# THE ECONOMIC EFFECTS OF SIZE AND ENTERPRISE DIVERSITY ON APIARY PROFITS IN CANADA

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## ABSTRACT

## THE ECONOMIC EFFECTS OF SIZE AND DIVERSITY ON APIARY PROFITS IN CANADA



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This paper is an investigation of how the size and level of diversification of Canadian apiaries are interrelated and how they affect their profits. Primary data was collected through the Canadian Pollination Initiative (CANPOLIN) 2010 Beekeeping Survey, the first of its kind targeting economic issues facing Canadian beekeepers. The methods of analysis included linear regression to gauge the effects of size and diversification on profits, and calculation of diversification indexes to measure the degree of diversification in beekeeping operations. Findings revealed that the variation in size of beekeeping operations did not account for changes in profit, but that the number of products and services offered by an apiary did explain variations in profit per colony. No significant relationship was detected between the level of diversification and the size of beekeeping operations. The survey also showed that lack of equipment and skills presented the greatest barriers to enterprise diversification. Recommendations for facilitating enterprise diversification include creating professional associations for specific beekeeping activities such as breeding, or commercial pollination, and forming partnerships with related industries like grower organizations. Policy initiatives should focus on making equipment and training available to beekeepers wanting to diversify or expand their operations.

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Honeybees have a lot to offer both in terms of agricultural products and ecosystem services. However, bees the world over are succumbing to a number of threats such as climate change, reduced biodiversity, and invasive species that are reducing their quality of health and longevity (UNEP, 2010). The cost of dealing with these problems is increasing for apiarists making the beekeeping business less profitable; Canada's beekeepers are not exempt from this trend. The purpose of this study is to examine the effects of size and diversification on Canada's apiary profits in order to propose ways of improving upon the economic viability of their industry.

## 1.1 Current State of Honeybees

Honeybees are probably the best-known pollinating species around the world; however, the significance of their decline is less understood. This paper begins with an overview of the current state of honeybees in both the global and Canadian contexts.

### 1.1.1 Honeybees: Global Context

Among the 20,000 species of bees on earth, the most commonly domesticated are honeybees (UNEP, 2010). 52 of the 115 leading global food commodities are dependent on honeybee pollination for either fruit or seeds (Klein et al., 2007 cited by vanEngelsdorp and Meixner, 2010,). The United Nations Food and Agricultural Organization estimates that 71 out of the 100 crop species that provide 90% of the global food supply are reliant on bee pollination (UNEP, 2010). With global food production moving toward large-scale, industrialized, and monocultural production managed, honeybees are becoming essential to farming systems as the most important pollinators of monocultures worldwide (McGreggor, 1976 cited by vanEngelsdorp and Meixner, 2010, Southwick and Southwick, 1992, UNEP, 2010). Between 1961 and 2006, global agriculture increased its reliance on pollinators by 50% and 62% in the developed and developing world, respectively (Aizen et al., 2009 cited by vanEngelsdorp and Meixner, 2010). "Honeybees remain the most economically valuable crop pollinators of monocultures worldwide" (Klein, 2007, p. 304). Honeybees are also an important indicator species and their decline signals potential problems for human health (UNEP, 2010, Klein et al., 2007). Our reliance on managed honeybees is increasing at a time when they are at their most vulnerable. Pollination is an essential ecosystem service for maintaining biodiversity and sustaining life. The collapse of honeybee colonies is rapidly becoming one of the most significant issues in agriculture (Sumner and Boriss, 2007).

