HOW SWEET ARE BEEKEEPER RETURNS FROM ALMOND POLLINATION AND HONEY PRODUCTION?

Sub-Theme: Entrepreneurship

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Abstract:

Beekeeping can be an attractive option for agriculture entrepreneurs because beekeeping enterprises often require less initial land and capital than other agricultural ventures. However, while beekeeping may have lower barriers to entry, there is little information about management and marketing characteristics that may maximize beekeeper profitability. This study formally assesses the extent to which firm size and location, production and service activities, and marketing decisions affect returns to beekeepers. Empirical analysis of data from 107 beekeepers in the U.S. mountain west region indicate that smaller, semi-commercial beekeepers receive higher average variable returns per colony than larger, commercial beekeepers but that more established firms do not have a significantly higher variable returns over younger firms. The results also show that beekeepers could earn higher average variable returns from increased honey marketing and almond pollination services, suggesting that recent increases in almond pollination fees did not sufficiently offset revenues from per colony honey sales. Broadly, this study can improve beekeeper cost-benefit analysis and trade-off evaluation when making managerial decisions and responding to changes in policy related to beekeeping business development.

Keywords: *Pollination, Honey, Entrepreneurial, Variable Returns, Marketing, Size*

1. Introduction

Over the last ten years, there has been uncertainty about the future supply of domesticated honey bees to pollinate crops (Aizen *et al.*, 2009, Aizen and Harder, 2009, United Nations Environment Program., 2010). In North America, wild pollinator availability has declined due to introduced diseases, parasites, and habitat fragmentation (Allen-Wardell *et al*., 1998, Petersen and Nault, 2014, Ricketts *et al*., 2008). Globally, there is increasing need to supplement wild pollination with managed honeybee colonies. These circumstances could provide entry opportunity for beekeeping to entrepreneurs. However, the growth in managed honeybee colonies has seemingly lagged the expected demand growth. In fact, the United States has had a decline in the number of managed honey bees (Calderone, 2012).

This research seeks to assess the apparent disconnect between market demand and new beekeeper firm entry and expansion by empirically evaluating the factors that create economic incentive for entry and expansion. Specifically, by analyzing beekeeping production costs and returns, we are able to provide important insights about the extent to which specific market conditions and policies could affect beekeepers' market entry decisions. Similarly, the study informs existing beekeepers about managerial decisions for providing pollination services and the potential trade-offs of offering such activities.

The discord between beekeeping start-ups and industry expansion may, in part, reflect the unique nature of this industry. Beekeeping enterprises are different from many other forms of production agriculture. For example, beekeeping does not require significant land ownership, which impacts the extent to which changes in fixed and variable costs affect a beekeeping business's size and management decisions.[1] First, beekeepers may not be constrained by the typical land ownership or acquisition challenges other agricultural producers face, but their smaller portfolio of assets could limit their leverage for acquiring financing to enter or expand their operations. This could restrict beekeeper abilities to optimally respond to changes in market prices (Daberkow *et al*., 2009, Knight, 1972). Second, transportation costs, rather than land costs, tend to be the binding constraint for firm expansion (Knight, 1972). Typically, the largest production cost is producer (imputed) labor and comparatively small amounts of hired labor are used in beekeeping than in other agricultural production across the board (Knight, 1972, Daberkow *et al*., 2009). Finally, in the United States, beekeeping

[1] Basic startup investment items includes hives, bees, clothing and handling equipment.

enterprises also differ from other production agriculture businesses because beekeepers are less likely to receive government payments (Daberkow *et al.*, 2009).

Interestingly, reduced financing and other expansion constraints may not be primary factors that limit beekeepers' profitability and sustainability. While there is evidence of economic benefits to larger beekeeping (Daberkow *et al.*, 2009), economies of scale may be less important to beekeeping enterprises than to other agriculture firms that have larger initial investments and higher fixed costs (Ferguson, 1972). Because initial investments in beekeeping are typically small and mostly associated with variable costs, expansion is largely associated with increases in production-related expenses — especially those for labor and extraction—that can limit beekeepers' ability to capture cost savings through expansion. Small to medium beekeepers (e.g., those with approximately 400 colonies) may have higher returns than larger scale beekeepers, say 700 colonies, because the larger beekeepers have larger extraction, transportation and labor expenses (Knight, 1972).

