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Abstract

Driven by growing consumer demand for fruits, nuts, and vegetables, U.S. growers are expanding their cultivation of these pollinator-dependent crops. To service the rising number of pollination contracts and seek out quality forage to produce honey, beekeepers move their bees around the country. Limited nationwide data exist on the number of honey bee colonies that pass through each State throughout the year, the routes these colonies take, and the distances traveled. Using data from a USDA survey of beekeepers, this report quantifies honey bee colony movements over the four seasons and provides a basis for understanding how the transport of honey bee colonies affects pollination services, honey production, and the loss of colonies. The intensity of the use of pollination services across a variety of pollinator-dependent crops in various regions and States is also summarized to explain the timing and volume of colony movements.

Keywords: honey bees, honey, pollination, pollinator, honey bee colonies, *Apis mellifera*, Conservation Reserve Program, beekeepers, almonds, forage, U.S Department of Agriculture, USDA, Economic Research Service, ERS

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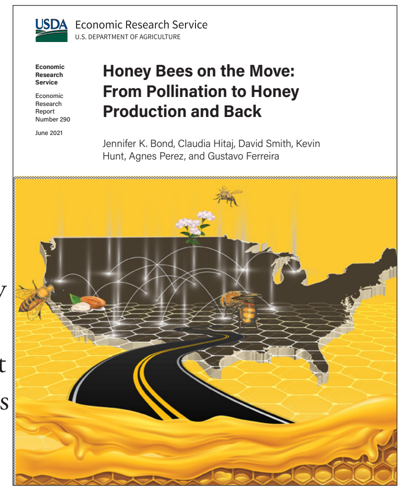


What Is the Issue?

The production of many fruits, nuts, and vegetables depends on pollination services provided by honey bees (*Apis mellifera)*. In recent years, increased demand for these crops has resulted in growing production and rising demand for pollination services. To provide pollination services and produce honey, many beekeepers transport their colonies (also called hives) around the country during the year. Limited nationwide data exist on the number of honey bee colonies that reside in or pass through each State throughout the year, the routes these colonies take, and the distances colonies are transported.

Using data from USDA, National Agricultural Statistics Service's survey of beekeepers, this report describes connections between colony movements, pollinated crop production, and forage availability. This study also quantifies honey bee colony movement patterns and distances, providing a basis to understand how the transport of honey bee colonies influences the provision of pollination services, honey production, and colony loss. Estimates of the varying intensity of pollination service use across crops and regions are also derived.

What Did the Study Find?

Honey bee colonies travel along seasonal routes across the United States. This travel is driven by the provision of pollination services (valued at roughly $250 million to more than $320 million annually); the search for forage to produce honey (valued at about $330 million annually); and the need to enhance colony survival and growth. These movements highlight the link between the production of pollinated nuts, fruits, vegetables, and seeds—especially in California—and access to the rich forage resources of the Northern Great Plains, including acreage enrolled in the Conservation Reserve Program (CRP).

- From winter (January 1, 2017) to summer (July 1, 2017), beekeepers transported about 30 percent of all U.S. commercial honey bee colonies into the Northern Great Plains from other States. After summer and as the weather turns colder, most hives are moved out of the Northern Great Plains and into warmer States in the Southern United States, including California, to overwinter. During the survey period, about 5 percent of all hives in the United States overwinter in the Northern Plains.

- From summer (July 1, 2017) to winter (January 1, 2018), the major flow of honey bees is into California (figure 1). By far, the largest share of colonies that moved into California by January came from the Northern Great Plains (63 percent). Two adjacent regions, the West and Pacific Northwest, are also important sources of colonies for California at 11 and 10 percent. A further 6 percent of colonies came from the Northeast.

- The intensity of pollination services used varies widely by crop, across regions, and even within the same crop family in different locations, helping to explain variations in seasonal colony transportation patterns.

- Almonds, the seventh most valuable crop in the United States at approximately $5.6 billion, represent the largest pollination service market for honey bees. California almond producers alone accounted for 80 percent of payments for pollination services during 2017.

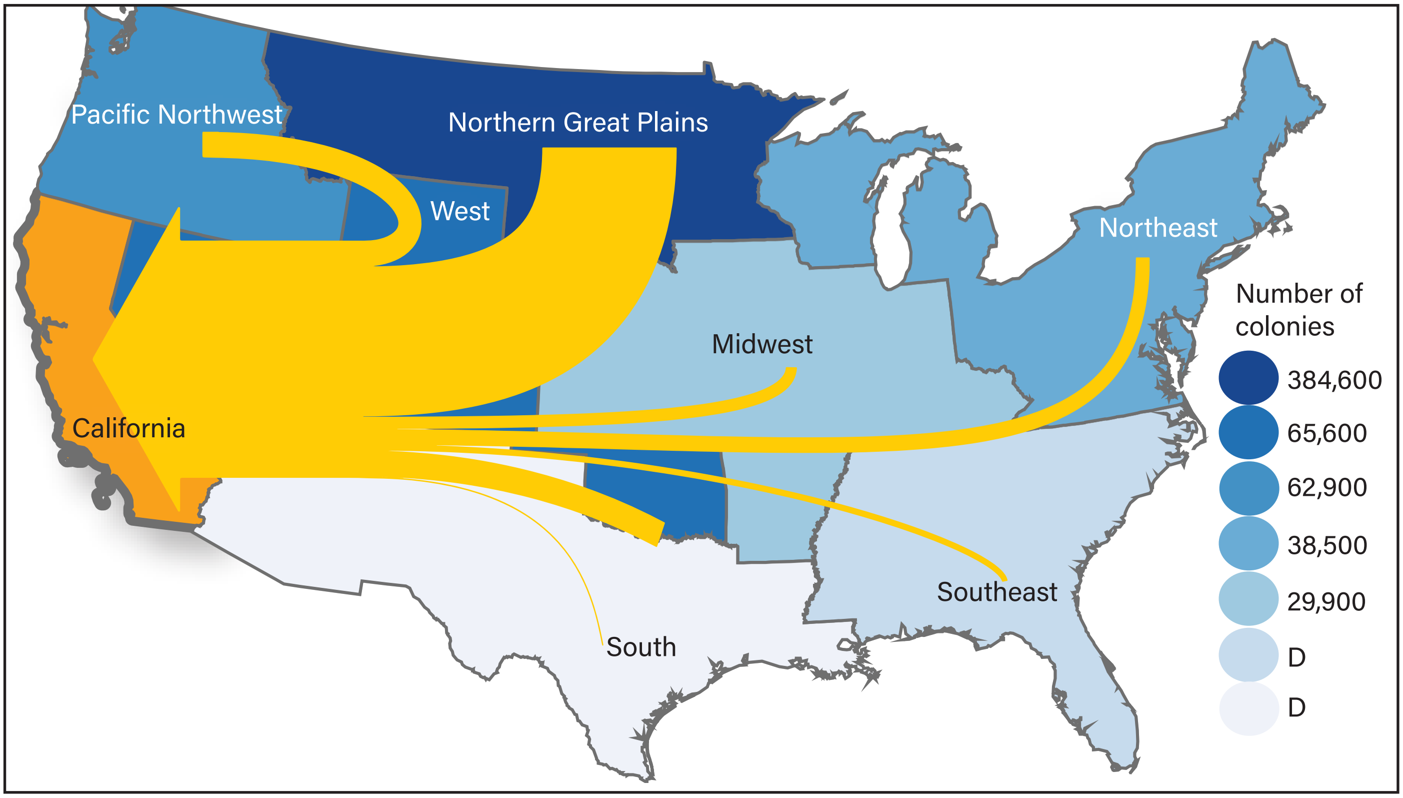
- Flowering grasslands in the Northern Great Plains, which includes Minnesota, Montana, North Dakota, and South Dakota, feature a relatively high concentration of Conservation Reserve Program (CRP) acreage. About 21 percent of the Nation's CRP land is in the Northern Great Plains, and CRP land in this region is highly suitable foraging ground for pollinators.

- Good forage resources are typically associated with higher volumes of honey production. Between spring and summer, the number of honey bee colonies in the Northern Great Plains—which is especially valued for its honey bee forage resources—more than quadruples. North Dakota alone typically accounts for nearly one-fifth of the total value of U.S. honey production.

- The declining availability of forage land that is highly suitable for honey bees contributes to the increasing cost of beekeeping. Rising beekeeping costs are at least partially passed on to pollination-dependent crop producers via increased pollination service fees.

- Long-distance transportation of colonies for pollination services and honey production is associated with increased colony stress and loss, as honey bees cannot forage during transport and may be subjected to excessive heat or cold, depending on the season. Transportation stress can be mitigated with enhanced management strategies.

Figure 1
Honey bee colony movements into California, July 1, 2017-January 1, 2018



Notes: D—Estimate is not shown to avoid disclosing data for individual operations. The width of the arrows is proportional to the number of colonies moved; line curvature is indicative of non-linear route paths. Hawaii and Alaska are excluded from this route map as local colonies are not indicated to travel to or from these States to other regions in the continental United States. Orange colored areas represent the predominate destination of transported honey bee colonies, in the indicated time period.

Source: USDA, Economic Research Service calculations using USDA, National Agricultural Statistics Service (NASS), Colony Loss Survey (USDA-NASS, 2018).

How Was the Study Conducted?

When in use, the USDA, National Agricultural Statistics Service (NASS) Colony Loss Survey collected honey bee colony data quarterly, including the number of colonies located in each State at the start of each quarter. This data was used to construct colony movement across States between quarters. This study also uses information on payments for pollination services from NASS' Cost of Pollination Survey, the value of honey production from NASS' Bee and Honey Inquiry Survey, and data from the NASS 2017 Census of Agriculture. Statistics for 2017 are used for consistency between the Census of Agriculture and other NASS surveys.

Honey Bees on the Move: From Pollination to Honey Production and Back

Introduction

The pollination of up to one-third of the world's food crops depends at least partially on insects—including managed honey bees (***Apis mellifera***) and more than 20,000 species of native bees (Berenbaum, 2007; Crane and Walker, 1984; Droege and Packer, 2015). Some crops, such as almonds and melons, require pollination to produce nuts or fruit. For other crops, such as tomatoes, apples, blueberries, cherries, and canola, pollination boosts yields and can improve produce quality (Burlew, 2019; USDA-ARS, 2017). Farmers growing crops that depend on animal-mediated pollination either rely on native pollinators, provide their own bees, or pay beekeepers for pollination services, or a rely on a combination.