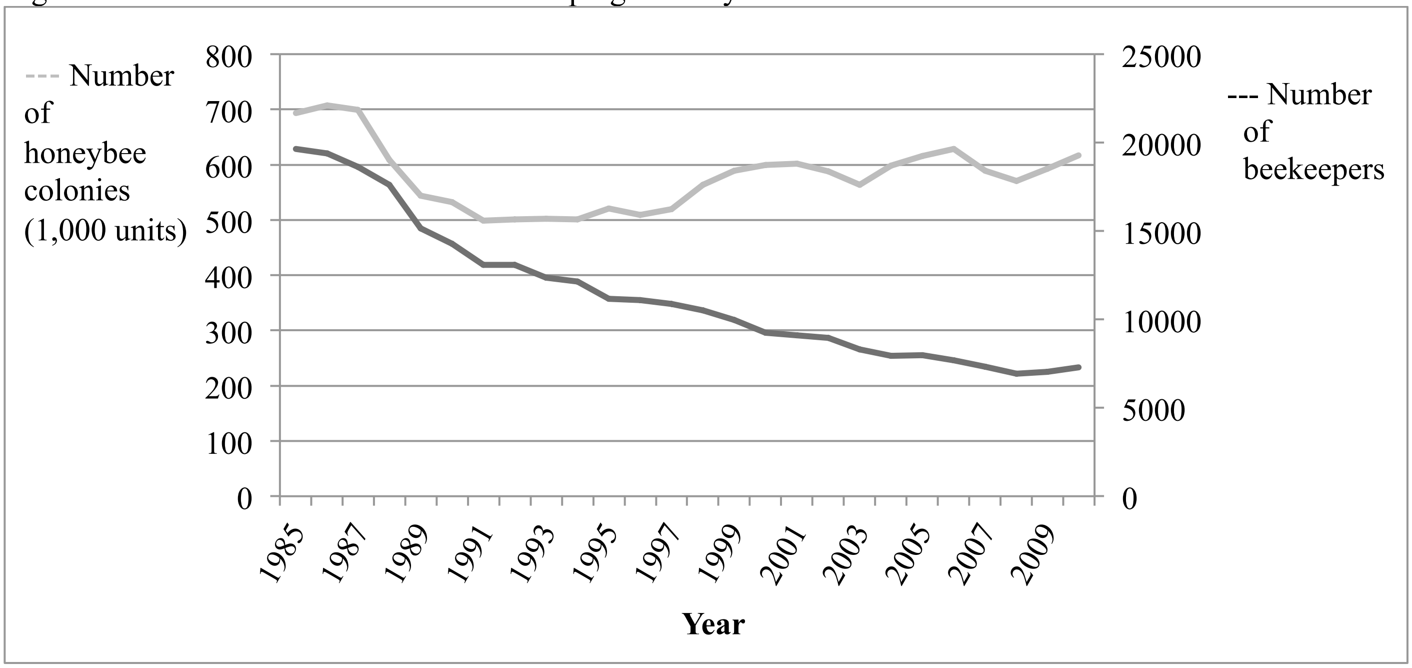
Although beekeepers are accustomed to abandoned hives and bee die-offs each year, theses rates are climbing (Ibid). World honeybee populations are most threatened by disease, increasingly harsh weather patterns, and loss of biodiversity. "Among the most dire threats facing managed honeybee populations is the *varroa mite* that has directly increased operational expenditures because of the costs associated with purchasing and applying control products" (NRC, 2006 cited by vanEngelsdorp and Meixner, 2010, p.S85, UNEP, 2010). Weather too has a serious effect on colony welfare: extended periods of cold, rainy, and hot weather have been blamed for severe colony mortality (Ibid.). Beekeepers have identified severe winter weather and overall weather patters as a major contributor to winter mortality (UNEP, 2010, vanEngelsdorp and Meixner, 2010). Loss of biodiversity has translated into fewer varieties and lower quality of plants available for bees. The introduction of large-scale agricultural production and monoculture have also reduced the variety of forage substances available to bees, consequently weakening their overall health (Ibid.). These trends are occurring both globally, and in Canada.

### 1.1.2 Honeybees: Canadian Context

Canada's beekeeping industry is not impervious to the problems other countries are currently experiencing. Unusual fall and winter weather patterns affecting bee populations, inadequate nutrition, biodiversity, and pathogens such as *varroa mites* and *Nosema* are among the most important causes of rising honeybee death rates (Currie et al., 2010). Over-winter death rates are believed to be a major cause of honeybee collapse in Canada. The average winter rate of mortality in Canada is 15%, however, in recent years, beekeepers have reported that as much as 35% of their colonies are perishing over winter (Ibid, HCC, 2010). Invasive species such as the *Varroa mit*e, which first appeared in Canada in 1989, have also had a negative effect on managed honeybee colonies throughout most of the country (Currie et al., 2010). Beekeepers compensate for high over-winter losses by splitting up remaining colonies, and purchasing packaged bees and new hives (Melhim et al., 2010). The overall effect of these honeybee scourges has raised the costs of commercial beekeeping (Rucker et al., 2005).

