agencies, universities, and organizations such as the California State Beekeepers Association (CSBA) play vital roles in funding and disseminating applied research. Investment should prioritize projects with direct benefits to beekeepers, including development of novel pest control methods, improved supplemental diets, and breeding programs for resistant bee stocks. At the same time, regulatory frameworks must adapt to ensure that new products and technologies can move efficiently from research to field application. Streamlined approval pathways for bee-safe products, particularly miticides and biological treatments, are urgently needed to keep pace with the evolving landscape of pest resistance and emerging threats.

Beekeeping is more challenging today than at any point in modern history. High annual colony losses, nutritional stress, limited access to effective treatments, and increasing operational costs threaten both the sustainability of commercial beekeeping and the broader agricultural economy.

A comprehensive strategy should include:

- Expanding forage resources through habitat restoration, public land access, and private landowner incentives.
- Strengthening financial safety nets, including expanded ELAP coverage and new drought-related support programs for apiculture.
- Accelerating the approval of new pest and disease management tools, including miticides, vaccines, and biologically based treatments.
- Expanding national monitoring systems to detect and respond to emerging threats like *Tropilaelaps* mites.
- Increasing research funding and streamlining regulatory processes to bring innovations to market faster.

Through coordinated action across federal and state agencies, growers, and beekeepers, the industry can move toward greater resilience. Investing in solutions for honey bee health is not only critical for beekeepers but also for the stability of U.S. agriculture and the security of global food supplies.

Summary and Policy Recommendations

Honey bees (*Apis mellifera*) remain indispensable to U.S. agriculture and ecosystems. Their role in providing pollination services to more than 100 crops, in addition to honey and other hive products, is valued at tens of billions of dollars annually. Yet, despite their importance, commercial beekeepers continue to face unprecedented challenges. High annual colony losses driven by *Varroa destructor*, viral diseases, pesticide exposure, poor nutrition, and habitat loss threaten the long-term sustainability of apiculture. Without meaningful intervention, these pressures risk undermining food production, agricultural profitability, and ecosystem stability.

This white paper underscores several urgent themes:

- **Forage and nutrition**: Declining access to diverse floral resources weakens colonies and amplifies vulnerability to other stressors. Expanded planting programs, improved access to public lands, and incentives for private landowners are critical.
- **Economic viability**: With replacement colonies costing upwards of $300 and annual losses exceeding 30–50%, beekeeping is increasingly unsustainable. Relief programs such as ELAP provide inadequate compensation. Expanding financial safety nets is necessary to stabilize the industry.
- **Pest and disease management**: *Varroa* mites and associated viruses remain the greatest threats to honey bee survival. Limited availability of effective miticides and growing resistance highlight the need for expedited regulatory review of new products, including biologically based tools and vaccines.
- **Monitoring and preparedness**: National surveillance through the USDA Honey Bee Survey is essential for early detection of emerging threats such as *Tropilaelaps* mites. Expanding funding for monitoring and rapid-response systems will strengthen resilience against future incursions.

- **Research and innovation**: Continued investment in honey bee research, particularly in nutrition, pest management, genetics, and technology, is fundamental. Streamlined approval pathways are needed to move innovations from research to application quickly.
- **Technology adoption**: Precision beekeeping tools, robotics, AI diagnostics, and feedants offer new opportunities to reduce costs and improve colony monitoring. Public-private partnerships should support pilot programs to evaluate and scale these tools.

Policy Recommendations

1. **Expand forage programs** by funding pollinator-friendly plantings, providing incentives for private landowners, and increasing beekeeper access to state and federal lands.
2. **Strengthen financial assistance** by expanding ELAP payouts to cover a greater proportion of beekeeper losses and establishing drought-related compensation programs for forage loss, modeled after the Livestock Forage Disaster Program.
3. **Accelerate regulatory approvals** for new miticides, vaccines, and biological products, particularly those addressing *Varroa* mite resistance, while encouraging research into synergistic tools such as adjuvants.
4. **Increase funding for surveillance** through the USDA National Honey Bee Survey to enhance early detection and response to exotic pests and pathogens.
5. **Support applied research** with direct relevance to beekeepers, including breeding for disease- and mite-resistant bee stocks, improved supplemental diets, and field trials of new technologies.
6. **Promote adoption of precision technologies** by creating cost-share programs or incentives for commercial operations to pilot in-hive sensors, AI-based diagnostics, and feedants.

The challenges facing honey bees are complex, but the path forward is clear. By investing in nutrition, economic stability, pest and disease control, monitoring, and research, policymakers can help ensure that the beekeeping industry remains viable. Protecting honey bee health is not only a matter of supporting beekeepers; it is essential to safeguarding U.S. agriculture, global food security, and ecosystem resilience. Coordinated action today will determine the sustainability of pollination services for generations to come.