Over the past decade, the pollination services market has grown, such that beekeepers now receive about as much of their income from providing pollination services as from producing honey (USDA-NASS, 2021). Beekeepers transport their honey bees around the country to meet the pollination demand from farmers, whose crops flower at different times during the year, while also securing time for the bees to produce honey in areas rich in forage, such as the Northern Great Plains.

Honey bees face a variety of stressors to their health. These stressors include Varroa mites and other pests, diseases, pesticide exposure, and lack of forage (Mullin et al., 2010; Otto et al., 2016; Paudel et al., 2015; Smart et al., 2016; Spivak and Le Conte, 2017). Beekeepers also note that long-distance travel is a stressor to honey bee health (Melicher et al., 2019). Honey bees can succumb to these stressors, such that the entire colony (or hive) dies. Overwinter colony loss rates in the pre-Varroa mite era (late 1980s) were anecdotally estimated at around 15 percent (Burgett et al., 2010; Pernal, 2008; vanEngelsdorp et al., 2007) or 17-20 percent (Johnson, 2010). In the subsequent Varroa mite era, beekeepers in the United States lost about 31 percent of colonies in the 2017-18 winter and 38 percent of colonies in the 2018-19 winter (BIP, 2019). However, the total number of honey-producing colonies increased from a low of 2.3 million colonies in 2008 to 2.8 million colonies in 2018, despite the rise in colony loss rates (USDA-NASS, 2019a). Intensified colony management and the creation of new colonies by splitting hives and purchasing new queens has supported this increase (Alaux et al., 2010; Ferrier et al., 2018; Grünewald, 2010).

Despite the importance of honey bees to fruit, vegetable, nut, and seed production, limited nationwide data exist on the number of honey bee colonies that pass through each State or region in the course of a year, the routes these colonies take, and the distances colonies are transported throughout the year. This information is critical to understanding how travel affects pollination services, honey production, and colony loss. However, data collection efforts are hampered by the scope and scale of data to be collected, as well as, the highly mobile nature of the beekeeping industry. In particular, increasing demand for both fruits and nuts that require pollination and honey (USDA-ERS, 2017; USDA-ERS, 2018) provides incentives to keep productive honey bees on the move. This movement challenges data collection, as pollination services are often provided in one State (e.g., almonds in California) while foraging activities that support commercial honey production, often take place in another location or even State (e.g., grasslands in North Dakota). As the demand for pollination services grows, so do the links between these regions (Champetier et al., 2019b).

The interdependence of crop pollination in one State on forage resources in another has potential implications for Federal policy. For example, USDA's Conservation Reserve Program (CRP)—which is concentrated in the Northern Great Plains Region where 30 percent of beekeepers bring their honey bee colonies in the summer—gives farmers incentives to take sensitive land out of agricultural production and plant species that improve environmental quality. Beekeepers actively target CRP land when selecting apiary sites partly because of the abundance of floral resources and lack of pesticide exposure associated with lands enrolled in some CRP programs (Gallant et al., 2014; Otto et al., 2018; Ricigliano et al., 2019). Accordingly, honey bee pollinator-supporting CRP acreage in one region can help support the production of pollinator-dependent crops in another region (Ricigliano et al., 2019). The 2018 Agricultural Improvement Act, also known as the 2018 Farm Bill, raised the CRP enrollment cap from 24 million acres in fiscal year (FY) 2018 to 27 million acres in FY 2023, potentially increasing the amount of forage available to honey bees and other pollinators.

While there is much anecdotal evidence on the pollination routes taken by beekeepers, until now there has been no quantitative analysis of honey bee colony movements beyond those targeted toward supporting the California almond pollination market (Goodrich et al., 2019). Bond et al. (2014) provided a qualitative analysis of pollination routes, determined mainly through conversations with beekeepers and USDA's Natural Resources Conservation Service (NRCS). However USDA's National Agricultural Statistics Service (NASS) (USDA-NASS, 2018) survey of beekeepers facilitates the tracking of colony movements by quarter and State for an entire year, providing a comprehensive, quantitatively-based picture of where commercial hives travel.

Background

Honey bees are social insects that live together as a colony, typically consisting of a single queen bee, tens of thousands of female worker bees, and hundreds of male drones. In addition to honey bees, a handful of other managed insects provide pollination, including leaf-cutting bees (non-honey producing bees) and bumble bees, which are largely used in greenhouses. The contribution of wild pollinators, such as butterflies, moths, birds, bats, and more than 20,000 species of native bees, is significant (Droege and Packer, 2015). As opposed to wild pollinators, honey bees can be managed by a beekeeper who provides the woodenware (e.g., boxes and frames for hives), manages honey collection, treats for diseases and mites, and controls colony size and numbers through hive size manipulations.

Historically, wild pollinators and locally managed honey bees pollinated nearby crops (Walker, 2020). The increase in field size and practice of monoculture means that large growers are less able to rely solely on wild pollinators, which require diverse forage resources and nesting habitat and have a shorter flight radius than honey bees for their pollination needs (MacDonald et al., 2013). Almond orchards are an example of large-scale monoculture of a pollinator-dependent crop. Over the last four decades, as the almond industry underwent significant expansion, demand for pollination services grew. At the same time, U.S. honey prices were trending lower—and an increasing number of beekeepers had incentives to shift focus from lower-value honey production towards providing potentially higher-value pollination services (Champetier et al., 2019a). The California almond bloom typically takes place when hives are overwintering in forage. Thus, the transport of honey bees, the rise in the demand for commercial honey bee services, and the expansion of California almond acres are all closely linked (Goodrich, 2019a; Bond et al., 2014).

The movement of honey bee colonies around the country is driven primarily by two factors: The demand by crop growers for pollination services in different parts of the country, and beekeepers' demand for forage to produce honey and ensure overwinter survival of colonies. Farmers who plant crops that require or benefit from supplemental pollination, such as almonds, typically pay beekeepers to pollinate their crops. After pollinating one crop, the beekeepers typically transport their colonies to the pollination service job, often apples or cherries which are in bloom nearby following the almond bloom, or move their colonies to landscapes that provide forage. For this second reason, the demand for good forage to produce honey drives beekeepers to move their colonies after crop pollination season to forage-rich areas of the country where honey can be produced, and the colony numbers can grow before the next pollination season begins.

Honey Bees Provide Pollination Services for Geographically Diverse Crops

While some growers maintain their own honey bee colonies, many growers rely on renting hives from commercial beekeepers. Beekeepers transport their honey bees around the country to meet pollination demands from farmers, whose crops flower at different times during the year. Pollination season starts with almond pollination in February, when upwards of 68 percent of all commercial U.S. honey bee colonies are used in California to pollinate almonds (Goodrich et al., 2019; USDA-NASS, 2018).

In 2017, U.S. farmers paid $320 million for pollination services (USDA-NASS, 2017). Almond producers alone accounted for 80 percent of that amount while the apple and blueberry industries paid almost $10 million each. In 2019, pollination service fees are estimated by USDA, NASS to total $309 before falling to an estimated $254 million in 2020, with almond pollination fees still accounting for the bulk of fees (USDA, NASS, 2020). Beekeeper revenue generated directly from the provision of pollination services varies considerably across regions and States, a function of the intensity of use of pollination services, fees charged (typically on a per colony/hive basis), and concentrations of crops produced (table 1).

The scale and early timing of almond pollination requires a large-scale effort by beekeepers to bring colonies out of dormancy and quickly replenish bee stocks to meet contractual obligations. Almond acreage has increased rapidly over the past decade, and pollination service fees for almonds have risen in response, partly because beekeepers must come from further afield to meet the growing demand for honey bees from California almond growers (see box on Almond Pollination Service Fees) (Goodrich et al., 2019). Also, while most crops require one strong colony per acre for adequate pollination, almond trees require two colonies per acre (Champetier et al., 2019a; Phillips, 2019). The combination of these factors contributed to the rising cost share of almond pollination. Pollination services fees accounted for about 7 percent of a representative almond orchard's costs of production in 1998 and have risen to close to 16 percent in 2018 (Champetier et al., 2019a). The pollination cost share is comparable to that for irrigation, which averaged about 16 percent in 2018 and is slightly less than the harvest cost share of 20 percent (Champetier et al., 2019a).

Supply and demand drive the pollination fees charged by beekeepers. Influential factors include the distance commercial bee colonies must travel to service a pollination contract, the length of time colonies are rented, and the marketability of the resulting honey production, all of which varies by crop (Bond et al., 2014; Goodrich, 2019a; Rucker et al., 2012). For example, honey produced from almond pollination is generally lower value as it tends to be bitter and is considered to be non-palatable for direct human consumption (though it does have some commercial use as an ingredient in brewing and baking). In part, beekeepers charge higher fees to pollinate almond orchards to compensate for the generally lower commercial value of the resulting honey that is produced. Higher fees are also charged for almond pollination in order to partially offset the higher costs associated with preparing hives to pollinate the crops relatively early-season bloom time that takes place between January to late March (Bond et al., 2014).

Table 1
Estimated beekeeper revenue generated from pollination services, by State where pollination occurred, 2017

State	Pollination revenue ($1,000)	State	Pollination revenue ($1,000)	State	Pollination revenue ($1,000)
California	271,505	Alabama	395	Oklahoma	127
Washington	12,638	Missouri	389	Connecticut	109
Michigan	4,410	New Mexico	341	Vermont	99
Oregon	3,891	Indiana	334	New Hampshire	84
Wisconsin	3,240	Virginia	332	West Virginia	79
Florida	3,032	Illinois	329	Montana	67
Georgia	2,479	Utah	311	Iowa	42
Texas	2,076	Minnesota	301	Nebraska	32
Massachusetts	1,948	Maryland	290	Kansas	27
Maine	1,795	Ohio	263	South Dakota	17
New York	1,623	Arkansas	220	Rhode Island	14
North Carolina	1,500	Idaho	196	Nevada	11
New Jersey	1,324	Delaware	191	Hawaii	5
Arizona	1,229	Tennessee	163	Wyoming	4
Pennsylvania	776	Kentucky	154	North Dakota	3
Mississippi	525	Colorado	141	Alaska	1
South Carolina	406	Louisiana	133		

Note: The Cost of Pollination Report (USDA-NASS, 2017) gives beekeeper pollination revenue only at the regional level. Beekeeper pollination revenue (equivalent to the cost of pollination services paid by crop producers) by State was estimated using the average cost of pollination per acre from the Cost of Pollination Report (USDA-NASS, 2017) and data on bearing and planted acres by crop in each State from the Census of Agriculture (USDA-NASS, 2019b). Since not all growers pay for pollination services, we multiply State crop acreage by the average ratio of paid pollinated acres to total acres for each pollinated crop in the region. This adjusted crop acreage number is then multiplied by the region-level average cost of pollination per acre for the specific crop to yield the total cost of pollination for each crop in each State. The figure above shows total estimated pollination revenue in each State.

