U.S. Pollination Markets:

Recent Changes and Historical Perspective

by MICHAEL BURGETT[1], STAN DABERKOW[2], RANDAL RUCKER[3], and WALTER THURMAN[4]

Acknowledgements: The authors acknowledge the assistance of Eric Mussen and Daniel Sumner in providing the California pollination fee data used in this report. Fritz Baird provided valuable research assistance.

Key Words: Managed beekeeping industry, pollination rental fees, honey income, pollination income, California almond industry, Colony Collapse Disorder.

Introduction

This article is the second of two to discuss trends in honey and pollination markets in the United States. The first focused on honey, discussing historical data on colony numbers, honey yields, aggregate honey production, imports and prices. The present article focuses on pollination markets: their defining characteristics, fees received by beekeepers, the size of the colony rental market in the United States, pollination income relative to honey income for the past two decades, and the growing importance to the managed beekeeping industry of California almond pollination in the spring. We also discuss the economic impacts of the latest "disease" to affect beekeepers—Colony Collapse Disorder—as well as pollination market conditions for the 2009 almond crop.

The sources for much of the information presented here are annual Oregon State University (OSU) surveys of beekeepers in the Pacific Northwest (PNW) and an annual survey of beekeepers conducted by the California State Beekeepers Association. The OSU survey has been conducted since 1987 by one of the authors {MB}, and the results of each of those surveys have been summarized in annual publications in *Honey Market News*. In the past five years, Burgett's survey has received responses from beekeepers who own (on average) 52 percent of the managed honey bee colonies in Oregon and Washington (based on annual estimates of colony numbers by the USDA). The California survey, which was modeled to some extent after the PNW survey, dates back to 1995.

Defining Features of Pollination Markets

Markets for pollination are unique in several respects. The flowering period for pollination is limited for most crops, and in some cases, colonies must be removed from the fields shortly after pollination to allow for the treatment of the crop with pesticides toxic to bees. Moreover, crops in different parts of the country require pollination at different times, with the brief pollination windows typically being later for crops grown at higher latitudes and altitudes. These features of crop pollination have encouraged the development of a migratory managed pollinator industry. Those who choose the livelihood of a mobile pollinator face considerable logistical management challenges. Nonetheless, a robust migratory pollinator industry has evolved, aided by the interstate highway system and an efficient trucking industry, and spurred on by the significant economic incentives of pollination fees.

An important feature of the industry is the considerable economies of scale available to mobile pollinators, who can use the same bees to pollinate several crops over the course of a crop year. Semi-commercial beekeepers (defined here to be less than 300 colonies) typically concentrate on honey

Table 1. Migratory Pollinators' Annual Rental activities

Year	Annual Rentals per Hive		PNW Rental Activities	
	PNW	California	Crops/Year	Counties/Year
1989			4.24	5.03
1990				
1991			4.34	5.06
1992	2.51		7.76	
1993	2.82		8	
1994	2.74		6.06	6.06
1995	2.61		5.33	6.16
1996	3.05	1.67	5.06	4.71
1997	2.95	1.77	5.88	
1998	2.74	1.66	5.4	
1999	2.74	1.85	5.1	6.53
2000	2.32	1.60	5.09	6.91
2001	1.91	1.41	4.67	6.4
2002	1.74	1.30	4.19	6.69
2003	2.37	1.82	5.17	8.5
2004	1.92	1.51	5.8	8.38
2005	2.25	1.63	4.43	5.5
2006	2.05	1.68	5.53	8.33
2007	2.54	1.55	5.71	6.83
2008	1.91	1.66	6.92	10.5
Average	2.42	1.62	5.51	6.77

1 Emeritus Professor of Entomology, Department of Horticulture, Oregon State University, Corvallis, OR 97331
2 Daberkow and Associates, University Park, MD.
3 Professor, Department of Agricultural Economics and Economics, Montana State University, Bozeman, MT 59717-2920
4 Professor, Department of Agricultural Economics, North Carolina State University, Raleigh, NC 27695-8190.

production, primarily because their scale of operations is not large enough to economically move colonies long distances.[5]

Consistent with this, the PNW surveys reveal that commercial beekeepers rely on pollination to a much greater extent than do semi-commercial beekeepers. Over the 1989-2008 span, commercial beekeepers received on average 63 percent of their income from pollination, while semi-commercial beekeepers received on average 32 percent of their income from pollination. Further, whereas there is no significant trend in the percentage of income from pollination for commercial beekeepers, there is a significant downward trend in this percentage for semi-commercial beekeepers. The data also indicate that since 1994, the semi-commercial beekeepers have earned on average more income from honey than from pollination in every year. Commercial beekeepers, on the other hand, have reported a larger percentage of their income coming from pollination than from honey in every year since 1989.