Our study focuses on beekeepers in the Mountain West states of Wyoming, Montana, and Utah. Typically, commercial beekeepers in this region have larger operations than those in other regions (Daberkow *et al*., 2009). Firms in this region produce a variety of products including honey, wax, pollination services, queen bees, package bees, or other specialty products (e.g., honey vinegars, sweets, and cosmetics). In aggregate, they are responsible for approximately ten percent of United States honey production (National Agricultural Statistics Service, 2017). This study focuses on the service and product most beekeepers most commonly market, pollination and honey.

Beekeepers provide pollination services to farms throughout the western United States for a variety of different crops, including almonds and alfalfa hay (Olmstead and Wooten, 1987, Sumner and Boriss, 2006, Burgett *et al*., 2010, Rucker *et al*., 2012, Seibert, 1980). Pollination from managed honeybees contributes an estimated $11.68 billion to United States Agriculture each year (Calderone, 2012). In 2012, U.S. beekeepers earn an estimated $655.6 million in gross revenue from pollination services (Bond *et al*., 2014).

The largest and most studied pollination market in the United States is that for almonds. There is ample research showing almond pollination fees are increasing and the market is in need of additional honeybee colonies (Rucker et al., 2003, Sumner and Boriss, 2006, Goodrich and Goodhue, 2016). It is less clear, however, how market participation impacts beekeeper returns, especially returns to for those beekeepers migrating from outside of California or the west coast.

Recent research and policy reports indicate the need for increased understanding of pollination markets and beekeepers offering services in those markets (Breeze *et al.*, 2014, Burgett *et al.*, 2004, Aizen and Harder, 2009). The supply side costs of pollination services are one of the least studied aspects of the pollination market. Traditionally, economists have focused on the value of honey production and considered pollination a by-product or positive externality of honey production.

Today, pollination services are more often seen as a separate output produced jointly with honey. But it is not clear whether beekeepers are more responsive to honey prices or pollination fees when making output decisions (Aizen and Harder, 2009, Burgett *et al.*, 2004). Further, if they do engage in pollination services, it is not clear how the gross returns from this additional enterprise compare to the incurred costs.

The following analysis of beekeeper returns offers entrepreneurs and those advising them information to make decisions regarding operation location and size, on the influence of pollination and honey production activities on returns, and about returns from different honey marketing channels. The results may also provide insight and explanations for previously observed phenomenon, such as beekeeper minimal output response to pollination fee fluctuations.

2. Methods

Our analysis focuses on the beekeeper's primary production decision unit, a single colony of bees. We estimate the general returns to the beekeeping operation and then average those returns across all colonies in the operation. Primary beekeeping inputs include package bees, queen bees, wood hardware/hives procurement and repair, foundation, smoking and handling supplies, extraction technology, fuel for colony transport and management, labor, and overhead (e.g., vehicles, packaging, insurance, accounting, buildings, etc.) The outputs may include honey, wax, package bees, queen bees, and pollination services. We focus on honey and pollination services—the two most common beekeeping enterprises. Honey is measured in kilograms produced and pollination service output is measured by the percent of colonies employed in pollination annually.[2]

[2] Some may argue the ultimate output of pollination is the resulting crop yields from those services. Unfortunately, managers of the business unit of analysis we are interested in, beekeepers, do not regularly have this information. Thus, our survey data reflects the

Beekeeper *i*'s returns to variable costs, R_i, are calculated as the sum of revenues received from beekeeping and honey production less production costs.[3] Pollination revenues are the sum over *n* crops of the product of pollination rate, *r*, paid to the beekeeper for pollinating crop *j* and the number of colonies, *q*, on each pollination crop *j* in a growing season. Additional beekeeping revenues arise from the sales of honey. The revenue from honey for beekeeper *i* is a sum over the product of the pounds of honey, *h*, sold and price received, $<p$, through distribution channel *k*.

Costs include colony replacement and hive costs, bee health investment, labor costs, and overhead items (e.g., advertising, accounting and insurance costs).[4] We do not have data on the long-term fixed costs for the firm (e.g., existing hardware and real estate). Rather, our data reflect variable costs for each beekeeper in 2013. Fixed inputs including vehicles, buildings, office equipment are treated as exogenous for the variable returns analysis. Each beekeeper *i* has *l* variable costs, c_{il}. The total variable costs are the sum of each c_{il}. The beekeeper's variable returns are summarized in equation 1.

$$R_i = \sum_{j=1}^{n} r_{ij}q_{ij} + \sum_{k=1}^{m} h_{ik}{<}p_{ik} - \sum_{l=1}^{r} c_{il} \tag{1}$$

The calculated returns are used as the dependent variable in a linear regression specification that models the relationships between returns and a vector of *s* firm characteristics, X_{is}, including location, production activities, marketing outlets, and firm longevity and size; that is,

$$R_i = a_0 + \sum_{s=1}^{n} P_s X_{is} + E_i. \tag{2}$$

This model is estimated using Ordinary Least Squares regression in Stata 14.1.