Sources: USDA, Economic Research Service calculations based on USDA, National Agricultural Statistics Service (NASS) Cost of Pollination Report (USDA-NASS, 2017) and Census of Agriculture (USDA-NASS, 2019b).

California leads all States in total fees crop producers paid beekeepers for pollination services, with growers paying more than $270 million to beekeepers for pollination in 2017. Washington and Michigan are the second- and third-largest source of pollination service fees at $12.6 million and $4.4 million. These States are associated with a large share of berry and tree fruit production for which fruit set is enhanced via commercial pollination. Melons (e.g., cantaloupe, honeydew, and watermelon) are grown mainly in the South and California. Demand for pollination services for these crops draws colonies to these regions each spring.

Regional pollination service trends track closely with State-level findings (table 2). Regions 6 and 7, which includes California—by far the State that spends the most on pollination—spent more than 10 times the amount of any other region on pollination services in 2017 and accounted for 85 percent of total service fees paid. While the combined number of acres pollinated in regions 6 and 7 is significantly higher than other States and accounts for 64 percent of total pollinated acres, the total amount spent on pollination services is greatly magnified by the relatively high average service fees per colony. In regions 6 and 7, the average price per colony in 2017 is estimated at $146.20 and is nearly double the next highest average fee of $74.30 per colony paid in region 1.

Table 2

Total amount paid for pollination services in 2017 by region[1]

Region	Total acres pollinated (acres)	Price per acre (dollars)	Colonies used (colonies)	Price per colony (dollars)	Total cost of pollination (1,000 dollars)
Region 1	232,850	62.40	221,500	74.30	16,450
Region 2	91,200	55.70	106,600	56.20	5,990
Region 3	50,500	55.50	150,300	45.50	6,843
Region 4	7,350	36.10	18,100	47.20	855
Region 5	245,150	65.20	333,800	50.10	16,726
Regions 6 and 7	1,122,250	239.00	1,865,300	146.20	272,740
U.S. Total	**1,749,300**				**319,604**

[1]Notes: Region 1 includes Connecticut, Illinois, Indiana, Iowa, Kansas, Massachusetts, Maine, Michigan, Nebraska, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, and Wisconsin.

Region 2 includes Alabama, Delaware, Georgia, Kentucky, Maryland, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia.

Region 3 includes Arkansas, Florida, Louisiana, Missouri, Mississippi, New Mexico, Oklahoma, and Texas.

Region 4 includes Colorado, Minnesota, Montana, Nevada, North Dakota, South Dakota, Utah, Wyoming; Region 5 includes Alaska, Idaho, Oregon, and Washington.

Regions 6 and 7 includes Arizona, California, and Hawaii.

Source: USDA, Economic Research Service calculations based on USDA, National Agricultural Statistics Service data.

Crop Dependency for Commercial Honey Bees for Pollination Varies Greatly by Crop and Region

A diverse array of crops benefit from commercial pollination services that are employed to enhance production. Individual crop physiology and other factors influence the level of dependency on commercial honey bees to ensure proper fertilization by transferring pollen from flower stamens to the flower stigma (USDA, ARS, 2017). Among the other factors that influence a crop's dependency on honey bees are:

- the degree to which abiotic (not living) processes, such as wind, are available and effective in pollinating a particular crop,
- the accessibility of substitute pollination aides such as bats, wasps, butterflies, or mechanized and hand pollination, and
- the prevalence of less pollinator-dependent cultivars (such as self-pollinating almond trees).

Growers will generally use managed pollinators when wild pollinators and other abiotic processes are not enough to support the desired level of pollination (Narges and Lippert, 2019). Based on data from USDA, NASS' Cost of Pollination Report, dependency-influencing factors vary by region. These factors support varying levels of demand for commercial pollination services, not just in aggregate (as noted above), but also for specific crops (table 3). For example, the share of apple-bearing acres that pay for pollination services ranges from a high of 75 percent (region 1) to a low of 36 percent (region 4).

Table 3

Percent share of bearing or planted acres that pay for pollination services (top row) and average pollination service fee paid per colony (bottom row), by crop in U.S. dollars, 2017

	Northeast Region 1	Southeast Region 2	South Region 3	Midwest and Mountain Region 4	Pacific Northwest Region 5	Pacific Southwest Regions 6 and 7
Almond						88% $171
Apple	75% $71	71% $52		36% $50	70% $52	56% $45
Blueberry	60% $77	71% $56	47% $58		67% $45	44% $106
Cantaloupe		50% $64	58% $55			67% $45
Cherry	77% $57			55% $31	71% $53	80% $71
Cranberry	80% $78				100% $75	
Cucumber	45% $67	60% $51	14% $16			21% $40
Peach		8% $40			73% $46	
Pear					58% $56	
Pumpkin	15% $76	28% $67	73% $52			
Raspberry					56% $33	92% $44
Squash	26% $68	46% $47	37% $29			
Watermelon	34% $78	51% $60	42% $56		99% $50	91% $39
Total	**57%** **$74**	**49%** **$56**	**37%** **$46**	**45%** **$47**	**69%** **$50**	86% $146

Notes: Bearing acres refer to mature orchard tree acreage, while planted area describes row crop sowings. The top number is the share of acres that use pollination services while the bottom number refers to the average service fee paid per colony.

Results are reported using the same regions as in the USDA, NASS Cost of Pollination Report. Those regions are numbered 1-7. Northeast (region 1) includes Connecticut, Illinois, Indiana, Kansas, Massachusetts, Maine, Michigan, Nebraska, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, and Wisconsin.

Southeast (region 2) includes Alabama, Delaware, Georgia, Iowa, Kentucky, Maryland, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia.

South (region 3) includes Arkansas, Florida, Louisiana, Missouri, Mississippi, New Mexico, Oklahoma, and Texas.

Midwest and Mountain (region 4) includes Colorado, Minnesota, Montana, Nevada, North Dakota, South Dakota, Utah, and Wyoming.

Pacific Northwest (region 5) includes Alaska, Idaho, Oregon, and Washington.

Pacific Southwest (regions 6 and 7) include Arizona, California, and Hawaii.

Source: USDA, Economic Research Service calculations based on USDA, National Agricultural Statistics Service data.

The shares noted in the table could be considered similar to a measure of the dependency of a specific crop, in a particular region, on commercial honey bees to facilitate pollination. This measure is comparable to other "dependency ratios," such as those published by Morse and Calderone (2000). Our measure contributes to the literature by considering regional variation in the intensity of pollinator use by crop, as opposed to reporting a national average level of commercial pollinator dependence. Further, our measure compares the number of acres known to be pollinated (from USDA, NASS' 2017 Cost of Pollination Report) with the number of bearing or planted acres (from the USDA, NASS Census of Agriculture) in the same region, returning the share of bearing (mature orchard tree) or planted (row crop) acres that paid for pollination by crop and by region. It should be noted that our ratio is calculated for crops produced in 2017 and represents a snapshot in time. The intensity of use of pollination services likely varies from year to year, based on fluctuating agronomic and economic conditions. Considering this expectation, improved measures of dependency on pollination services should be averaged over a period of years. It is also recognized that the intensity of use of pollination services is distinct from the relative attractiveness of agricultural crops for nectar and pollen gathering by pollinating insects. For insights into the relative attractiveness measures, please see the USDA report *Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen* (USDA, 2017).

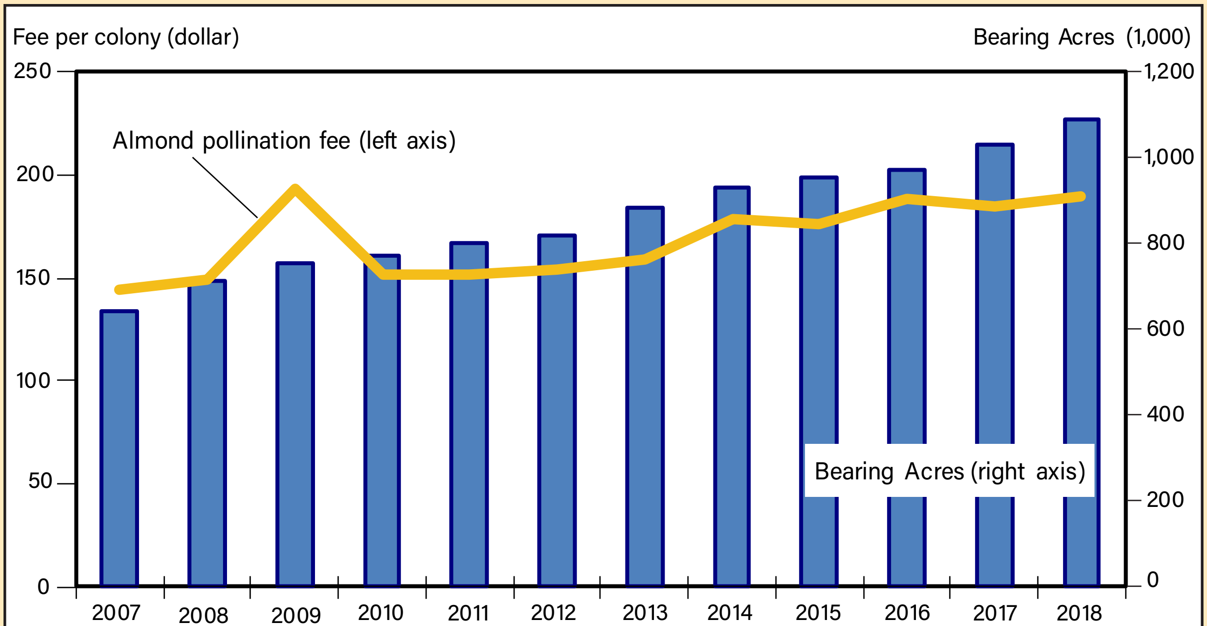
The regional differences in intensive use levels are likely attributable to several factors—both economic and environmental. Apple pollination service fees in region 1 are the highest of all regions and are nearly $20 per colony higher than for the next most expensive region. Pollination fees are likely higher in this region as apple producers in region 1 are likely to be competing for hives from the far-larger area (in terms of bearing acres) of apple and pear production in the Pacific Northwest (region 5). Hive availability may also be a factor, as well as the relative availability of wild pollinators.