[5] **Semi-commercial and commercial is the taxonomy used in the annual reports of the PNW survey. Other researchers have used other taxonomies, with a common breakdown being hobby (1–25 colonies), part-time (25-300 colonies), and full-time (more than 300 colonies) beekeepers. Hoff and Willett (1994) discuss issues related to economies of scale and mobile pollination operations.**

Supply Factors

A basic determinant of the supply of pollination services is the number of managed honey bee colonies. In our previous article (Daberkow et al. 2009), we presented U.S. Department of Agriculture data indicating that the number of colonies has declined over time. A change in the survey methodology used by the USDA in the mid-1980s makes it difficult to draw conclusions regarding the actual extent of the long-run decline in colony numbers. Since the mid-80s change, however, the inventory of colonies has fallen by roughly 25 percent.

Holding other factors constant, a reduction in colony numbers will lead to a reduction in pollination services. But the quantity of pollination services from a given number of colonies is not fixed. Beekeepers make tradeoffs between the quantities of honey they produce and pollination services they provide. Pollination arrangements often call for placement densities that are too high to yield commercial quantities of honey (and typically require supplemental feeding of the bees). Further, movement of colonies from orchard to orchard and field to field places stress on the bees and reduces their honey productivity. Thus, a reduction in honey prices, or an increase in pollination fees, can induce beekeepers to shift their emphasis from honey to pollination, resulting in an increase in pollination services supplied—and a reduction in the quantity of honey produced.

Another factor affecting the quantity of pollination services from a given quantity of colonies is the number of pollination sets for which each colony is used. The number of pollination sets increases with the willingness of beekeepers to move their colonies from their home bases to distant orchards and fields. The migratory aspect of beekeeping has been well-documented. The national migratory calendar begins with movement of colonies into California during December and January in anticipation of almond pollination during February and March. For at least the last 15 years, a considerable number of beekeepers have migrated to California from the Pacific Northwest to pollinate almonds. More recently, in response to dramatic increases in almond acreage and almond pollination fees, more beekeepers have migrated to California, some from as far away as the East Coast.

After the almond crop is pollinated, some colonies (primarily those that are California-based) then pollinate other crops in California. Colonies whose home base is in the Pacific Northwest migrate back north and pollinate such crops as apples, pears, cherries, cranberries, and blueberries. Other colonies are moved to the Northern Plains and Lake States primarily for honey production in the nectar-rich fields of alfalfa, clover, and sunflowers.

On the eastern side of the continent, another important migration occurs starting in the Southeastern states, then moving northward along the East Coast for apple, cranberry and blueberry pollination. In the fall,

Table 2. Value, acreage, and estimated colony rentals for major crops that require or benefit from pollination.[a]

Crop	Major Producing States	Colonies per Acre	Crop Value 2000	Crop Value 2007	Crop Acreage 2000	Crop Acreage 2007	Colony Rentals 2000[m]	Colony Rentals 2007
			$1,000		Acres		Number	
Almond	CA	2.5	908,090	2,360,254	510,000	615,000	1,275,000	1,537,500
Apple	WA, NY, MI, PA, CA	1.5	1,799,344	2,434,626	433,650	363,440	650,475	545,160
Melons, all	CA, FL, TX, AZ, GA, IN	1.5	963,249	884,772	315,410	272,240	473,115	408,360
Cucumber, all	MI, FL, GA, NC, CA	2	520,012	402,199	163,510	155,020	327,020	310,040
Alfalfa seed	CA, ID, WA, OR, NV						220,000	220,000
Avocado	CA	2.5	451,529	327,122	65,220	73,250	163,050	183,125
Cherry	WA, MI, OR, CA	1.5	446,196	634,565	103,330	118,250	154,995	177,375
Plum/prune	CA, OR, WA, MI, ID	1	336,718	214,257	128,110	105,370	128,110	105,370
Blueberry	MI, ME, NJ, OR, GA, NC	2	303,205	597,921	40,820	52,120	81,640	104,240
Pear	CA, WA, OR	1.5	355,103	351,260	66,910	59,530	100,365	89,295
Squash, all	GA, MI, CA, FL, NY	1.5	286,517	231,008	56,800	56,600	85,200	84,900
Vegetable seed	CA, OR, WA						55,000	55,000
Pumpkins	IL, OH, PA, CA, MI	1.5	119,474	119,294	41,000	47,100	61,500	70,650
Sunflower	CA, TX, MN						45,000	45,000
Cranberry	WI, MA, NJ, OR, WA	1	137,410	284,194	37,200	38,800	37,200	38,800
Macadamia nuts	HI	2.5	40,194	21,931	17,700	15,000	44,250	37,500
Specialty citrus	FL	0.5	113,613	90,133	37,400	21,100	18,700	10,550
Kiwifruit	CA	2.5	18,922	22,862	5,300	4,000	13,250	10,000
Total (value and acreage for food crops only)			6,799,576	8,976,397	2,022,360	1,996,820	3,933,870	4,032,865