In response to rising colony losses, the Canadian beekeeping industry has undergone an important structural change over the last 20 years. Figure 1 shows the number of beekeepers in Canada compared to the number of honeybee colonies. The overall number of colonies in Canada has remained stable over time despite a sharp drop in the late 1980s coinciding with the introduction of the *varroa mite*. While the number of colonies has recovered from the shock, the number of beekeepers in the industry appears to be declining. Canada now has fewer beekeepers per colonies. Beekeeping operations in Canada are becoming fewer and larger: this industry is on a path towards consolidation.

Figure 1: Consolidation of Canadian beekeeping industry




Source: CANSIM, 2010

Though it is clear what is happening to the Canadian beekeeping industry in general, it is not clear what beekeepers are doing to maintain economic viability under these increasingly difficult circumstances. The trend toward consolidation shows that the average size of apiaries is increasing. What is not know, is how this change in size is affecting profits. Moreover, there exists no economic information about the range of products and services offered by these operations. Thus, there is a need to examine factors affecting the economic viability of apiaries in Canada by considering how the size of these operations and their range of outputs differ with their profits.

## 1.2 Canadian Honey Beekeeping Industry

While Canada is a net exporter of honey with almost half of its annual production of 75 million pounds exported, honeybees have more to offer the agricultural sector than just their honey (HCC, 2011, Melhim et al., 2010). Other lucrative Canadian apiary activities include production of wax, pollen, royal jelly, queen rearing, nuc breeding, and commercial pollination of crops (Melhim, 2010).

In Canada pollination is a major contributor to crop production; honeybees are in high demand for pollination of hybrid seeds, and crops such as vegetables, fruits, oilseed and soybean (HCC, 2011, Melhim et al., 2010). Examples of crops that are heavily reliant on honeybee pollination in Canada include apples, blueberries, and most vegetables as well as field crops such as soybeans and canola (Morse and Calderone, 2000). In Canada, The value of honeybees to pollination of crops is estimated at over $2 billion annually (HCC, 2011). Pollination of canola is also major activity in Canada; in 2010 it ranked as the third largest field crop accounting for 6,806 thousand hectares of acreage (Statistics Canada, 2011). The most obvious consequence of insufficient pollination is that crop value and yields are likely to suffer translating into lower quality and variety of products available to consumers who will also end up paying higher prices (Kevan and Phillips, 2001). The Role of managed honeybees has grown in recent years due to increased acreage of monocrops and the decline of wild pollinators (Rucker et al., 2005). “The elimination of feral bee colonies represents a rightward shift in the demand for commercial pollination services and a spur to contracting and markets” (Rucker et al., 2005, p.7). Amidst the current global decline of pollinators, the need for crop pollination is now greater than ever. Canadian apiarists can potentially increase profits by offering pollination services to growers thereby diversifying their farm business, and adding another source of income. The aim of this study is to examine how the size and the number of products and services offered by beekeepers, such as commercial pollination, affect their profits.

### 1.3 Research Problem Statement

Are honeybee keepers in Canada maximizing their profits by increasing the number of colonies they manage, or by diversifying their apiaries to offer more products or services? Which of these paths offers the most profit for apiarists? Canadian apiarists would benefit from this study by learning how their fellow beekeepers are managing their operations and the effects size and enterprise management practices are having on profits. Regional beekeeping associations also stand to gain from this research by using the findings to offer their members the most pertinent information for expanding or diversifying operations.

In some industries, size of operation is the most significant indicator of profits while in other cases diversification allows entrepreneurs to secure the most profit. Expansion or diversification of an existing apiary present two opportunities for increasing profits, but it is not clear which of these two options has the greatest potential to affect profitability.