Other crops with large regional variation in the share of paid pollination acres include peaches (ranging from 8-73 percent), pumpkins (15-73 percent), watermelons (34-99 percent), and blueberries (44-71 percent). Across all regions, it is expected the supply of wild pollinators and local honey bees is likely to influence how many honey bee colonies need to be transported from outside the area. Generally, for specific crops and regions that indicated a low level of dependency on commercial pollination services, the associated pollination fee is relatively low. Some examples of this are cucumbers in regions 3 and peaches in region 2.

Almond Pollination Service Fees

Almond bearing acres reached nearly 1.1 million in 2018 (figure 2)—up from 710,000 acres in 2008—representing a 54-percent increase in the last 10 years. In 2018, the rental fee for a single honey bee colony for almond pollination ranged between $165 and $210, with an average rate of approximately $190 (California State Beekeepers Association, 2019). This is a significant increase from the $76 per-colony rental rate for almonds in 2006 (Bond et al., 2014) ahead of a hike in rental rates in 2017. Rental rates also depend on colony strength or the number of bees in a colony with strong hives (measured by frame counts), commanding a premium over smaller hives. Colony strength may be affected by overwinter survival rates and thus influence per colony rental rates accruing to the beekeeper. Lower strength colonies (fewer than eight frames) will bring in lower pollination service fees during the February almond bloom as pollination contracts increasingly have a strength requirement and/or per-frame bonuses (Goodrich, 2018). In a related study, Goodrich (2019b) estimates that beekeeper revenue from almond pollination will fall 16 percent for every 10 percent increase in hive overwinter mortality rates. Greater overwinter mortality rates can result in smaller hives and, all else being equal, rental rates tend to be less for smaller hives. If a beekeeper's average hive size declines because of increasing overwinter mortality rates, this can cause lower rental rates and returns. The value of almond production was more than $5.6 billion in 2017, making it the seventh most valuable crop in the United States (USDA-NASS, 2019c). The bearing acreage is projected to continue to rise, as there are approximately 300,000 non-bearing acres that will mature into almond production in the next 3-4 years (USDA-NASS, 2019d). As these non-bearing acres begin to bear almond flowers, more honey bees will be needed for pollination.

Figure 2
Pollination fees and almond bearing acres in California from 2007-18



Note: Pollination service fees are reported in nominal dollars and have not been adjusted for inflation.

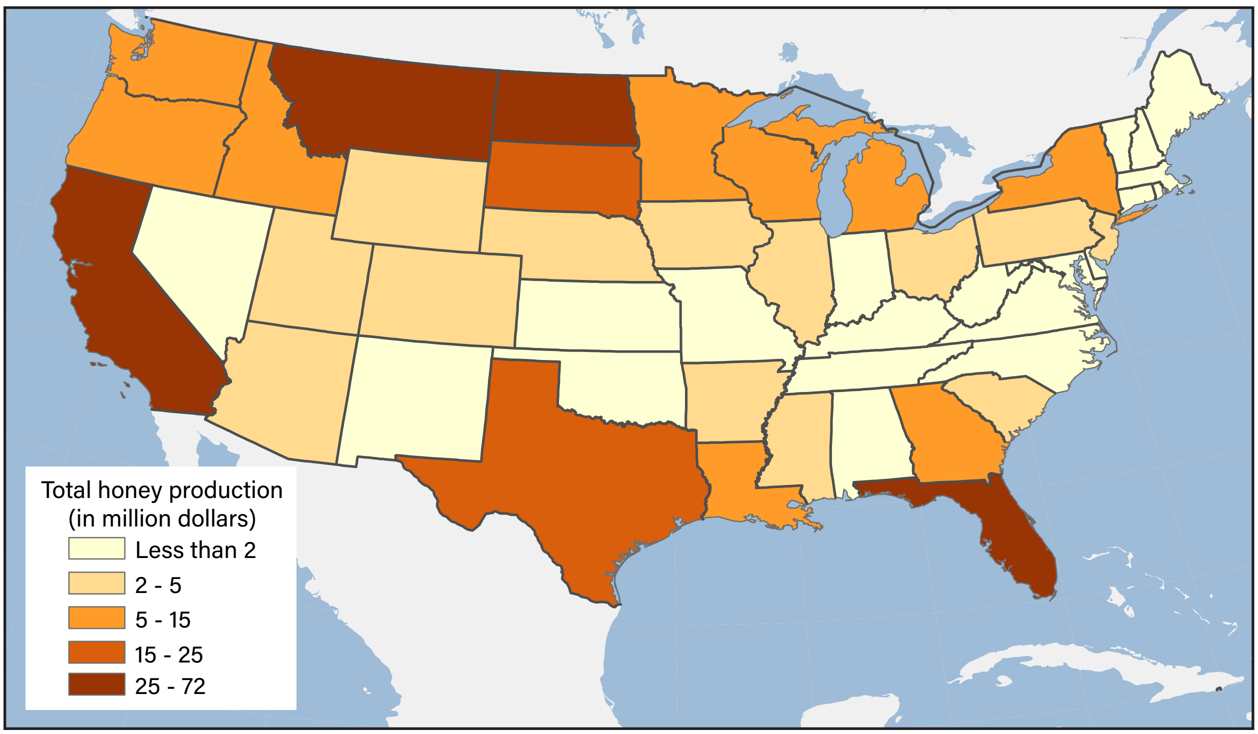
Sources: USDA, Economic Research Service calculation based on USDA, National Agricultural Statistics Service Quick Stats data; and the California Beekeepers Association.

Honey Production Linked to Forage Resource Access

Managed honey bees collect nectar and pollen from flowering plants and produce and store honey inside of hives on frames that can be removed by the beekeeper. Honey production and other products respectively provided $333 million and $95 million in revenue to beekeepers in 2018 (USDA-NASS, 2019a).[1]

While honey production and foraging activities are closely linked, colonies that provide pollination services do not always produce marketable honey. For example, the honey produced when bees forage during the almond bloom has limited commercial value. In contrast, bees that forage on clover produce a sweeter honey that consumers prefer. Honey bees feed on the honey they produce, and beekeepers must decide how much honey to pull from a colony without jeopardizing colony survival. Pulling too much honey can result in the loss of the colony or a weaker colony. To help strengthen colonies, especially during the winter months when forage resources are low, some beekeepers supplement honey supplies with feed in the form of sugar water or fondant.

Figure 3
Value of honey production by State, 2018



Note: Honey colonies that produced honey in more than one State were counted in each State where the honey was produced.

Source: USDA, Economic Research Service calculations using USDA, National Agricultural Statistics Service (NASS) data from the Honey Report (USDA-NASS 2019a).

Good forage resources are typically associated with higher volumes of honey production. North Dakota and other States in the Northern Great Plains—including South Dakota, Montana, and Minnesota—are known for their foraging grounds. A combination of a short growing season, ample precipitation, and cooler temperatures result in a burst of flowering plants over the summer that beekeepers seek out for their colonies. Not

[1]Other products included in the annual USDA, NASS Honey Report include: honey bee queens, packaged bees, and nucleus colonies.

surprisingly, North Dakota leads the Nation in honey production, while Montana, Florida, and California are also major producers (figure 3). In terms of value, more than 20 percent of U.S. honey in 2018 was produced in North Dakota. Typically, between spring and summer, the number of honey bee colonies in the Northern Great Plains has been observed to more than quadruple (table 4).

When honey bee colonies are crowded together, competition for forage resources can result in a decline in honey production and colony health (Abbott, 2018). South Dakota, Montana, Wyoming, Arkansas, and New Mexico require exclusion zones or buffer areas around registered apiary sites to protect the forage resources. During the summer months, when almost a third of all colonies are moved into the Northern Great Plains, there is a 3-mile exclusion zone in South Dakota and Montana; Wyoming has a smaller 2-mile exclusion zone and North Dakota has none. Smaller exclusion zones mean that relatively more hives can be placed to forage on a given parcel of land. This partly explains why North Dakota annually draws an estimated 40 percent of all commercial hives to the forage opportunity rich State (Smart et al., 2016).

Table 4
Honey bee colony stocks by State

State	Honey bee colonies			
	Summer (July 1, 2017)	Fall (October 1, 2017)	Winter (January 1, 2018)	Spring (April 1, 2018)
California	590	680	***1,150***	1,140
North Dakota	***470***	410	64	72
Florida	176	180	245	***270***
Montana	***154***	115	35	50
South Dakota	***152***	111	23	11
Minnesota	***136***	98	39	69
Georgia	121	125	***134***	***134***
Texas	104	127	205	***305***
Michigan	***103***	88	17	36
Oregon	94	94	***81***	41
Idaho	89	113	***164***	60
Washington	***82***	66	44	55
Wisconsin	***74***	51	21	24
Louisiana	***64***	58	50	48
New York	***59***	51	26	20
Nebraska	***46***	42	7	11
Iowa	40	***45***	41	***45***
Colorado	***35***	34	13	17
Utah	***35***	29	8	15
Wyoming	***35***	28	6	9
Other	***336***	305	260	263
United States	***2,995***	***2,850***	***2,631***	***2,693***