[a] Sources for table entries available from authors.

Table 3. Real (2008 dollars) average pollination fees per colony for selected California crops, 1995-2008[a]

Year	Almonds	Plums	Cherries, early	Cherries, late	Alfalfa Seed	Avocados	Vegetable Seed	Watermelon	Melons, Other	Sunflowers	Apples	Prunes
1995	$58.96	$57.45	NA	NA	$39.45	NA	$32.27	NA	NA	$24.14	$22.23	$12.90
1996	$58.05	$57.84	NA	NA	$37.99	$31.23	$33.57	NA	NA	$23.45	$20.29	$15.32
1997	$60.62	$57.68	NA	NA	$39.58	$35.89	$30.76	NA	NA	$23.22	$19.67	$14.89
1998	$64.72	$61.11	NA	NA	$45.25	$39.51	$34.34	$36.67	$32.39	$26.59	$28.25	$15.46
1999	$67.48	$61.79	NA	NA	$47.07	$44.63	$44.54	$34.86	$31.13	$24.56	$25.77	$16.64
2000	$65.89	$58.38	NA	NA	$43.42	$39.79	$37.68	$36.90	$32.84	$26.68	$23.63	$15.55
2001	$68.62	$66.25	NA	NA	$42.89	$36.38	$34.96	$28.10	$28.01	$24.85	$30.42	$13.98
2002	$67.74	$65.12	$60.31	$23.41	$40.27	$39.87	$30.35	$40.68	$32.14	$25.40	$20.78	$15.71
2003	$74.21	$65.06	$59.88	$26.49	$37.13	$36.81	$30.19	$30.01	$23.91	$25.12	$20.81	$31.94
2004	$72.67	$68.80	$63.95	$24.29	$37.37	$33.48	$28.72	$35.47	$39.09	$26.61	$21.55	$11.14
2005	$92.83	$95.48	$91.82	$33.80	$47.58	$51.64	$39.65	$48.06	$28.85	$30.85	$32.04	$19.18
2006	$166.06	$107.05	$150.32	$43.54	$41.78	$36.46	$40.57	$31.11	$26.85	$31.72	$26.23	$17.96
2007	$162.86	$133.50	$148.55	$30.92	$43.48	$39.19	$37.06	$33.71	$26.92	$30.32	$23.47	$17.74
2008	$148.50	$55.95	$86.13	$36.99	$43.33	$44.01	$40.34	$40.29	$25.98	$30.60	$23.54	$13.99

[a]Source: California State Beekeepers Association survey. Prices are deflated using the Index of Prices Paid by Farmers, Commodities, interest, taxes and wage rates, 2008=100 (found at www.nass.usda.gov webpage).

a reverse migration flow occurs as beekeepers move colonies into milder climates for over-wintering.

Quantitative insights into migratory pollination are provided in Table 1. In California, the average number of pollination rentals per hive for the years 1996-2007 is 1.62 and there is no evidence of a significant trend in this variable. It appears from the available data (discussed in more detail below) that almost all California commercial beekeepers pollinate almonds. Following that, on average between one-half and two-thirds of colonies are used to pollinate one more crops. In the Pacific Northwest, the average number of rentals per hive for the years 1992-2008 is larger, at 2.42 pollination sets per colony–about 50 percent higher than in California.

These numbers mask, to some extent, the complexity of beekeeper migration. Available data from the PNW surveys suggest that on average, over the time span of the data, an individual beekeeper contracted to pollinate 5.5 different crops per year. Moreover, they contracted to pollinate crops in an average of 6.8 counties per year. Thus, while a typical *colony* in the PNW pollinates almonds and then is used to pollinate another 1.4 crops, a typical PNW *beekeeper* contracts with almond growers in one or more counties in California and then with producers of four or five more crops distributed across several counties in Washington and Oregon.