The economic problem this research aims to address is whether the size or diversity of an apiary affects its profits. The proposed research will focus on honeybee keepers in Canada who are engaged in honey production, commercial pollination, nuc and queen breeding, or production of wax, jelly, or pollen either as hobbyists or full time, commercial apiarists.

## 1.4 Research Purpose and Objectives

The purpose of this research is to identify the differences in profits per colony between different sizes of apiaries and levels of diversification in Canada.

The objectives of the proposed research are as follows:

1. To collect primary information on sales, costs, number of colonies, and apiary products and services of Canadian beekeepers
2. To determine whether size and level of diversity of an operation has an influence on profit per colony, and
3. To determine whether there is a relationship between apiary size and level of diversification

## 1.5 Summary

Canada's honey beekeeping industry is changing: its consolidation suggests that apiarists are aiming to secure profits by increasing the size of their operations. There is also potential for Canadian beekeepers to increase profits through enterprise diversification. It is imperative that strategies for achieving economic viability in a farming sector that is so important to both agriculture and the environment be examined. The remainder of this paper is divided into four sections. First, a review of pertinent concepts in beekeeping such as apiary activities, trade-offs, and the relationship between farm size and diversity will be provided. Subsequently, methods and data necessary for the proposed analysis will be explained. Next, the results of the survey and findings about the relationships between apiary profits, farm size, and diversification as well as barriers to diversification will be discussed. Finally, perspectives from the European Union will be offered to propose new beekeeping industry and policy initiatives for Canada's apiarists.

## 2. THE BUZZ: GENERAL CONCEPTS OF BEEKEEPING FARM OPERATIONS

The purpose of this research is to determine whether the size and diversity of apiaries affect their profits and to propose ways for the Canadian honey beekeeping industry to improve upon its profitability. The objective of this section is to review economic concepts in beekeeping as well as the discourse on the relationship between farm size and diversification, and relevant research gaps motivating this study.

### 2.1 Apiary Productivity

Beekeeping, like most farming activities, is about choices and trade-offs between outputs. Most beekeepers must choose between producing honey and related goods, and offering pollination services. While some of these outputs can be complimentary, they can also be viewed as substitutes from the apiarists' point of view given the volatility of prices in agricultural markets.

The primary input in apiculture is the honeybee colony. Beekeeping, and the decision to produce honey versus offering pollination services represents an example of what Meade (1952) has described as a case where production in one industry reacts to production in another industry. Beekeepers, like most farmers have to make difficult decisions given the trade-offs between honey production and pollination even when these enterprises are viewed as being complementary. Table 1 offers a look at some of the trade-offs between honey and pollination for Canadian crops. Crops that are the most reliant on pollination do not always offer the best nectar for producing marketable honey. What follows is a discussion into the trade-offs between different apiary enterprises.

Table 1. Honey producing potential from Canadian crops

| Pollinated crops | Dependence on honeybee pollination (%) | Quality of honey | Canadian region of production |
|---|---|---|---|
| Alfalfa | 10 | High | MB |
| Apples | 85 | High | NS, NB, QC, ON |
| Apricots | 56 | Moderate | ON, BC |
| Blueberries | 90 | Low | NL, NS, PEI, NB, QC, ON, BC |
| Buckwheat | 64 | High | ON, MB |
| Canola | 18 | Low | ON, MB, SK, AB |
| Clover seed | 70 | High | MB |
| Cranberries | 90 | Low | BC |
| Cucumbers | 90 | Low | ON, BC |
| Fava beans | 40 | High | MB |
| Grapes | 1 | Low | QC, ON, BC |
| Gourds | 60 | Moderate | QC, ON, MB |
| Melons | 80 | Moderate | BC |
| Nectarines | 28 | Low | ON, BC |
| Peaches | 28 | Low | ON, BC |
| Pears | 90 | Low | ON, BC |
| Plums | 72 | Moderate | ON, BC |
| Pumpkins | 60 | Moderate | QC, ON, MB, BC, |
| Raspberries | 72 | Moderate | NL, NS, PEI, NB, QC, ON, MB, SK, AB, BC |
| Sour cherries | 63 | Low | BC |
| Soybeans | 5 | High | ON |
| Strawberries | 24 | Low | NL, NS, PEI, NB, QC, ON, MB, SK, AB, BC |
| Sunflower | 16 | Moderate | MB |
| Sweet cherries | 90 | Low | ON, BC |

