The Estimated Impact of Bee Colony Collapse Disorder on Almond Pollination Fees

Hoy Carman

Almond pollination fees have risen sharply in recent years. This article shows that the fee increase is due in roughly equal parts to the expansion of almond acreage and the occurrence of Bee Colony Collapse Disorder.

Production of many California crops is heavily dependent on pollination by honeybees provided by commercial pollination services. The most important tree crop users of pollination services include almond, apple, avocado, cherry, kiwi, pear, and prunes/plums. Other important California crops using pollination services include alfalfa seed, cucumbers, melons (cantaloupes, honeydew, watermelons), sunflowers, and vegetable seeds.

There is a well-organized market for pollination services with beekeepers from upper midwestern, northwestern and other states, as well as California, contracting with California producers to provide bees during the bloom periods for their crops. Beekeepers typically contract their colonies (hives) for more than one crop and often move their colonies from state to state to take advantage of differing bloom periods for contracted crops.

The pollination market and production of many important crops is threatened by a phenomenon, first identified in 2005 and 2006, in which worker bees leave their colonies in search of nectar and pollen and do not return. Named Colony Collapse Disorder (CCD), this phenomenon differs from other causes of bee mortality (e.g., pathogens and parasites) in that there are no dead or dying worker bees around or in the hive—the worker bees just disappear.

While researchers are still attempting to determine the causes of CCD, the economic effects are evident. Beekeepers' costs increase, as they must replace the lost bees to fulfill their pollination contracts, and the cost increase must be passed on to the producers using pollination services for the beekeepers to remain economically viable.

Almond producers, the largest user of pollination services in California and the United States have faced sharp fee increases as a result of CCD and acreage expansion. This article estimates the separate effects of CCD and almond acreage expansion on the fees that almond producers pay for pollination services.

California Almond Production

California, with 740,000 acres of bearing almond trees in 2010, produces about 80% of the world's almonds. Approximately 70% of almond production is exported, making almonds California's largest-value agricultural export.

Almonds are also California's largest user of pollination services by a considerable margin. Estimates place some 60% of all U.S. bee colonies being used for pollination in California almond orchards during the February/March bloom period. After the almond bloom, the hives move on to other crops with a typical hive being rented two to three times during the season. Almonds were responsible for 30% of all rentals and 58% of all rental income in a 2007 Northwest survey by Burgett.

Bee Colony Requirements

University of California cost and return studies to establish and produce almonds include 2.0 hives per acre for pollination in the San Joaquin Valley (North and South) and 2.5 hives per acre in the Sacramento Valley. Literature on almond pollination requirements also typically lists a requirement of 2.0 hives per acre, with five to six frames per hive.

Thus, the total number of hives required for almond pollination is a linear function of the number of bearing acres of almonds. The number of hives required for almond pollination has, thus, increased from approximately 802,000 in 1992 (401,000 acres) to 1,480,000 in 2010 (740,000 acres)—an 84.5% increase in two decades.

California County Agricultural Commissioners' data reported 1,192,687 hives used for pollination on all California crops in 1992, growing to 1,725,070 hives in 2008. Thus, with 680,000 bearing acres in 2008, almonds accounted for almost 79% of total bee colony pollination use in California.

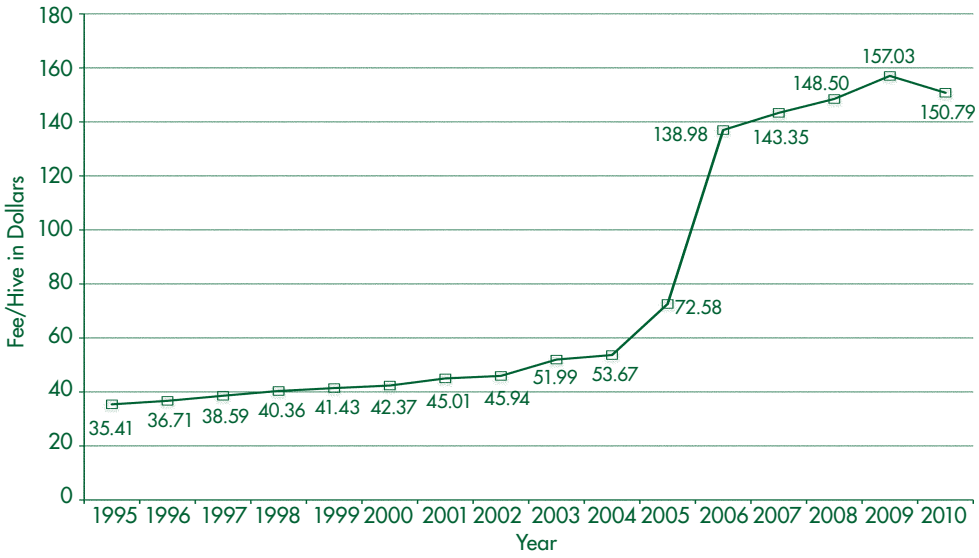
Pollination Fees

As pointed out by Sumner and Boriss, there is a well-developed and functioning market for pollination services, with fees responding to changes in the supply and demand for pollination services. Fees vary seasonally, geographically, and by crop characteristics, with valuable honey crops having fees about 50% below crops that do not provide nectar valuable for honey.