The data were collected using a survey of beekeepers registered with beekeeping associations or State Departments of Agriculture in Montana, Utah and Wyoming. The

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information beekeepers are likely to have—the number of colonies used to pollinate different crops.

[3] As discussed above, fixed costs represent a small proportion of total beekeeping costs. As such, returns to variable costs can reasonably approximate overall net returns.

[4] Pollination costs are inclusive of both cash payments and gifts-in-kind from beekeepers to growers.

University of Wyoming's Internal Review Board approved the survey. The survey design follows the Dillman method to maximize the response rate (Dillman, 1978). All survey sample members received a pre-survey post card; an individually signed cover letter and survey; appreciation token; self-addressed stamped envelope; and return postcard. Early non-respondents also received an additional post card reminder to complete the survey.

There were a total of 1,026 registered beekeepers in the three states with 239 beekeepers in Montana, 645 in Utah, and 142 in Wyoming. Due to the low density of Wyoming beekeepers, a stratified sample of beekeepers was surveyed to ensure more equitable sample across the states and statistical power of location variables. The survey included all Wyoming beekeepers and half of the Montana and Utah beekeepers. Montana and Utah beekeepers were selected for study inclusion adhering to a random sample selection method. Thus, the final sample size of 585 beekeepers included 120, 323, and 142 beekeepers from Montana, Utah and Wyoming, respectively. In all, we received 41 surveys from Montana, 140 from Utah, and 76 from Wyoming, resulting in an overall, strong response rate of approximately 44 percent (Baruch, 1999).

3. Results

Table 1 presents the summary statistics for model variables. Across 110 commercially active survey respondents, the mean overall firm returns were $75,929 in 2013. The average beekeeper in this area reported keeping 431 colonies. Thus, the per colony variable return average was $43.73. Following Burgett *et al*. (2010), responding producers were classified as commercial (i.e., 300 or more colonies) and semi-commercial (<300 colonies). Seventy seven percent of the sample is semi-commercial while 33 percent of the sample is commercial. Beekeepers from Utah make up a slight majority of the sample, 53 percent, while 15 percent are from Montana, and 33 percent are from Wyoming. An average, 22 percent of colonies in the three states are employed in California almond pollination. That is, the average colony pollination employment rate is 22 percent.

The average honey marketed per colony was 15.58 kilograms.[5] This was marketed through a variety of channels and many beekeepers indicated using more than one channel. Only two percent of beekeeper respondents marketed their honey directly to a commercial extractor. The majority of beekeeper respondents market their honey via an

[5] The amount of honey marketed per colony is not a direct measure of each colony's honey production. Beekeepers do not always market all of the honey they produce. Thus, this measure only accounts for the honey that is marketed.

alternative marketing channel (36 percent), a farmers' market (21 percent), a farm stand (25 percent), or a wholesaler (15 percent). A remaining three percent market to local food cooperatives.

For the purpose of our econometric model, only 107 observations are complete for analysis because three producers did not report either the enterprise age or the quantity of marketed honey. To ensure unbiased and consistent regression estimates, we tested for multicollinearity and presence of outliers. These tests were performed using Stata. Multicollinearity was tested using variance inflation factors (VIFs) for the independent variables in the model. The VIF measures do not suggest multicollinarity for explanatory variables. Outlier observations were identified using DFBETA analysis. The DFBETA measure for the Colony Number coefficient indicates these observations change the value of the Colony Number coefficient by more than one standard deviation when included (i.e., $|DFBETA_i| > 2/\sqrt{n}$). Five outlier observations were dropped from the data set and the final estimation sample included 102 beekeepers.[6] The regression model in equation 2 was estimated using two specifications. The first, Model 1, only includes measures of location, output, and firm size as explanatory variables. Model 2 includes these variables plus additional dummy variable indicating the beekeeper's use of alternative marketing channels.