Sources: CAPA (1999), Jaycock (1985)

### 2.1.1 Honey and Pollination Services

Honey

"Honey is the natural sweet substance produced by honeybees from the nectar of blossoms or from the secretion of living parts of plants […], which honeybees collect, transform and combine with specific substances of their own, store and leave in the honey comb to ripen and mature" (Codex Alimentarius, 1989 cited by Krell, 1996, p. 2.1). Since ancient times, honey has been the most economically important product of beekeeping (Ibid). Plants best suited for honey production include legumes such as alfalfa and clovers as opposed to fruit trees which generally have lower nectar flows, with the exception of citrus fruit (Cheung, 1973). Bees feed off of nectar and as such, they must be given the opportunity to produce honey in order to increase their productivity (Meade, 1952). Low honey yield from fruit trees is often attributable to the short time period devoted to pollination as well as yield dependence on seasonal cycles (Ibid). Although beekeepers can specialize in honey, there is a strong incentive to offer pollination services as well given the joint productive nature of honey and pollination services; this is the predominant feature of the economics of beekeeping (Cheung, 1973). It is difficult to assess the economic value of honey without taking into account pollination, which is the fundamental required activity for honey production.

Pollination

"The practice of relocating hives from farm to farm, by truck, enables the beekeeper to obtain multiple crops a year, either in rendering pollination service or in extracting honey" (Cheung, 1973, p.16). Pollination markets fluctuate between seasons forcing beekeepers to make careful production decisions (Ibid). Pollination fees vary by crop season, but other factors may also come into play. Crops differ in the timing of their bloom, the fees crop growers are willing to pay for the pollination services of bees, and the amount and quality of nectar and pollen that crops provide to bees as food (Ibid p.8). Tree fruit, berries, and vegetables are among the most pollinator-reliant crops for producing uniform, high quality yields (Rucker et al., 2005). The rental value of hives is at its highest during the late spring followed by the major honey season, and lowest in early spring (Cheung, 1973). Annual cycles of bees and honey production vary according to the relative prices of honey and pollination services (Champetier, 2010). "Pollination fees vary inversely with the amount of honey that can be produced from the pollinated crop" (Ibid, p.5). When forage crops do not provide adequate, or palpable nectar, pollination fees will be higher (Rucker et al., 2005). Pollination markets function by taking into account the pollination value of bees to growers as well as the value of honey produced to apiarists (Ibid). The market rate at which beekeepers are willing to offer pollination services is a function of the costs of keeping bees (Burgett et al., 2004). Findings by Rucker et al. (2005) do not support the conjecture that honey and pollination are substitutes, or that beekeepers will chose to offer more pollination services when the price of honey is deemed low.

### 2.1.2 Queen Rearing and Nuc Breeding

Queen Rearing

The queen bee is the dominant reproductive female of her colony; she carries all of the genetic traits of her subjects and helps to maintain the colony's strength and industry by producing eggs (Laidlaw and Eckert, 1962). A well-bred queen should be disease-resistant, capable of laying many eggs, produce gentle brood, and be a good honey producer.

The process of rearing queens is describes as being relatively simple provided that a beekeeper already has a strong colony and a queen with good traits (Withers, 2002). An adequate population of young bees is needed to feed and care for the young larvae and provide the necessary temperature in the hive. One single colony can be used to produce enough successor queens, and some for sale as well as some for sale (Withers, 2002).