Another important pollination supply factor is the rate of winter mortality. All else equal, an increase in winter mortality leads to a reduction in the supply for pollination. From the mid-1980s until recently, the "normal" winter mortality rate increased as a result of the North American arrival of two devastating species of honey bee mite parasites (*Acarapis woodi* and *Varroa destructor*). Recent research suggests that since the winter of 2006/07 mortality has increased again, as a result of Colony Collapse Disorder. (See Burgett et al. 2009, for a historical perspective on these mortality increases.) Beekeepers can and do, however, regularly replace lost overwintered colonies. The predominant method, at least in the PNW, is to split existing colonies. Purchasing package bees to re-populate dead colonies is a less frequently used alternative.[6] Furthermore, with the exception of a period during the late 1980s, a limited supply of queens and packaged bees have been imported from Canada for a number of years and since 2004, New Zealand and Australia also have been permitted to export bees to the United States. These methods increase the supply of pollination services—but at a cost—which one might expect to be reflected in the prices for pollination services.

Demand Factors

Pollination is an important input in the production of numerous economically significant crops. Table 2 lists crops that are major demanders of pollination services, as well as the major producing states for the crops. It also lists recommended colony densities, and for both 2000 and 2007, pollinated crop values and acreages, as well as estimates of the number of colony rentals. The values of production for the pollinated crops in Table 2 have had the effects of general inflation netted out and are expressed in terms of 2008 dollars. For 2007, the total value of the crops was nearly $9 billion, which represents an increase of 34 percent in inflation-adjusted terms over 2000. Other specialty crops, less dependent on insect pollination and not included in the table, would add to the crop values. With only a few exceptions, such as alfalfa seed and sunflower seed, the crops listed in Table 2 are not considered good nectar sources. Moving colonies multiple times during the year among a number of nectar-limited sites does rarely yield sufficient honey for sales or even over-wintering.

Although the total acreage of the pollinated crops in Table 2 has not changed much since 2000, almond acreage has increased substantially and almonds are clearly the dominant crop influencing demand for pollination services—certainly for California and PNW beekeepers, but nationally as well. Of the roughly 4 million rentals reported in the table for 2007, almonds account for 38 percent of the total, with apples a distant second at about 14 percent. Although the total estimated number of colony rentals has changed little, the importance of almonds in pollination rental markets has increased since 2000, when they accounted for about 32 percent of total rentals.

Forecasts of almond acreage by the Almond Board of California suggest nearly a doubling of acreage from around 400,000 acres in the late 1990s to almost 850,000 acres by 2012 (Sumner and Boriss, 2006, Table 2). Assuming a hive density for pollination of 2.5 per acre, almond colony rentals would need to increase to over 2 million colonies to pollinate that number of acres. Based on the 2008 colony estimate for the United States of 2.30 million and almond acreage of 660,000, almond pollination required about 72 percent of all U.S. colonies during the 2008 almond pollination season. If colony numbers remain constant and the almond acreage projections are realized, by 2012 almonds will require over 90 percent of all U.S. colonies during the early spring pollination season.[7]

Pollination Fees

Average pollination fees from the annual surveys of California and Pacific Northwest beekeepers are shown in Tables 3 and 4. The fees in the tables, deflated to correct for inflation, are expressed in terms of 2008 dollars. Looking first at almonds, it can be seen that fees increased gradually through 2004. After that, almond pollination fees reported by both California and Pacific Northwest beekeepers increased rapidly—more than doubling in real terms. It is noteworthy that CCD was first reported in the Fall of 2006, but that fees for almonds increased sharply in the spring of 2006, prior to the initial re-

6 See Burgett et al., 2009 and van Engelsdorp et al., 2007 for additional discussion of these replacement methods.

7 In figure 1 of our previous article on honey markets we presented data indicating that colony numbers have actually fallen over time. See Daberkow, Rucker, Thurman, and Burgett (2009).

ports. Figure 1 displays almond acreage and prices. The rapid increase in almond pollination fees is likely due in part to increased almond acreage, which likely resulted from substantially increased almond prices (the average real price of almonds for 2003–2006 was almost double the price for 1999–2002.)

Tables 3 and 4 also reveal that pollination fees for most pollination-dependent crops in California and in the Pacific Northwest have not risen nearly as sharply in recent years as have almond fees. Exceptions to this are plums and early cherries in California, both of which require pollination at about the same time as almonds, implying that producers must compete directly with almond producers for colonies.[8] Table 3 shows the considerable increases in pollination fees for plums and early cherries from 2004 to 2007, roughly in line with pollination fees for almonds.