[6] The exclusion of outliers did not change the statistical significance of any explanatory variables. Comparing Model 1 with and without outliers, removing the outliers did increase the constant coefficient value from -175.38 to -139.03 and Honey Marketed Coefficient value from 2.14 to 2.95. There was a decrease in the coefficient values for the Colony Pollination Employment Rate variable from 2.21 to 1.60 and the Semi-Commercial coefficient from 86.04 to 78.40.

Table 1. Key variable summary statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Returns	110	75,928.85	24,6708.00	-56,750	1,926,806
Variable Returns per Colony	110	43.73	146.20	-418	601.01
Montana	110	0.15	0.35	0	1
Utah	110	0.53	0.50	0	1
Wyoming	110	0.33	0.47	0	1
Colony Pollination Employment Rate	110	21.86	35.91	0	100
Enterprise Age	108	18.85	21.83	1	98
Total Number of Colonies	110	431.42	1158.36	1	8000
Semi- Commercial	110	0.77	0.42	0	1
Kilograms of Honey Marketed Per Colony	109	15.58	13.71	0	60.98
Commercial Extractor	110	0.02	0.13	0	1
Wholesale	110	0.15	0.36	0	1
Farm Stand	110	0.25	0.43	0	1
‘Other’ Marketing Outlet	110	0.36	0.48	0	1
On-Line Distribution	110	0.05	0.21	0	1
Local Food Coop	110	0.03	0.16	0	1
Farmers’ Market	110	0.21	0.41	0	1

Table 2 presents the regression results for both specifications. Both models have strong, significant F-Statistics (p<0.001) and R-Square statistics. In both models, the firm's location did not significantly affect the colonies' earning potential, suggesting that the study's results and insights are applicable to the northern Rocky region regardless of a producers' specific location choice. However, colony earning potential was significantly related to the beekeeper's commercial status and involvement in almond pollination and honey markets. Semi-commercial producers—those with fewer than 300 colonies—receive approximately $78 more in variable returns per colony in Model 1 than larger, commercial beekeepers with 300 or more colonies. Increasing the colony's almond pollination employment rate by one percentage point is associated with a $1.60 increase in variable returns to that colony. Additionally, beekeepers that indicated a one point (0.45 kilogram) higher honey quantity sales were associated with $2.95 higher variable returns per colony.

Table 2. Ordinary least squares coefficient and standard error estimates for Models 1-2.

	1		2	
Montana	-32.1459	24.1855	-20.9596	22.7297
Utah	-3.9790	17.4778	-1.6006	16.2064
Colony Pollination Employment Rate	1.6020***	0.4163	1.5944***	0.4072
Honey Marketed per Colony	2.9486***	0.2908	2.5645***	0.3008
Enterprise Age	0.3174	0.4375	0.2682	0.4053
Total Number of Colonies	0.0020	0.0086	0.0004	0.0083
Semi-Commercial	78.4033**	35.4335	87.4423**	32.9026
Wholesale			42.2740	21.7938
Farm Stand			26.4369	20.3737
'Other' Marketing			-29.0704	18.9981
On-Line			3.6932	37.0814
Local Coop			102.5937*	43.9075
Farmers Market			1.0027	19.1291
Constant	-139.0311***	39.0960	-138.8483***	37.7287
Observations	102		102	
F-Stat	31.70***		22.08***	
Prob >F	0.00		0.00	
R-Square	0.70		0.77	
Adjusted R-Square	0.68		0.73	

*** indicates greater than 99% confidence, ** indicates greater than 95% confidence and * indicates greater than 90% confidence

When we account for marketing strategies in Model 2, we see slight changes in previously significant coefficients. Assessed independently, the results indicate that higher variable returns per colony are associated with selling honey in local food retail cooperatives compared to the left out category, sales to a commercial extractor. Additionally, a joint F-test of restrictions on the marketing variables (e.g., Wholesale, Farm Stand, ‘Other’, On-Line, etc.) rejects the null joint hypotheses they are equal to zero (F-Stat=3.93, p=0.0016). This suggests that not considering marketing channel options for beekeepers can limit the insights about their management decisions. For example, Table 2 shows that the marginal effect of being a smaller, semi-commercial producer is larger (relative to the effect in Model 1) when the regression model takes into account the alternative honey marketing options. That is, Model 2 results suggest that smaller beekeeping operations may be more cost-effective than larger operations conditional on placing a higher effort on marketing to local cooperatives. If, as is the case of Model 1, all marketing channels are assumed to be the same or producers are assumed to not be able to differentiate across marginal returns from different marketing channels, then the estimated benefits from having a semi-commercial operation would be incorrectly biased downward (i.e., the relatively lower marginal effect of semi-commercial producers in Model 1 relative to Model 2). As such, management decisions and policies aimed at improving beekeepers' variable returns could be ineffectively crafted.