Only larvae from fertilized female eggs can develop into a queen if it is properly nourished and cared for by the colony. "In the natural course of colony activities, queens are reared only under three major impulses: queenlessness, swarming, and supersedure" (Laidlaw and Eckert, 1962, p.15). While swarming refers to the separation and development of a new colony, supersedure occurs when a queen needs to be replaced because of her age (Ibid). Withers (2002) described three approaches for raising queens that are simple enough for all beekeepers: queenless cell raising, queenright cell raising, and raising one queen in a nucleus. Some methods for queen rearing such as artificial insemination, and controlled mating are quite complex and require specialized equipment (Laidlaw and Eckert, 1962). However, the methods described by Withers (2002) are simpler, and require very little extra equipment, most of which can either be easily made, or purchased at low cost.

According to the Honey Council of Canada (2011) a solitary queen bee can fetch between $15 and $40, with additional fees to have them clipped or marked. Queen breading presents little disruption to normal hive activities such as foraging, pollinating, and honey production (Withers, 2002). However, beekeepers may find it time-consuming to produce a sufficient volume of queens to generate considerable extra revenue from this activity. Nonetheless, given the low level of interference with other apiary activities and the limited requirements in terms of equipment, queen breading appears to be a simple enterprise for beekeepers that could, at the very least, save on the cost of purchasing new queens.

Nuc and Package Breeding

A nuc, or nucleus consists of three or five frames of bees and a laying queen, supplied in a box, and used to start a new colony (Joycock, 1985). Similar to queen breeding, making nucs and splitting hives is a fairly simple procedure (Ibid). Hive splitting and nuc-making are relatively simple and requires little additional equipment. New nucs are usually achieved by swarming, which occurs when worker bees begin to create a new colony by following a queen who leaves the nest. (Laidlaw and Eckert, 1962). Packages of bees usually include a queen, and depending on the weight of the package (usually measured in pounds), sales can range between $80 and $120 according to the Honey Council of Canada's Internet classified ads (http://www.honeycouncil.ca/index.php/classifieds). Similar to queen rearing, nuc-making poses little interference with other apiary activities, and requires little time, equipment, or effort. Nuc-making is far more profitable than queen breeding alone, and as such should be considered by any beekeeper that plans to raise queens.

### 2.1.3 Wax, Pollen and Jelly

Beeswax

Beeswax is produced by worker bees using carbohydrates to build honeycomb cells for nesting and storage of honey and pollen (Krell, 1996). Beeswax is produced from old hive combs, which should be removed regularly to encourage more comb production and avoid infection from dirt build-up (Bogdanov, 2009). Raw beeswax can easily be collected by placing combs on a sun melter, a special piece of equipment designed to hold frames and collect melted wax; these can be constructed or purchased (Ibid). The type of hive being used makes a big difference: moveable frame hives are designed to maximize honey production: "Using these sorts of hives, the ratio of honey to beeswax production is approximately 75:1[…] The ratio of honey and beeswax production using fixed comb or movable-comb hives is about 10:1" (Bradbear, 2009, p.104). Beeswax is typically used for foundation sheets to be processed into cosmetics, pharmaceuticals, and candles or similar artisan products (Krell, 1996). "One kilogram of beeswax is worth more than one kilogram of honey" (Bradbear, 2009, p.103). Beeswax, as a natural byproduct of beekeeping, which can easily be harvested from discarded combs, presents an excellent opportunity for added revenue from beekeeping. However, depending on the choice of hive, there can be considerable tradeoffs with honey production, but the higher value of beeswax may, in some cases, offset these tradeoffs.