To what extent has the increased demand for pollination from almond producers affected pollination fees for other crops? An examination of Tables 3 and 4 reveals that although pollination fees for most other (later season) crops increased following 2004, none of them increased as dramatically as almond fees. Moreover, whereas almond fees remain high relative to pre-2005 levels, no comprehensive statement can be made regarding the level of other pollination fees relative to their pre-2005 levels—some are higher, some are lower, and some are about the same. Explaining the changes in all pollination fees in Tables 3 and 4 is beyond the scope of this article. It is noteworthy, however, that the annual year-to-year variation in pollination fees can be considerable. But the fact that the number of beekeepers sampled for some crops is relatively small suggests that a portion of the observed variation may simply be due to which beekeepers happen to respond to the survey in

[8] **Sumner and Boriss (2006) also make this point.**

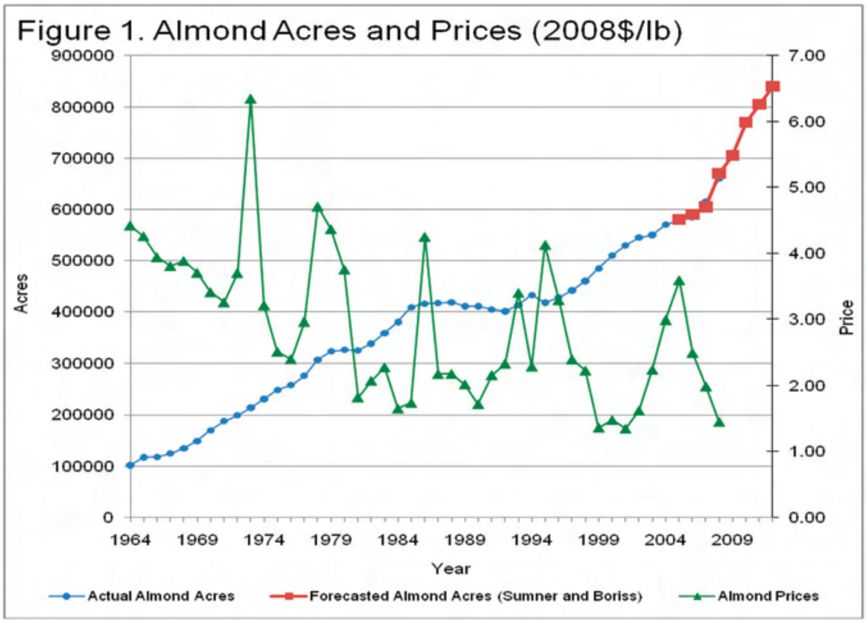


Table 4: Real (2008 dollars) average pollination fees per colony for selected Washington and Oregon crops, 1987-2008

Year	Cranberries	Blueberries	Clover Seed	Sweet cherries	Pears	Apples	Almonds
1987	$57.10	$27.30	$28.93	$41.76	$38.06	$39.05	NA
1988	$54.77	$31.75	$19.60	$38.59	$36.92	$40.87	NA
1989	$55.23	$32.01	$27.89	$34.78	$30.84	$29.12	NA
1990	$54.21	$35.00	$12.18	$36.04	$33.44	$42.34	NA
1991	NA	$29.31	$20.33	$36.84	$39.38	$34.48	NA
1992	$51.73	$31.61	$21.38	$38.79	$38.07	$42.20	NA
1993	$52.59	$40.67	$19.11	$47.68	$45.05	$48.12	$55.40
1994	NA	$49.58	NA	$49.41	$50.52	$48.13	$55.91
1995	NA	$42.04	$18.81	$49.45	$49.87	$46.21	$57.61
1996	$48.23	$37.48	$22.61	$48.39	$47.43	$51.08	$57.32
1997	$56.13	$38.94	$27.45	$45.73	$45.67	$43.81	$56.10
1998	$55.94	$41.25	$19.75	$45.67	$42.11	$44.17	$58.39
1999	$47.53	$41.43	$34.23	$50.07	$50.07	$51.97	$63.22
2000	$55.95	$43.15	$47.42	$46.80	$48.25	$49.93	$45.74
2001	$56.48	$37.86	$28.09	$42.62	$48.54	$42.22	$60.17
2002	$57.51	$31.64	$47.18	$44.28	$45.49	$47.62	$66.37
2003	$57.10	$35.26	$28.91	$40.83	$43.04	$46.17	$66.38
2004	$32.50	$43.13	$44.14	$45.56	$42.38	$38.25	$65.94
2005	$38.37	$47.78	$48.22	$48.24	$49.11	$47.16	$101.55
2006	$53.82	$39.24	$36.16	$47.89	$45.80	$48.51	$156.61
2007	$50.46	$40.56	$50.14	$48.03	$46.30	$48.71	$156.04
2008	$50.00	$36.92	$31.16	$42.36	$42.34	$45.39	$148.15