Pollination fees are highest during the almond bloom in the February/March period when hive demand is at a peak. Almonds are not a desirable source for honey production. Crops that overlap the almond bloom, including early cherries and plums, pay fees similar to almonds.

Data available from the 2010 California State Beekeeping Association Pollination Survey report an average fee per hive of $150.79 for almonds, $145.89 for early cherries, and $128.29 for plums. Average pollination fees for crops that bloom later, when supply of hives is high

Figure 1. Average Almond Pollination Fee, 1995–2010



Source: California State Beekeeping Association Annual Pollination Surveys, 1995–2010

relative to demand, are much lower than for almonds. For example, average 2010 pollination fees per hive were $25 for apples, $28.45 for melons, $29.37 for sunflowers, and $47.30 for alfalfa seed.

Average pollination fees per hive for California almonds for 1995 through 2010 are shown in Figure 1. Average fees increased from $35.41 in 1995 to $53.67 in 2004. The fees then increased to $72.58 in 2005 when CCD first became evident, and shot up $45.31 to $136.98 between 2005 and 2006.Almond pollination fees continued to increase and peaked at an average of $157.03 in 2009.

Pollination services are a growing and important cost component for almond production, recently accounting for about 20% of budgeted cultural costs per acre. We hypothesize that the two major factors associated with annual changes in almond pollination fees were (1) increased acreage of almonds, and (2) changes in overwintering bee colony losses.

Almond Bearing Acreage: California almond bearing acreage increased continually from 1995 through 2010, with the annual increase ranging from 5,000 to 40,000 acres (Figure 2). The largest increases occurred in 2007, 2008 and 2009, which was after the sharp increases in pollination fees that occurred in 2005 and 2006. Thus, while greater almond acreage increases the demand for hives, and perhaps the costs of providing them if the average distance that hives are transported increases, it does not explain the sharp increases in pollination fees in 2005 and 2006.

Overwintering Bee Losses: High winter losses of bees, regardless of the cause, impact beekeepers' costs and the supply of hives for pollination. Losses of bee colonies over the winter are expected, a loss of 15–20% to be in the usual or "normal" range. USDA reports that bee colony losses have averaged 17%–20% per year since the 1990s, attributable to a variety of factors, such as mites, diseases, and management stress.

Heavy overwintering losses were reported in 2003–2004 for many northern beekeepers. Beginning in 2005, CCD appears to be the major explanation for high winter losses. In their annual surveys, vanEngelsdorp et al reported four consecutive years of high winter losses in managed honeybee colonies in the United States. Losses totaled 32% in 2006–07, 36% in 2007–08, 29% in 2008–09 and 34% in 2009–10. The majority of beekeepers in each survey reported losses greater than what they considered acceptable. California State Beekeeping Association Annual Pollination Surveys reported winter mortality ranging from 20% to almost 30% from 2005 through 2009.

Increased loss of bees associated with CCD increases the costs of beekeeping and reduces the supply of pollination services. Beekeepers with pollination contracts must replace the lost colonies by purchasing bees to fill the empty hives. Package bees with a queen can cost over $100 per hive, depending on shipping, size of package, and type of bees. The empty beehives due to CCD are typically discovered just prior to, or as hives are being placed in almond orchards. In the scramble to secure enough hives for pollination requirements, almond producers have raised their bids for per colony pollination fees.

National surveys of overwintering bee colony losses did not occur until two years after the appearance of CCD. There are descriptions of unusually high losses in particular states or regions for years prior to 2007, but there are no national estimates of the average loss for the United States.

Estimation of an Equation for Annual Fees

While the lack of a time series for overwintering bee losses makes it difficult to determine the separate impacts of acreage increases and CCD on almond pollination fees, we can still obtain an estimate. First, we specify an equation for pollination fees as a function of bearing acreage and overwintering losses. Although we lack data on overwintering losses, we do observe that the sharp increase in pollination fees occurred when CCD was first identified as a problem.

The impact on fees of such a structural change can be estimated using a zero-one indicator variable. The equation to be estimated is:

$$\mathbf{Fee = f(BA, D)}$$

where Fee is the average annual almond pollination fee in real (2010) dollars per

hive, BA is annual California bearing acreage of almonds (1,000 acres), and D is a variable that has a value of zero for years 1995 through 2004, and a value of one from 2005 through 2010. The coefficient for D is the average annual impact of the structural change (the onset of CCD) on almond pollination fees.