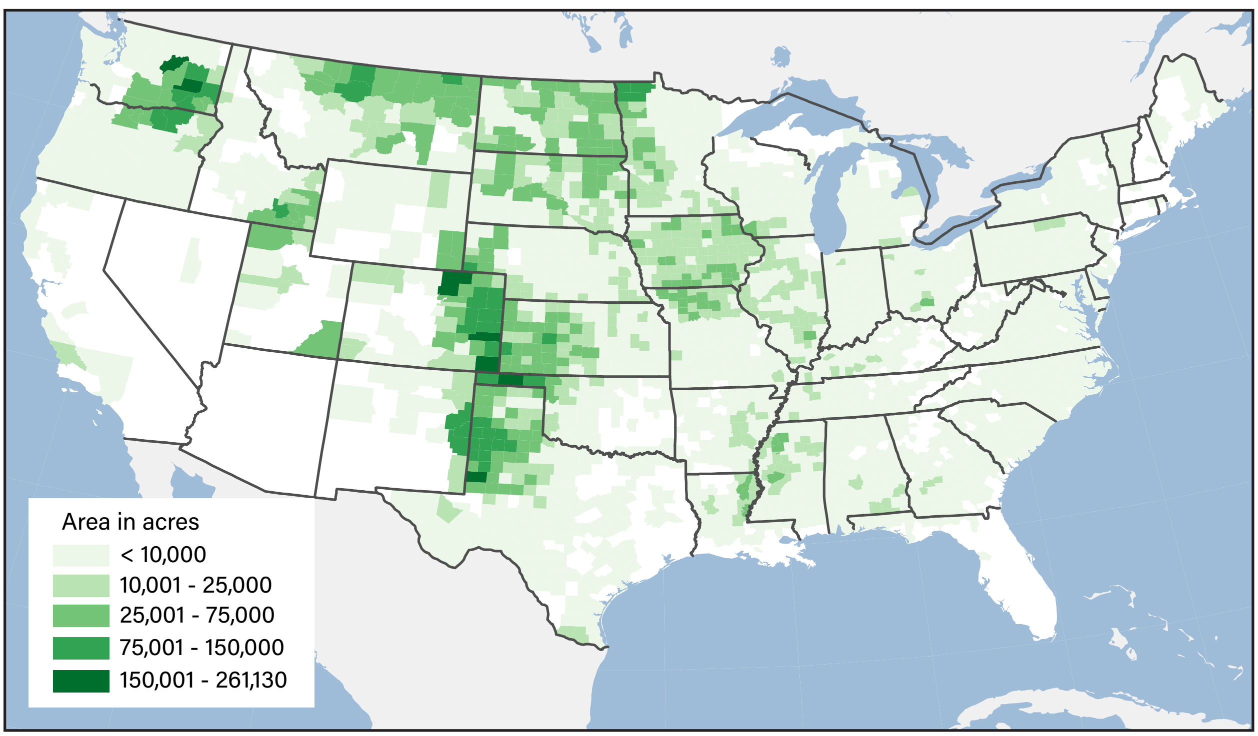
Note: Numbers in bold represent the season in each State with the most honey bee colony stocks.

Source: USDA, Economic Research Service using data from the USDA, National Agricultural Statistics Service (NASS), Honey Bee Colonies report (USDA-NASS, 2018)

The Northern Great Plains also features a concentration of acres (about 21 percent of the total) that are enrolled in the USDA, Farm Service Agency's CRP (figure 4). Some, but not all, of this CRP land is prime for honey bee forage. Beekeepers seek out places with quality forage and a low risk of chemical exposure; often, CRP land meets these criteria. Further, North Dakota is also noted for its pollinator-friendly spans of uncultivated grasslands and wetlands, especially in the Prairie Pothole Region. Smart et al. (2016) found that placing honey bee colonies on these areas of uncultivated forage land—including pasture, USDA conservation program fields, fallow land, grassland, hay land, and roadside ditches in North Dakota—had "a positive impact on annual apiary survival and honey production" relative to colonies in areas with agricultural production.

Both honey bees and wild pollinators benefit from programs that increase forage resources, such as certain practices supported under CRP. In addition to supporting the establishment of grasslands (the most common practice), USDA's Farm Services Agency also specified several pro-pollinator programs (Gallant et al., 2014; Otto et al., 2018; Ricigliano et al., 2019). The USDA, Natural Resources Conservation Service (NRCS) also has targeted conservation efforts in this area of the country and reports that 35,000 acres of land have been enhanced through their efforts (USDA, NRCS, 2016a). One such program, the USDA, NRCS Environmental Quality Incentives Program (EQIP), has 37 conservation practices that can be used by landowners to create or enhance pollinator habitat. Some practices include planting cover crops, planting wildflowers and native grasses in buffers, and improving management of grazing lands (USDA, NRCS, 2016b). The Conservation Stewardship Program (CSP) and Agricultural Conservation Easement Program (ACEP) also are aimed at helping landowners and producers to implement conservation practices, some of which benefit pollinators (USDA, NRCS, 2019).

Figure 4
Enrolled acres by county in the USDA Conservation Reserve Program, September 2018



Note: 22.6 million total acres enrolled in the USDA Conservation Reserve Program in September 2018.

Source: USDA, Economic Research Service calculations using data from the USDA, Farm Service Agency (USDA-FSA, 2019).

Following Honey Bee Colonies Through the Seasons

In 2015, USDA, NASS began surveying beekeepers with five or more colonies about colony health to build a body of knowledge on honey bees in the United States (USDA, NASS, 2018). The USDA, NASS Colony Loss Survey collects honey bee colony data from a panel of beekeepers quarterly, starting in the third quarter (the first month is July) and ending in the second quarter of the following year (the first month is April). As part of the survey, beekeepers indicate in which State their colonies were in that quarter. Combining data from multiple quarters allows for the tracking of movements of colonies by quarter and State.

The 2017 and 2018 USDA, NASS Colony Loss Survey report summarizes the quarterly responses of beekeepers to several questions, including colony locations at the time of the survey. For beekeepers who kept their colonies in the same location during a particular quarter, it is known where each of these colonies came from and where they went. A majority (97-98 percent) of the 14,532 beekeepers included in the 2018 survey report that they do not move colonies from multiple States to multiple States from quarter to quarter. For these beekeepers and colonies, it is known from which States they came and to which States they go. However, for the 2 to 3 percent of beekeepers reporting colonies in different States within a quarter, it is only known from where these honey bee colonies came if, in the prior quarter, that beekeeper only had colonies in a single State (or where they went if the beekeeper in the next quarter only had colonies in a single State).

For example, suppose a beekeeper has colonies in California, Montana, and Washington and moves them to North Dakota and South Dakota the following quarter. In that case, the data do not specify which colonies moved from California to North Dakota. To address the tracking issue with a relatively small proportion of our survey data, proportionality in colony movements is assumed. Using the example above, if beekeepers split their colonies evenly between North Dakota and South Dakota in the following quarter, it is assumed that half of all the colonies in California, Montana, and Washington moved to North Dakota and the other half moved to South Dakota. These movements are summarized by State and by region (described in table 5). Regions were chosen to be representative of the pollinated crops, forage, and colonies in these locations.

Commercial Honey Bee Movements Are Strongly Seasonal

Two events dominate the movement of honey bee colonies around the United States: An influx into California for almond pollination in February and outflow into the Northern Great Plains for access to high-quality forage in the summer. A small minority of colonies remains in the same State throughout the year. Table 5 shows the number of resident and transitory colonies in select States on the first of January (winter) and the first of July (summer). Resident colonies are those that were in the State for the first half of the year and on the indicated date, 6 months later (e.g., the hive was in the State for a full year), while transitory colonies were in different States on each survey date.

At the beginning of 2018, almost half of the colonies in California had been in California since July 1, 2017. These 540,000 resident colonies remained in California for the second half of 2017 or left and returned within that period. Further, these commercial honey bee colonies, that likely were in position to aid in the early spring almond pollination, were also available to supplement the smaller scale use of other wild and managed pollinators in the pollination of alfalfa (July), melons (August), sunflowers (August), and squash (September). Resident California colonies may also produce honey during the summer months when colonies are not foraging in almond orchards. According to the Honey Report (USDA, NASS, 2019a), honey was pulled from 335,000 colonies in California in 2018. States with the greatest summer influx of non-resident or transitory colonies include those in the Northern Great Plains, such as North and South Dakota—where 432,000 and 140,000 colonies, present on July 1, were not in those States on January 1—representing more than 90 percent of colonies in those States.

Table 5

Transitory and resident honey bee colonies in the summer and winter for select States

Region	State	Colonies on July 1, 2017 Summer		Colonies on January 1, 2018 Winter	
		Transitory (in other State on January 1, 2017)	Resident (in same State on January 1, 2017)	Transitory (in other State on July 1, 2017)	Resident (in same State on July 1, 2017)
California	California	11,100	578,800	609,900	540,000
West	Colorado	26,300	8,600	3,800	9,200
	Nevada	D	D	D	D
	Oklahoma	1,800	2,600	16,100	D
	Utah	20,200	14,800	0	7,500
	Wyoming	D	D	D	D
South	Arizona	1,300	24,700	2,800	22,100
	Louisiana	1,200	62,700	D	49,900
	New Mexico	D	D	D	D
	Texas	2,200	101,700	174,800	30,200
Southeast	Alabama	D	6,300	D	7,000
	Florida	16,100	159,900	88,900	156,100
	Georgia	7,600	113,400	29,500	104,500
	Mississippi	1,600	22,400	9,600	9,400
	North Carolina	7,000	18,900	1,200	17,200
	South Carolina	1,100	13,400	3,100	10,400
	Tennessee	1,000	9,000	D	9,300

Region	State	Colonies on July 1, 2017 Summer		Colonies on January 1, 2018 Winter	
		Transitory (in other State on January 1, 2017)	Resident (in same State on January 1, 2017)	Transitory (in other State on July 1, 2017)	Resident (in same State on July 1, 2017)
Pacific Northwest	Idaho	32,500	56,400	94,500	69,500
	Oregon	27,600	66,400	14,700	66,200
	Washington	25,700	56,300	18,800	25,200
Northern Great Plains	Minnesota	103,800	32,200	14,200	24,700
	Montana	132,900	21,100	4,100	30,800
	North Dakota	431,600	38,300	16,600	47,400
	South Dakota	139,500	12,500	8,500	14,500
Midwest	Arkansas	10,000	18,900	3,000	18,900
	Illinois	1,400	11,500	D	9,600
	Indiana	6,800	6,100	D	6,800
	Iowa	25,600	14,400	8,200	32,800
	Kansas	1,300	5,700	D	3,600
	Kentucky	1,600	7,300	600	4,900
	Missouri	400	8,600	1,100	6,800
	Nebraska	38,700	7,300	D	5,700
Northeast	Connecticut	D	2,900	D	2,400
	Delaware	D	D	D	D
	Maine	3,700	1,700	0	1,900
	Maryland	1,400	7,000	2,700	5,300
	Massachusetts	6,400	2,500	D	2,900
	Michigan	79,000	24,000	1,600	14,800
	New Hampshire	D	D	D	D
	New Jersey	7,900	8,100	500	5,900
	New York	27,800	31,100	2,100	23,900
	Ohio	4,600	18,400	600	11,400
	Pennsylvania	2,100	16,400	600	13,800
	Rhode Island	D	D	D	D
	Vermont	2,000	5,400	200	5,300
	Virginia	2,300	9,200	900	6,000
	West Virginia	3,600	5,400	1,000	3,700
	Wisconsin	52,000	21,900	1,500	19,400

Notes: D = Estimates less than or equal to 1,000 not shown to avoid disclosing data for individual operations. Data rounded to nearest 100 colonies.