[a]Source: Michael Burgett, Department of Horticulture, Oregon State University. Prices are deflated using the Index of Prices Paid by Farmers, Commodities, interest, taxes and wage rates, 2008=100 (found at www.nass.usda.gov webpage).

Table 5: The Role of Almonds in California and PNW Pollination Activities

YEAR	Proportion of Pollination Income from Almonds[a]		Proportion of PNW Commercial Beekeepers who Pollinate Almonds	Almond Rentals as a Proportion of Pollination Rentals[a]	
	PNW	California		PNW	California
1993	0.336		0.833	0.243	
1994	0.372		0.909	0.319	
1995	0.507		0.850	0.434	
1996	0.438	0.784	0.895	0.382	0.595
1997	0.392	0.715	0.885	0.333	0.537
1998	0.416	0.660	0.813	0.334	0.510
1999	0.325	0.621	0.867	0.270	0.488
2000	0.291	0.687	0.905	0.246	0.538
2001	0.436	0.807	0.824	0.361	0.664
2002	0.443	0.824	0.786	0.358	0.707
2003	0.470	0.888	1.000	0.368	0.770
2004	0.543	0.877	0.800	0.431	0.765
2005	0.517	0.884	1.000	0.333	0.736
2006	0.689	0.931	1.000	0.394	0.823
2007	0.583	0.942	1.000	0.301	0.781
2008	0.659	0.891	1.000	0.366	0.671
Average	0.464	0.808	0.898	0.342	0.660

[a]For the PNW, these proportions are for commercial beekeepers. For California, because we do not have information on the number of commercial and non-commercial beekeepers, these proportions are for all beekeepers.

a particular year.

Perhaps the most puzzling change seen in Tables 3 and 4 is the precipitous decline in the 2008 fees for plums and early cherries. If the decline in almond fees in 2008 is partly the result of a positive supply response on the part of both local and distant beekeepers, then competitive market forces should also result in a decline in plum and early cherry fees. Why these fees fell so much more dramatically than almond fees, however, remains unanswered.

Our data on pollination fees are from California and Pacific Northwest beekeepers. The vast majority of these beekeepers have been pollinating almonds for many years. We speculate that the primary change facing these beekeepers in recent years is that they are now receiving higher fees for almonds, and that their pollination schedules have not been much affected otherwise. Insofar as CCD is a serious continuing problem, there may, of course, be increased costs of operating, but the increased pollination fees for almonds likely have offset all or part of these increased costs.

It seems likely that much of the increase in the quantity of pollination services being provided to California almond producers is due to beekeepers coming from more distant home bases. Although it is possible that this change has resulted in important changes in pollination fees for later crops in those areas, without data on those pollination fees we can only speculate on this issue.

The Growing Role of Almond Pollination

Information from the California and PNW pollination surveys documents the expanding role of almonds in the activities of U.S. beekeepers. The second and third columns of Table 5 display the proportions of pollination income for PNW and California beekeepers that are derived from almond rentals. For both groups, this proportion has trended upward at a statistically significant rate. In the PNW, income from almond pollination has increased from about one-third to about two-thirds of total pollination income since 1993. For California, almond pollination income has comprised 90 percent or more of total pollination income in recent years.

The next column in Table 5 indicates that all PNW commercial beekeepers who responded to the OSU survey have pollinated almonds in all but one year since 2003. The last two columns show the annual number of hives rented for almond pollination as proportions of all hive rentals for the PNW and for California. In California, on average about two-thirds of all pollination rentals have been for almonds and this fraction has increased (at a statistically significant rate) over time. In Washington and Oregon, about one-third of hive rentals are for almonds, and this fraction has been relatively constant over the time span of the data.