In both Models 1 and 2, direct measures of size and firm age do not effect per colony variable returns. While the significance of the semi-commercial variable indicates threshold size effects, the continuous measure of firm size, Colony Numbers, is not significant.

4. Discussion

The positive sign on Semi-Commercial indicates that smaller operations are more profitable per colony. Thus, larger isn’t necessarily better in this industry. As Knight (1972) observed, larger beekeepers (e.g., commercial beekeepers with >300 colonies) do have more substantial overhead costs to recover, including a central extraction and bottling facility and greater transportation costs to place their colonies across landscapes. However, our results only reflect variable costs. In these data, the decreased per colony profitability in large operations may be attributed to increased hired labor expenses, although larger operations could increase their overall profit through larger sales volume.

The results also indicate that it is possible for new producers to be competitive in this industry. First, our results indicate that there is not a significant advantage in variable returns per colony for existing firms, despite the potential knowledge acquired about the specific nature of the industry as an established participant in the industry. Moreover, the empirical results show that information about marketing channels can enhance a smaller producer's—which could potentially also describe a producer who recently entered the industry—variable returns.

The primary driver of variable returns to beekeepers in this region appears to be honey. Based on Model 2 results, they can earn $5.68 per colony by increasing marketed honey output by one kilogram, but only $1.59 per colony by increasing its employment in almond pollination by one percent.

5. Conclusion

We find beekeepers engaging in almond pollination do have the potential to increase their returns to variable costs. However, a potentially more cost-effective management strategy to increasing returns would be to increase their efforts to marketing additional honey. Still, almond pollination may offer substantial revenue enhancement, especially since it occurs when bees would otherwise be dormant.

These results offer lessons to beekeepers and professionals advising new entrepreneurs considering beekeeping. Beekeeping appears to have fewer size-related advantages than other forms of agriculture requiring greater initial capital investments. The potential profitability, however, may depend more closely on local honey markets and honey prices. Offering pollination services to even a high fee market, such as the California almond pollination market, will not increase variable returns as quickly as effective honey marketing practices.

While this research provides a substantial contribution to the existing literature, certain limitations must be recognized. First, the results are limited by the geographic specificity of the honey production, honey price, and pollination fee data for producers in this area. Lower honey prices combined with higher pollination fees would likely create divergent results from those presented here (i.e., the pollination market would play a more dominate role in beekeeper returns). Second, while the data for this study provide good representations from on point in time, we cannot predict how beekeeper returns behave over multiple time periods. The development and use of panel data related to beekeeper returns in this area and others would greatly improve this and similar research.

Beekeeping offers an attractive opportunity for entrepreneurs interested in entering agriculture. Entrepreneurs may receive positive returns without prohibitive land and capital initial costs often associated with entry into other agricultural enterprises.

Existing firms do not appear to have a significant advantage—at least on the margin—than new firms. Startups are generally feasible. Marketing matters. If an entrepreneur is willing to learn the art and science of beekeeping, there may be lower risk of experiencing competitive stings from existing firms.

6. References

AIZEN, M. A., GARIBALDI, L. A., CUNNINGHAM, S. A. & KLEIN, A. M. 2009. How much does Agriculture Depend on Pollinators? Lessons from Long-Term Trends in Crop Production. *Annals of Botany,* 103**,** 1579-1588.

AIZEN, M. A. & HARDER, L. D. 2009. The Global Stock of Domesticated Honey Bees is Growing Slower Than Agricultural Demand for Pollination. *Current Biology,* 19**,** 915-918.

ALLEN-WARDELL, G., BERNHARDT, P., BITNER, R., BURQUEZ, A., BUCHMANN, S., CANE, J., COX, P. A., DALTON, V., FEINSINGER, P., INGRAM, M., INOUYE, D., JONES, D. E., KENNEDY, K., KEVAN, P., KOOPOWITZ, H., MEDELLIN, R., MEDELLIN-MORALES, S. & NABHAN, G. P. 1998. The Potential Consequences of Pollinator Declines on the Conservation of Biodiversity and Stability of Food Crop Yeilds. *Conservation Biology,* 12**,** 8-17.