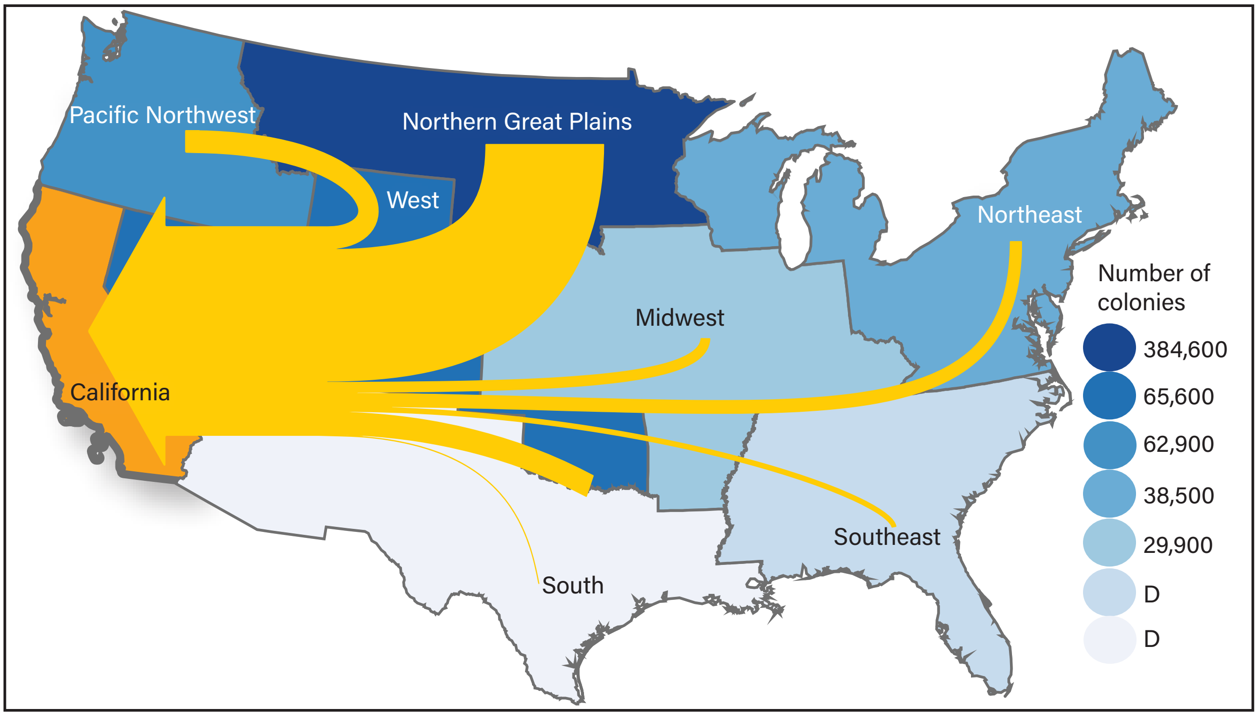
Source: USDA, Economic Research Service analysis using USDA, National Agricultural Statistics Service, Colony Loss Survey (USDA-NASS, 2018).

Figure 5 shows the movement into California from July 1, 2017, to January 1, 2018. The largest share of colonies that move into California in this time period come from the Northern Great Plains (384,600 colonies). Two adjacent regions, the West and Pacific Northwest, are also important sources of colonies for California. Almost 39,000 colonies come from as far away as the Northeast. Another dataset of honey bee colony movement into California, from the California Department of Food and Agriculture (CDFA) (2019), is discussed in the box titled Honey Bee Colonies Entering California.

Figure 6 shows the movement out of California from January 1, 2017, to July 1, 2017. Again, most colonies (473,000) moving out of California are destined for the Northern Great Plains. An additional 73,000 colonies went to the neighboring Pacific Northwest, while 51,000 more headed to the region labeled "West". In the first 6 months of the year, almost 55,000 colonies from the West Coast went to the Northeast and Southeast regions.

Figure 5

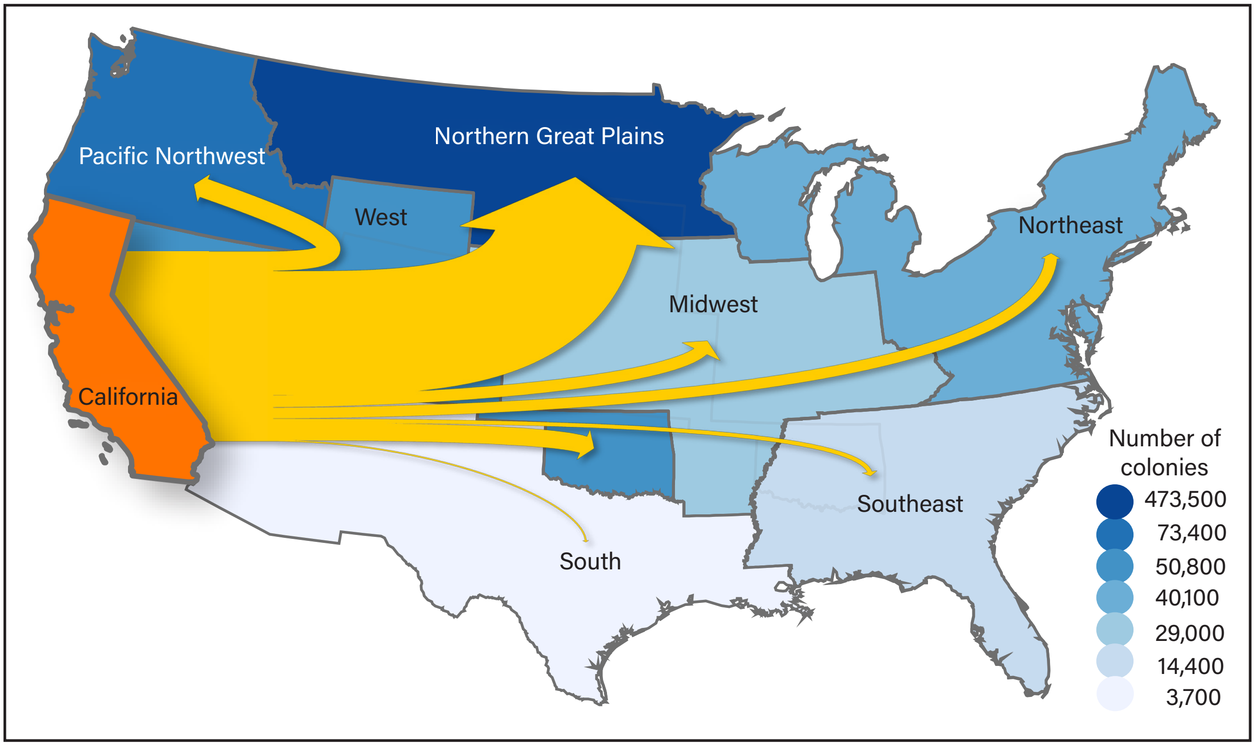
Honey bee colony movements into California from July 1, 2017 - January 1, 2018



Notes: D = Estimate not shown to avoid disclosing data for individual operations. The width of the arrows is proportional to the number of colonies moved; line curvature is indicative of non-linear route paths. Hawaii and Alaska are excluded from this route map as local colonies are not indicated to travel to or from these States to other regions in the continental United States. Orange colored areas represent the predominate destination of transported honey bee colonies, in the indicated time period.

Source: USDA, Economic Research Service calculations using USDA, National Agricultural Statistics Service, Colony Loss Survey (USDA-NASS, 2018).

Figure 6
Honey bee colony movements out of California from January 1, 2017- July 1, 2017



Note: The width of the arrows is proportional to the number of colonies moved; line curvature is indicative of non-linear route paths. Hawaii and Alaska are excluded from this route map as local colonies are not indicated to travel to or from these States to other regions in the continental United States. Orange colored area represents the origin of transported honey bee colonies, in the indicated time period.

Source: USDA, Economic Research Service calculations using USDA, National Agricultural Statistics Service, Colony Loss Survey (USDA-NASS, 2018).

Honey Bee Colonies Entering California

Honey bee colonies entering California are subject to two inspections, a cursory one at the border and a more detailed inspection at the destination (CDFA, 2019). The California Department of Food and Agriculture (CDFA) conducts the inspections and maintains records of the number of honey bee colonies entering California, as well as the State of origin. According to data from the CDFA, about 915,000 colonies entered California in the second half of 2017 (CDFA, 2019). This is more than the 610,000 colonies estimated as having entered during the same period, based on NASS data from the USDA-NASS Honey Bee Colonies report (table 4).