Figures and tables

Figure 1:

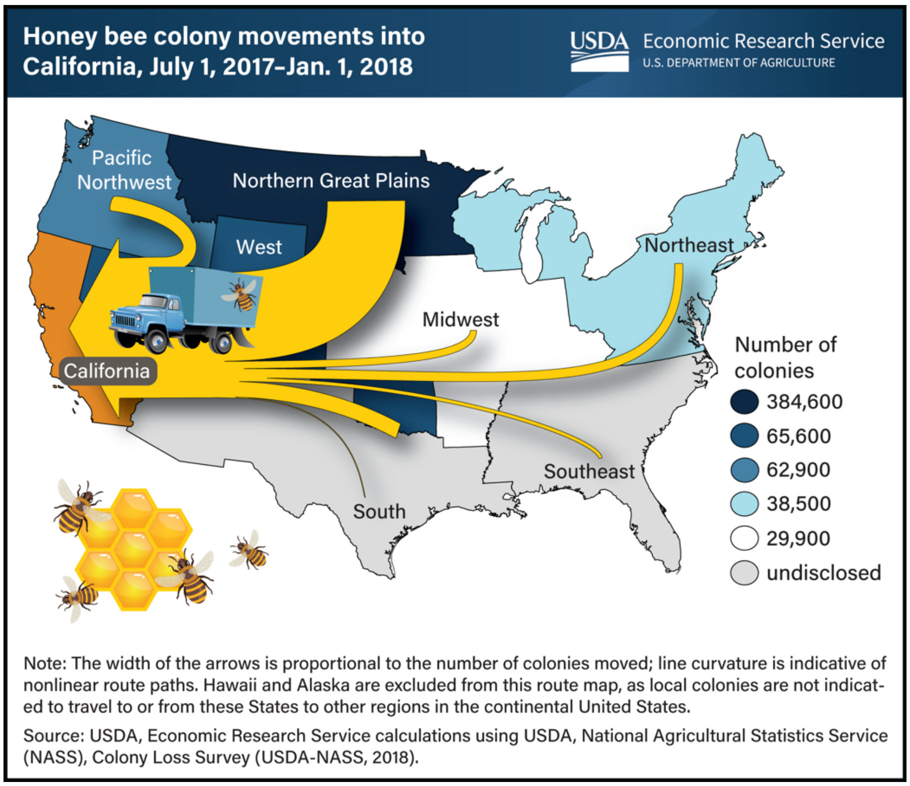

Figure 2: Visual representation of stressors impacting honey bee colony health.

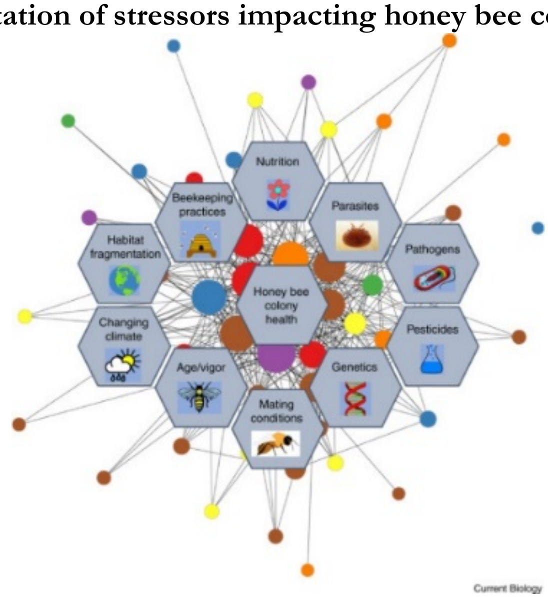

Table 1: California crops for which honey bee colonies are most commonly rented for pollination (based on the Annual CSBA Pollination Survey).

ALFALFA SEED	CARROTS	PLUMS
ALMONDS	CLOVER SEED	PLUOTS
APPLES	CUCUMBERS SEED	PUMPKINS
APRICOTS	CORRIANDER	PRUNES
ASPARAGUS	DRAGON FRUIT	PRUNES N/C
AVOCADOS	KIWIS	QUINCE
BLUEBERRIES	MELONS (WATERMELONS)	SQUASH
BUSH OR CANE BERRIES	MELONS (ALL OTHERS)	SUNFLOWERS
CHERRIES	ONION SEED	OTHER VEGETABLE SEEDS

Table 2. Table showing federally registered products as of September 1, 2025 (taken from the EPA website https://www.epa.gov/pollinator-protection/epa-registered-pesticide-products-approved-use-against-varroa-mites-bee-hives). Products in red are not registered for use in California.