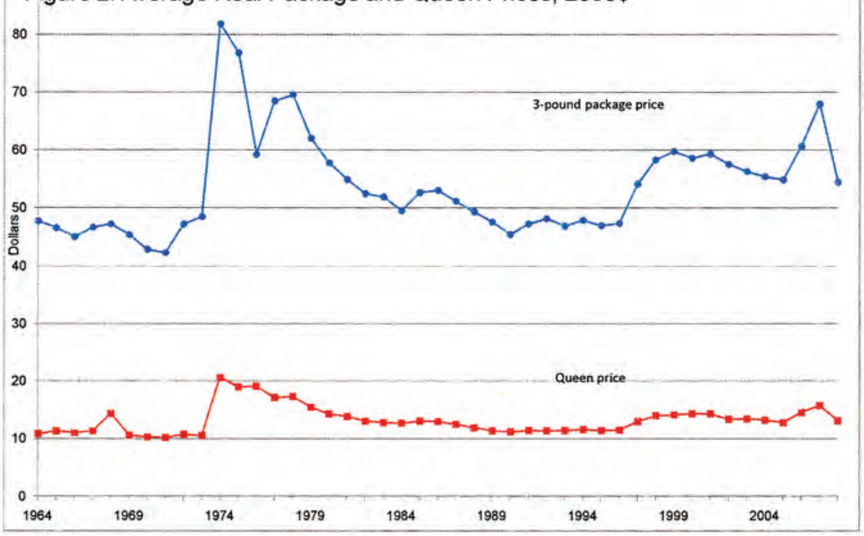
Recent Events: Market Evidence of CCD?

Since the fall of 2006, Colony Collapse Disorder (CCD), has received extensive media coverage. Current research indicates that it has affected beekeepers throughout the country and that mortality rates in the winters of 2006/07 and 2007/08 were likely between 30 and 35 percent. We discuss above how beekeepers are able to respond to winter losses by replacing lost colonies, primarily through splitting healthy ones and, to a lesser extent, rebuilding lost colonies with purchased packages of bees. That beekeepers have done this is supported by the fact that the average USDA-estimated number of U.S. colonies in 2007 and 2008 is only about 4 percent lower than in 2004 and 2005, despite the overwinter loss of over 30 percent of colonies.

But is there any evidence from market data that CCD is affecting prices paid by consumers, farmers, or beekeepers? Perhaps most directly, one might look at pollination fees. If CCD has caused a decrease in the supply of pollination services, then we should be seeing increases in pollination fees. We point out above that while there *have* been dramatic increases in pollination fees in the past several seasons, they appear to have been restricted to almond pollination fees and crops that are pollinated contemporaneously with almonds. Further, the almond fee increases began at least one year before any evidence of abnormal winter losses. Both of these facts argue against attributing recent pollination fees to CCD.

A second place to look for an economic CCD impact is the prices that beekeepers pay for colony-replacing inputs. While the dominant method by which beekeepers augment their colony numbers is by splitting healthy colonies, an alternative is to buy a

Figure 2. Average Real Package and Queen Prices, 2008$



package of bees (typically weighing three pounds and containing about 12,000 worker bees and a queen) and place them in an empty hive unit. It generally takes 60 to 90 days for hives restarted with this method to reach full strength. The estimated cost of replacing lost colonies through splits is about $19 per hive, considerably less than the $52 estimated cost of replacement with packaged bees and queens (see Burgett, et al., 2009). But is there evidence from the package and queen segment of the beekeeping industry that such costs have risen due to CCD?

Suppose that CCD is having important impacts on *Apis* pollinators. Suppose further that there are economic constraints on the ability of suppliers of packaged and queen bees to expand their operations to meet the CCD-induced increased demand. In this case, one would expect to see substantial increases in the prices for queens and possibly packaged bees.[9]

Figure 2 shows real prices for these products since the 1960s, obtained from advertisements in the *American Bee Journal*. The prices shown are the real prices (in 2008 dollars) per three pound package (or per queen) for an order of 50 packages (or queens). Note first, that there has not been a strong upward trend in the real prices of packaged and queen bees—the trend rate of increase for three pound packages of bees is $0.12 per year and for queens is slightly greater than $0.01 per year. Note second, that package and queen prices increased substantially in 2006, prior to the appearance of CCD. Although prices were again up substantially in 2007, they were down considerably in 2008, back roughly to their levels in 2005. This pattern is inconsistent with what would be expected if CCD were having substantial impacts. More formal statistical analysis of these prices suggests that although increases in almond acreages have had significant impacts on queen and package prices, there is no support for the hypothesis that there has been either a statistically or economically significant increase in prices that could be attributed to the appearance of CCD.