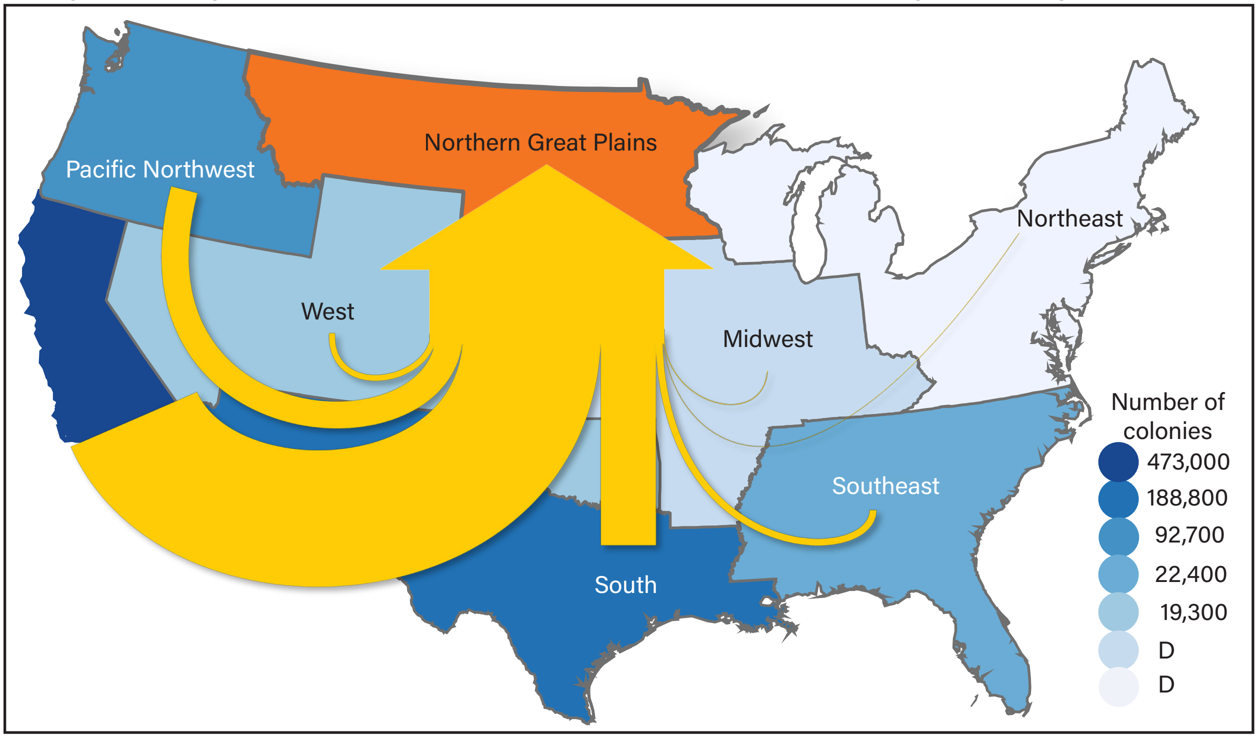
The discrepancy likely arises because only those colonies entering California before July 1, 2017 are captured. Some colonies may have left California after July 1, 2017 and re-entered sometime before the end of the year. These colonies are not captured in our estimates, whereas these colonies would be counted in the CDFA data. Our estimate of 610,000 colonies entering California in the second half of 2017 is combined with the 540,000 colonies that were already in the State. Our aggregate estimate of the total number of colonies (1.15 million) in the State matches that on January 1, 2018, published by USDA's National Agricultural Statistics Service (NASS) (USDA-NASS, 2018) and presented here in table 4.

The Northern Great Plains is one of the main destinations for honey bee colonies in the summer, and figures 7 and 8 show colony movements into and out of this area for the summer of 2017. In addition to 473,000 colonies from California, another 189,000 colonies came from Texas and other States in the South. That colonies are moved to the Northern Great Plains in the summer, despite the relative lack of demand for paid pollination services in the region, indicates that beekeepers bring the colonies mainly to forage rather than paid pollination work; the region including the Northern Great Plains accounts for less than 1 percent of total paid pollination services in 2017.

After the summer and ahead of the cold winter months, most honey bees are moved out of the Northern Great Plains and into warmer States in the South. Some honey bees can overwinter in the North in heated warehouses. Heated potato cellars—which are protected from the harsh northern weather—are an overwintering option for some colonies in some Northern States. However, not all colonies travel along these major routes into California in the winter and into the Northern Great Plains in the summer. About 58 percent of all colonies do not leave their region between July and January of the following year. Of the colonies that do move regions between July and January, 47 percent move into regions other than California. Beekeepers transported about 95,200 colonies from the Northeast into the Southeast for the winter of 2018 and another 24,500 colonies from the Northeast into the South. Finally, about 15,900 colonies from the Southeast and 11,100 colonies from the South moved into the Midwest for the summer of 2017.

Figure 7

Honey bee colony movements into the Northern Great Plains from January 1, 2017-July 1, 2017

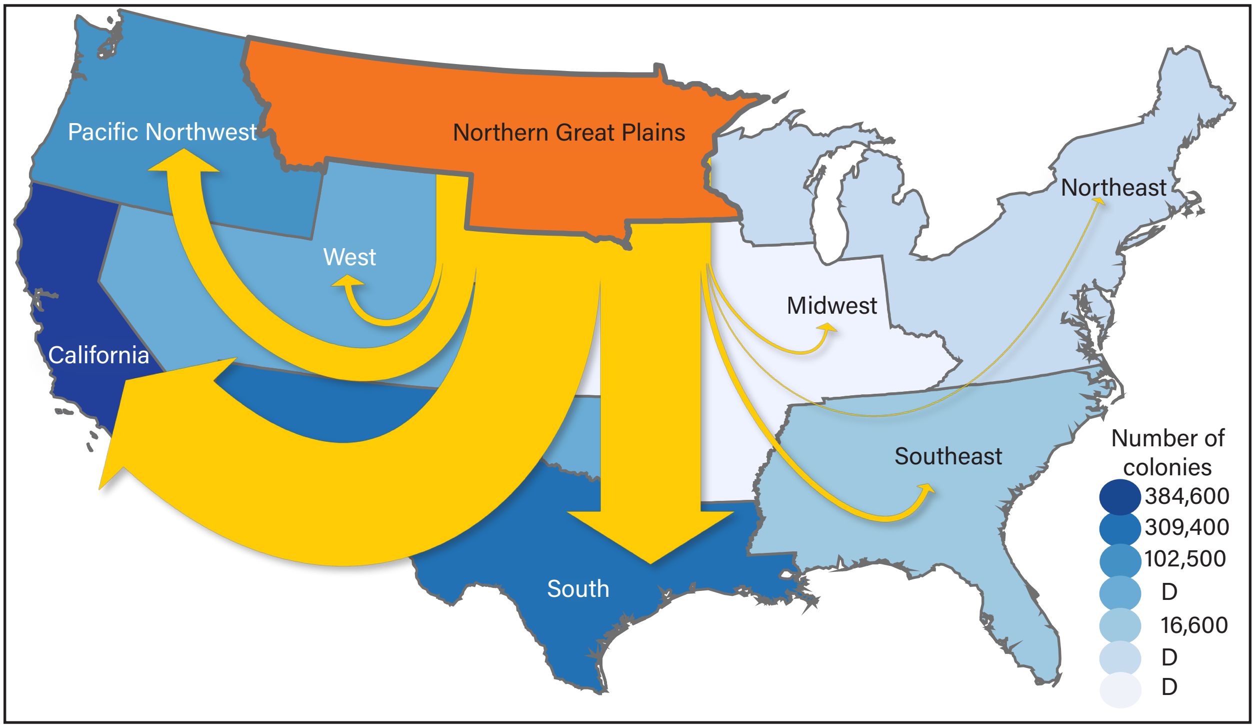


Notes: D = Estimate not shown to avoid disclosing data for individual operations. The width of the arrows is proportional to the number of colonies moved; line curvature is indicative of non-linear route paths. Hawaii and Alaska are excluded from this route map as local colonies are not indicated to travel to or from these States to other regions in the continental United States. Orange colored areas represent the predominate destination of transported honey bee colonies, in the indicated time period.

Source: USDA, Economic Research Service calculations using USDA, National Agricultural Statistics Service, Colony Loss Survey (USDA-NASS, 2018).

Figure 8

Honey bee colony movements out of the Northern Great Plains from July 1, 2017- January 1, 2018



Notes: D = Estimate not shown to avoid disclosing data for individual operations. The width of the arrows is proportional to the number of colonies moved; line curvature is indicative of non-linear route paths. Hawaii and Alaska are excluded from this route map as local colonies are not indicated to travel to or from these States to other regions in the continental United States. Orange colored area represents the origin point of transported honey bee colonies, in the indicated time period.

Source: USDA, Economic Research Service calculations using USDA, National Agricultural Statistics Service, Colony Loss Survey (USDA-NASS, 2018).

Colony Health Is Affected by Long-Distance Travel

Transporting commercial honey bees to pollination service and forage grounds often involves long-distance travel and variable environmental conditions that harm colony health (Melicher et al., 2019). During travel, honey bees are unable to access foraging resources and are instead fed supplements such as sugar water or fondant. During the summer, overheating while in transit can become a problem if the hive boxes, often transported on a flat-bed truck, are not configured for proper ventilation (Melicher et al., 2019).

Four recent studies document the biophysical effects of transportation for pollination services on honey bee health. Honey bees maturing during transportation have trouble fully developing their food glands that might affect their ability to nurse the next generation of worker bees (Ahn et al., 2012). Zhu et al. (2014) found an increase in the abundance and prevalence of the fungal pathogen *Nosema ceranae* in honey bees transported for pollination, in contrast to colonies not moved. In a set of field experiments, Simone-Finstrom et al. (2016) detected a significant decrease in the lifespan, as well as higher oxidative stress levels, in migratory adult bees relative to stationary bees. A more recent study by Melicher et al. (2019) confirms that hives experience considerable temperature stress and that this should be considered a contributing factor to annual colony losses.

To help inform research on the impact of travel on honey bee health and colony loss, in this section, the average distance traveled by colonies within quarters is estimated, as well as over the course of a year. Using distances between State centroids (mathematical mean or middle of a shape), the total distance colonies moved throughout the year can be approximated. These calculations rely on the more detailed State-to-State movement data rather than the region-to-region movement data discussed elsewhere in the report.[2] Table 6 shows the average distance traveled by a colony for various pairs of quarters from April 1, 2017, to April 1, 2018—the latest set of quarterly data available from USDA, NASS at the time this research was completed. The first column shows the average distance for the subset of colonies that were moved out of State across the pairs of quarters. The second column shows the average for all colonies, including those that remained in the same State and, therefore, assumed to travel zero miles.

The nature of the data does not allow us to calculate distances traveled by an individual commercial honey bee colony within a State nor for a full year. However, the average distance between the States in which a beekeeper moved colonies from one quarter to the next quarter can be calculated. Accordingly, the average, full-year distance traveled estimate by "All" colonies is 1,153-miles and captures both colonies that were transported during the year along with colonies that never moved (table 6). Because the total number of colonies in each State is used in the numerator, the average annual distance traveled by migrating colonies is likely higher than the 1,153 reported over all the colonies. The annual distance estimate for colonies that have moved cannot be calculated as the sum of quarterly distance estimates as colonies may have moved during one quarter but not the next. As such, the "full year" estimate of miles traveled for colonies that have been moved during at least one quarter cannot be accurately tallied.