BARUCH, Y. 1999. Response Rate in Academic Studies--A comparative Analysis. *Human Relations,* 52**,** 421-438.

BOND, J., PLATTNER, K. & HUNT, K. 2014. U.S Pollination-Services Market. Washington, D.C.: United States Department Agriculture.

BREEZE, T. D., VAISSIERE, B. E., BOMMARCO, R., PETANIDOU, T., SEAPHIDES, N., KOZAK, L., SHEPER, J., BIESMEIJER, J. C., KLEIJN, D., GYLDENKAERNE, S., MORETTI, M., HOLZSCHUH, A., STEFFAN-DEWENTER, I., STOUT, J. C., PARTEL, M., ZOBEL, M. & POTTS, S. G. 2014. Agricultural Policies Exacerbate Honeybee Pollination Service Supply-Demand Mismatches Across Europe. *PloS one,* 9**,** 1-8.

BURGETT, M., DABERKOW, S., RUCKER, R. & THURMAN, W. N. 2010. U. S. Pollination Markets: Recent Changes and Historical Perspectives. *American Bee Journal,* January 2010**,** 35-41.

BURGETT, M., RUCKER, R. R. & THURMAN, W. N. 2004. Economics and Honey Bee Pollination Markets. *American Bee Journal,* 144**,** 269-271.

CALDERONE, N. W. 2012. Insect Pollinated Crops, Insect Pollinators and US Agriculture: Trend Analysis of Aggregate Data for the Period 1992-2009. *PloS One,* 7**,** 1-27.

DABERKOW, S., KORB, P. & HOFF, F. 2009. Structure of the U. S. Beekeeping Industry: 1982-2002. *Journal of Economic Entomology,* 102**,** 868-886.

FERGUSON, C. E. 1972. *Microeconomic Theory,* Homewood, Illinois, Richard D. Irwin, INc.

GOODRICH, B. & GOODHUE, R. 2016. Honey Bee Colony Strength in the California Almond Pollination Market. *Gianni Foundation of Agricultural Economics.* Davis, California: University of California.

KNIGHT, R. C. 1972. Results of a Survey of Beekeepers in New South Wales. *Quarterly Review of Agricultural Economics,* 25**,** 56-65.

NATIONAL AGRICULTURAL STATISTICS SERVICE 2017. Honey Bee Colonies. *In:* AGRICULTURE, U. S. D. O. (ed.). Washington, D.C.

OLMSTEAD, A. L. & WOOTEN, D. B. 1987. Bee Pollination and Productivity Growth: The Case of Alfalfa. *American Journal of Agricultural Economics,* 58**,** 56-63.

PETERSEN, J. D. & NAULT, B. A. 2014. Landscape Diversity Moderates the Effects of Bee Visitation Frequency to Flowers on Crop Production. *Journal of Applied Ecology,* 51**,** 1347-1356.

RICKETTS, T. H., REGETZ, J., STEFFAN-DEWENTER, I., CUNNINGHAM, S. A., KREMEN, C., BOGDANSKI, A., GEMMILL-HERREN, B., GREENLEAF, S. S., KLEIN, A. M., MAYFIELD, M. M., MORANDIN, L. A., OCHIENG, A., POTTS, S. G. & VIANA, B. F. 2008. Landscape effects on crop pollination services: are there general patterns? *Ecology Letters,* 11**,** 499-515.

RUCKER, R., THURMAN, W. N. & BURGETT, M. 2012. Honey Bee Pollination Markets and The Internalization of Reciprocal Benefits. *American Journal of Agricultural Economics,* 94**,** 956-977.

RUCKER, R. R., THURMAN, W. N. & BURGETT, M. 2003. Internalizing Reciprocal Benefits : The Economics of Honeybee Pollination Markets. *Working Paper.* Montana State University.

SEIBERT 1980. Beekeeping, Pollination, and Externalities in California Agriculture. *American Journal of Agricultural Economics,* 62**,** 165-171.

SUMNER, D. A. & BORISS, H. 2006. Bee-conomics and the Leap in Pollination Fees. *Giannini Foundation of Agricultural Economics.* Davis, California.

UNITED NATIONS ENVIRONMENT PROGRAM. 2010. Global Honey Bee Colony Disorders and Other Threats to Insect Pollinators. *In:* VAISSIÈRE, B. & DUTHIE, D. (eds.) *UNEP Emerging Issues.* Nairobi, Kenya: United Nations.

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