Using annual data for 1995 through 2010, the estimated equation is:

Fee = -27.76 + 0.166 BA + 55.97 D
(-0.77) (2.30) (3.83)

R^2 = .90 D.W. =1.89

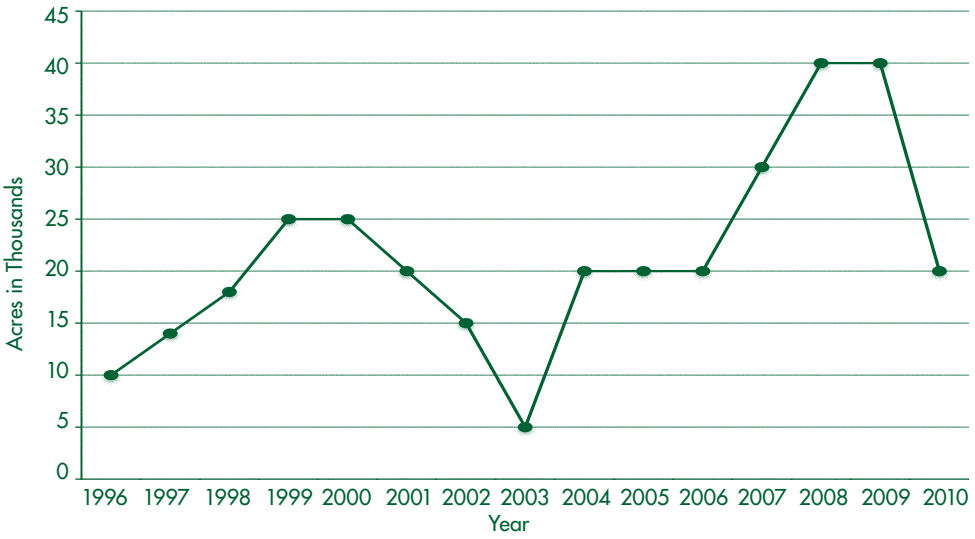
where the values in parentheses are the t-statistics for the respective coefficients, R^2 = .90 and the Durban-Watson statistic is 1.89. The R^2 statistic means that the model explains about 90% of the variation in pollination fees between 1995–2010.

The estimated coefficients have the expected signs and indicate that the annual almond pollination fee increased an average of $0.166 per hive for each 1,000 acre increase in bearing acreage. After accounting for the impact of increased acreage, the fee increased an average of $55.97 per hive during the six years since CCD was first recognized.

We can do a few simple calculations to place these estimates in perspective. California's bearing acreage of almonds increased 322,000 acres over the period of the data sample—from 418,000 in 1995 to 740,000 in 2010. With an estimated real fee increase of $0.166 per hive per 1,000 acres increase, the real fee increase due to the increase in bearing acres from 1995 through 2010 is estimated to be $53.45 in 2010 dollars. In real (2010) dollars, the almond pollination fee increased from $49.84 per hive in 1995 to $150.79 in 2010, or just over $100.

Thus, it appears that increasing almond acreage and CCD each explain roughly half of the increase in almond pollination costs. Even if CCD had not occurred or if there were a complete solution to the problem of CCD, pollination fees for almonds would probably still be in the range of $100.00 per hive.

Figure 2. California Almonds: Annual Change in Bearing Acreage, 1996–2010



This does not minimize the real costs of CCD to the California almond industry. Using an average of two hives per bearing acre and an average fee increase of $55.97 per hive due to CCD, the estimated cumulative cost to the California almond industry for the six years, 2005 through 2010, is about $445 million. From 2010 forward, given current bearing acreage and recent winter bee losses, estimated costs due to CCD total almost $83 million annually.

Concluding Comments

The appearance of CCD in commercial bee colonies in the spring of 2005 focused attention on economic problems facing beekeepers and the importance of bee pollination for the production of many fruit and vegetable crops.

This paper documents another important impact of CCD, its effect on increasing costs of production for California almonds, the largest contractor for commercial pollination services. Costs of production for California almonds increased an estimated $112 per acre annually during the first six years after CCD was identified, with CCD estimated to be responsible for about half of this cost increase. Pollination fees now account for about 20% of budgeted almond cultural costs per acre. The estimated annual cost increase of $83 million for almond production due to CCD is just a portion of the economic impact of CCD in California, given that several other crops use pollination services as well.

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Hoy Carman is a professor emeritus in the ARE department UC Davis. He can be reached by e-mail at carman@primal.ucdavis.edu.

For additional information, the author recommends:

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