[2]The underlying State-to-State movement data are not discernible from the national averages of distance traveled that are presented here.

Table 6

Estimated average distance traveled by honey bee colonies each quarter from April 1, 2017 to March 31, 2018

	Distance between the States where the colony was on the first day of the quarter	
	Average miles for colonies that were moved	Average miles for all colonies
April 1, 2017 – June 30, 2017	990	363
July 1, 2017 – September 30, 2017	803	113
October 1, 2017 – December 31, 2017	1,014	388
January 1, 2018 – March 31, 2018	1,031	288
Full year	-	1,153

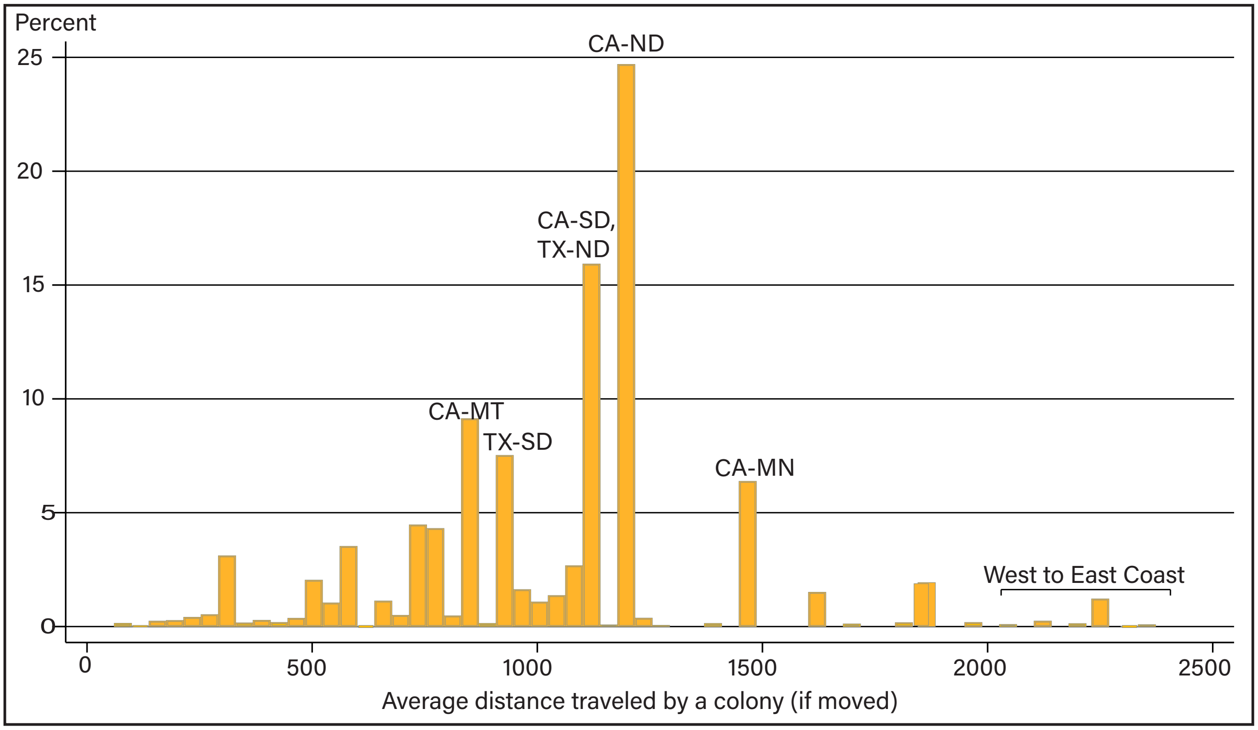
Note: "-" indicates data are not available.

Source: USDA, Economic Research Service analysis using USDA, National Agricultural Statistics Service, Colony Loss Survey (USDA-NASS, 2018).

The concentration of almond pollination in California and its location at the edge of the contiguous United States is one explanation for the long distances honey bee colonies travel throughout the year. The average distance traveled by colonies coming from various States in October 1, 2017, into California by January 1, 2018, was 1,100 miles, equivalent to a 20-hour drive at 55 miles per hour. Figure 9 shows the percent of colonies moved by the average distance traveled between January 1, 2017, and July 1, 2017. Spikes can be seen in the bars containing the distance between California and North Dakota, South Dakota, and Montana, as well as Texas and North and South Dakota. Colonies moved to the East Coast from the West Coast traveled more than 2,000 miles. Movement between States on July 1, 2017, and January 1, 2018, follows a similar pattern (figure 10).

Figure 9

Percent of honey bee colonies that were moved, by the average distance traveled between January 1, 2017-July 1, 2017

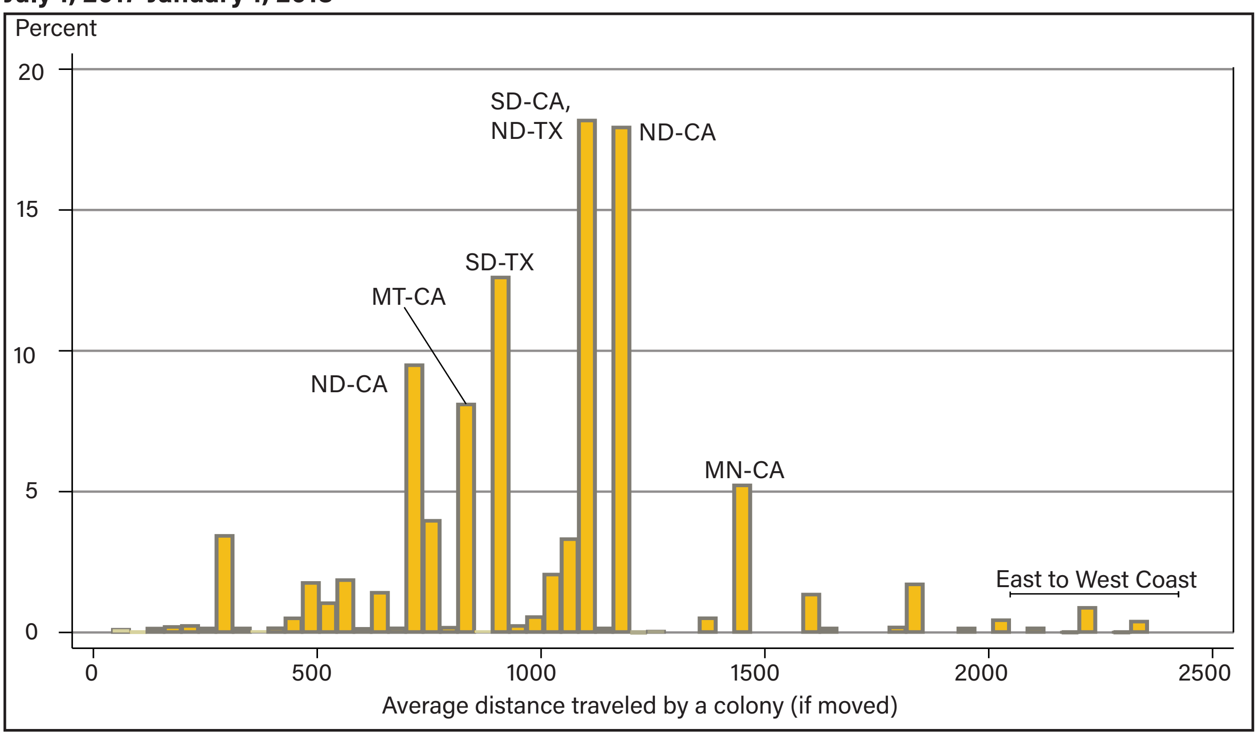


Note: CA=California, MT=Montana, TX=Texas, SD=South Dakota, ND=North Dakota, MN=Minnesota.

Source: USDA, Economic Research Service calculations based on USDA, National Agricultural Statistics Service data.

Figure 10

Percent of honey bee colonies that were moved, by the average distance traveled between July 1, 2017-January 1, 2018



Notes: WY=Wyoming, CA=California, MT=Montana, TX=Texas, SD=South Dakota, ND=North Dakota, MN=Minnesota.

Source: USDA, Economic Research Service calculations based on USDA, National Agricultural Statistics Service data.

Conclusion

Beekeepers must make complex determinations about whether, when, and where to move their honey bees to produce honey, service pollination contracts, and provide their honey bees with access to nutritious forage. Using data from USDA, NASS, our analysis is the first to quantify the seasonal flow of honey bees, as hives are moved into and out of regions in the United States to pollinate crops and forage over the course of an entire year. Further, evidence of the intensity of reliance on pollination services is documented to vary, not just by crop as other researchers have found, but also by region. Significant variances between our survey-based rates of pollination service used and previously published crop-specific dependency ratios suggest more work is needed to better understand what factors influence farmers' decisions to employ honey bees to aid in crop pollination.

In this study, the effect of market factors on the transportation of honey bees is documented. Specifically, the demand for honey bee colonies to provide pollination services for crops is growing. This demand is driven primarily by one event, the flowering of almond trees in February in California. Almond acreage has grown 576 percent, from 710,000 acres in 2008 to 1.25 million acres in 2020. The almond bloom is estimated to employ nearly 1.5 million honey bee colonies, some from as far away as the East Coast. This movement from honey-producing regions in the summer to other areas of the country to pollinate crops means that honey bee colonies travel long distances multiple times a year. The average colony is estimated to have moved more than 1,000 miles during the 12-month period starting April 1, 2017.

The largest single source of honey bee colonies for almond pollination is the Northern Great Plains. This region provides rich forage in the summer, including large areas of CRP-enrolled grasslands and farm acreage. Beekeepers move their colonies into this region after pollinating crops in the winter and spring, such that acreage enrolled in CRP in the Northern Great Plains and other uncultivated lands can be characterized as supporting the production of honey bee-pollinated crops throughout the United States. The Northern Great Plains foraging colonies also produce nearly half of the honey produced in the United States. In recent years, however, forage in this region has declined because of increases in corn and soybean acreage and decreases in acreage enrolled in the Conservation Reserve Program (Hellerstein et al., 2017; USDA, NASS QuickStats, 2019).

Through tracking the wide-ranging seasonal flow of honey bees across the United States while noting the related stressors placed on the bees, policy discussions concerning honey bee health may be informed. Further, documentation of seasonal colony movements may be useful in the conversations centered on State, Federal, and private efforts to assess the provision of forage resources for both honey bees and wild pollinators.

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