Finally, and most recently, reports from California's almond orchards in the spring of 2009 are noteworthy. In response to a recent 30 percent drop in almond prices, combined with drought-induced water shortages, orchard owners reportedly cut their costs, including those associated with pollination (*The Economist*, March 7, 2009). Reports indicate that there was a glut of bees in spring 2009, that some almond growers reduced their honey bee stocking densities, and that beekeepers who went to the orchards without advance contracts received considerably lower pollination fees than they had in the previous two years. While not definitive by themselves, these facts are inconsistent with there being drastic economic effects from CCD.

Conclusion

In this article we have presented and discussed economic trends in honey bee pollination, using data drawn from two decades of surveys of PNW beekeepers and 13 years of CA surveys. These data suggest the following:

- Commercial beekeepers in the PNW make roughly 60 percent of their income from providing pollination services, whereas semi-commercial beekeepers make about 60 percent of their income from selling honey. Although the percentage of income from pollination has not changed significantly for commercial beekeepers, it has decreased in recent years for semi-commercial beekeepers.
- PNW beekeepers make about 50 percent more pollination sets (per colony) than California beekeepers. On average, California beekeepers pollinate almonds and then use one-half to two-thirds of their colonies to pollinate one additional crop. PNW beekeepers, on the other hand, contract to pollinate almonds and then on average, use each of their colonies to pollinate another 1.4 crops. Moreover, each PNW beekeeper pollinates more than five crops per year in about seven different counties.
- Whereas the acreage of crops pollinated and the number of colonies rented in the United States changed little between 2000 and 2007, the aggregate value of the crops pollinated increased by about one-third. The relative importance of almond pollination has increased considerably.
- Over the time span of our data, real pollination fees have increased for most crops in California and the PNW. The rates of increase have, however, been relatively low, with the notable exception of almond fees, which increased dramatically in 2005 and 2006, more than doubling in just two years.
- In recent years, 90 percent or more of the pollination income of California beekeepers was from almond pollination. Although the proportion of PNW beekeepers' pollination income from almonds has increased over the past 15 years, they still receive a third or more of their income from pollinating other crops. Virtually all commercial PNW beekeepers have pollinated almonds in recent years.
- A multitude of factors drive pollination fees: the costs of beekeeping (which are influenced by honey bee disease); demands for pollinated crops; and honey sales income opportunities for beekeepers chief among them.[10] Looking at recent data, it is difficult to construct an explanation for recently high pollination fees that involves increased mortality due to CCD.

References

Anon. "*The Bees are Back in Town*," *The Economist*, March 7, 2009, pp. 85-86.

Burgett, M., R. Rucker, and W. Thurman (June 2009). *Honey Bee Colony Mortality in the Pacific Northwest (USA) Winter 2007/2008. American Bee Journal*, Vol. 149, No. 6, pp. 573-576.

Daberkow, S., R. Rucker, W. Thurman, and M. Burgett (2009). *U.S. Honey Markets: Recent Changes and Historical Perspective., American Bee Journal*, Vol. 149, No. 12, pp. 1125-1129.

Hoff, F. and L. Willet (1994). The U.S. Beekeeping Industry. AER No. 680, Economic Research Service, U.S. Dept. of Agriculture, Wash. DC.

Robinson, W., R. Nowogrodzki, and R. Morse (1989). *The Value of Honey Bees As Pollinators of U.S. Crops. American*

[9] Splitting colonies requires a new queen, which is typically purchased from queen suppliers. Creating new colonies with packages appears to be used to replace lost colonies much less frequently than splitting colonies, at least in the PNW (see Burgett et al., 2009).

[10] See Rucker, Thurman, and Burgett (2008) for a statistical and economic model of the various factors influencing pollination fees.

Bee Journal, June.

Rucker, R., W. Thurman, and M. Burgett (2008). *Internalizing Reciprocal Benefits: The Economics of Honeybee Pollination Markets.* Unpublished working paper.

Sumner, D. and H. Boriss (2006). *Bee-conomics and the Leap in Pollination Fees,* Agriculture and Resource Economics Update, Vol. 9, No. 3. Giannini Foundation of Agricultural Economics (April).

Van Engelsdorp, D., R. Underwood, D. Caron, J. Hayes, Jr. (2007). *An Estimate of Managed Colony Losses in the Winter of 2006 - 2007: A Report Commissioned by the Apiary Inspectors of America, American Bee Journal*, July 2007. [http://www.ento.psu.edu/MAAREC/ColonyCollapseDisorderInfo.html#reportsResearch]