EPA Registration Number	Primary Brand/Product Name	Active Ingredient (% Active Ingredient)
100908-1	**MGB2X5G Strips**	**l-glutamic Acid (25.1%)**
2724-406	**ZOECON RF-318 APISTAN STRIP**	**Fluvalinate (10.25%)**
2724-406-62042	APISTAN ANTI-VARROA MITE STRIPS	Fluvalinate (10.25%)
2724-406-79671	APISTAN VARROA CONTROL STRIPS FOR BEES	Fluvalinate (10.25%)
11556-138	**CHECKMITE+ BEE HIVE PEST CONTROL STRIP**	**Coumaphos (10%)**
11556-138-61671	CHECKMITE+ BEE HIVE PEST CONTROL STRIP	Coumaphos (10%)
73291-1	**API LIFE VAR**	**Thymol (74.09%)**
		Oil of Eucalyptus (16%)
		Menthol (3.73%)
73291-2	**API-BIOXAL**	**Oxalic Acid Dihydrate (97%)**
75710-2	**MITE-AWAY QUICK STRIPS**	**Formic Acid (46.7%)**
75710-3	**FORMIC PRO**	**Formic Acid (42.25%)**

EPA Registration Number	Primary Brand/Product Name	Active Ingredient (% Active Ingredient)
79671-1	APIGUARD	Thymol (25%)
83623-2	HOPGUARD3	Hop Beta Acids Resin (16%)
87243-1	APIVAR	Amitraz (3.33%)
87243-4	AMIFLEX	Amitraz (2%)
94413-3	VARROXSAN	Oxalic Acid Dihydrate (18.42%)
94424-1	ORGANISHIELD SUCROSE OCTANOATE (40%)	Sucrose Octanoate (40%)
101743-2	EZ-OX TABLETS	Oxalic Acid Dihydrate (97%)

Addendum: General Safety

Honey bees are generally not aggressive when left undisturbed. Foraging bees that are collecting nectar, pollen, water, or propolis have no nest to defend and typically do not pose a threat. In these cases, the best course of action is simply to avoid disturbing the bee and walk away. By contrast, if a hive or feral nest is encountered, it is important to leave the area quickly without provoking the colony. This guidance applies to both people and pets. Because ground vibrations from landscaping or construction equipment can agitate colonies, areas should be checked for feral nests before beginning such work.

Southern California Considerations

In Southern California, extra caution is warranted due to the prevalence of unmanaged *Apis mellifera scutellata* hybrids, often referred to as Africanized honey bees (Zarate et al. 2022). Unlike European lineages typically used in managed beekeeping, these hybrids swarm more frequently and exhibit heightened defensiveness. While beekeepers actively requeen colonies with European stock to maintain gentle behavior, unmanaged colonies may still display defensive traits.

If confronted by a defensive colony and pursued by guard bees, the recommended response is to run immediately from the area, shielding the head and face, and seek shelter in an enclosed space such as a vehicle or building (Texas Apiary Inspection Services).

Stings and Medical Response

When stung, the stinger should be removed as quickly as possible by scraping with a flat, stiff object such as a credit card, rather than pinching with fingers, to avoid injecting more venom. The affected area should then be washed if possible. Honey bee stings release an alarm pheromone that can attract additional bees, so rapid removal from the area is essential.

Reactions to bee stings vary. Most individuals experience localized swelling, redness, and discomfort, but a small percentage of the population, estimated by USDA at less than 1%, may experience severe allergic reactions, including anaphylaxis. For individuals with known allergies, carrying an epinephrine auto-injector (EpiPen) prescribed by a physician is strongly advised.

Swarms and Structural Colonies

Swarms are a natural part of the honey bee reproductive cycle and may temporarily settle in visible clusters. Colonies may also take up residence inside structures. In either case, individuals should not attempt removal themselves. Instead, contact a local beekeeper or swarm removal service for assistance. A directory of resources can be found at Bee Swarm Removal.

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Additional resources:

USDA Resources

- **USDA National Agricultural Statistics Service (NASS)**
  - Honey Bee Surveys and Reports
  - Bee and Honey Inquiry Survey & Annual Honey Report
  - Colony Loss Survey & Honey Bee Colonies Report
  - Cost of Pollination Survey & Report
- **USDA Farm Service Agency (FSA)**
  - Honey Bee Fact Sheet
- **USDA APHIS**
  - Honey Bee Survey Project Plan
- **USDA Agricultural Research Service (ARS)**
  - Bee Safety Resources – Carl Hayden Bee Research Center

Industry & Nonprofit Resources

- **Almond Board of California**
  - Pollination
- **Honey Bee Health Coalition**
  - Habitat and Nutrition Program
  - Honey Bee Nutrition Guide: Supplementary Feeding Guide (2024)
  - Farmers for Monarchs USDA Recommendations (2022)
- **Project Apis m**
  - https://www.projectapism.org/

State & Regional Resources

- **Texas Apiary Inspection Service**
  - Africanized Honey Bees
- **California Apiary Protection Act**
  - California Food and Agricultural Code – Apiary Protection