### Pollen

Pollen collected by honeybees in their daily foraging activities is usually mixed with nectar or regurgitated honey in order to make it stick together and adhere to their hind legs (Bradbear, 2009). "After bees gather pollen from flowers they carry it back to their nest as pellets of pollen stored in hair 'baskets' on their back legs. It is possible to harvest these pollen pellets by placing a wire mesh at the hive entrance." (Ibid, p.113). The resulting pollen pellets harvested from a bee colony are therefore usually sweet in taste though certain pollen types are very rich in oils and stick together without nectar or honey (Krell, 1996, p. 3.1) Pollen traps, which consist of a frame and mesh sheeting remove pollen pellets from the bees before they enter the hive (Ibid). Pollen traps can be purchased inexpensively (starting at $10 per trap) according to the Honey Council of Canada's classified ad Internet site (2011). Bee pollen is typically used as a food or vitamin supplement, as well as in the manufacturing of cosmetics (FAO, 2011). Commercial sale of raw bee pollen fetches approximately $5 per 100g, depending on the form, and purity of the product (HCC, 2011). Collection and sale of bee pollen is a relatively simple and inexpensive apiary enterprise. However, Bradbear (2009) cautions that beekeeper must be careful not to collect too much pollen from a single colony as this forces bees to seek out more pollen for honey production potentially leading to exhaustion or reduced lifespan.  Since pollen collection could take away from honey (and wax) production, this activity is likely to be most appropriate for larger operations.

Royal Jelly

Royal Jelly is a secretion from the glands of young, worker bees used to feed larvae and the adult queen bee (Krell, 1996).  While production of royal jelly requires little investment, it is necessary to use removable comb hives (Ibid). "Expert personnel are required, who are able to devote considerably more time than is commonly required for the production of other bee products." (Ibid, p.6.5).  Although royal jelly can be sold fresh, either frozen or refrigerated, most companies selling this product on the Internet combine it with honey as a preservative.  In addition to being sold as extra feed for honeybee colonies, royal jelly can also be used as a dietary supplement, and as an ingredient in food, and cosmetics (HCC, 2011). Classified ads on the Honey Council of Canada's Internet site suggest that 100 grams of pure royal jelly can fetch between $30 and $50 (2011).  "A well-managed hive during a season of 5-6 months can produce approximately 500g of royal jelly"(Krell, 1996, p.6.6).  Although production of royal jelly does not enter into competition with other hive activities, and requires little investment, a high level of skill and time commitment are necessary.  Thus, production of royal jelly is likely to be most profitable and accessible for large-scale commercial beekeepers who possess the necessary training and knowledge.  With a better understanding of apiary activities in place, the discussion now turns to a description of farm size and enterprise diversification.

## 2.2 Farm Size and Diversification

Farm size and diversification are the two main concepts believed to be affecting apiary profits in this study. What follows is an overview of how prior, relevant research has defined and examined these concepts. To define and measure apiary size and diversification, this section surveys a number of pertinent studies that look at the relationship between farm size and diversification, which prior to White and Irwin's 1972 paper entitled *Farm Size and Specialization* were treated as unrelated forces.

### 2.2.1 Definition and Measurement of Farm Size

Competing concepts of farms size are especially important for this type of study because different measures of size are more appropriate for different objectives. Literature on the relationship between farm size and diversification is divided into two camps: those who use productive inputs as a measure of farm size and those who favour the use of output or sales. One key question for this study is whether to include off-farm income as a form of diversification.

The first study on the subject of farm size and diversification by White and Irwin (1972) employed input measures as the best way of grouping farms by size. Similarly, Sumner and Wolfe (2002) chose to use the number of production units, cows in their case. Weiss and Briglauer (2002) also measured size of farms based on the number of livestock (production) units. Conversely, Mishra et al. (2004) measured farm size by the value of the agricultural products sold. It is not clear how farm size was determined for Pope and Prescott's (1980) analysis since their data came from the U.S. Agricultural Census and no details on farm size classification are provided.

While employing different measures of farm size may lead to different conclusions about relationships, there is no evidence to suggest that the measure employed affected the findings in any of these studies. Using an input-based measure of farm size, White and Irwin (1972) concluded that larger farms are more specialized; Mishra et al. (2004) arrived at the same conclusion measuring farm size in terms of output sales. Thus, while it is important to use an appropriate measure, results are not necessarily likelier to lean in one direction or another where the size-diversification relationship is concerned. After carefully considering the literature on farm size and diversification and the objectives of this project, it has been determined that the definition of farm size employed by Sumner and Wolfe (2002) and Weiss and Briglauer (2002) is most appropriate. For the proposed research, farm size will be measured by the number of productive units (honeybee colonies).

### 2.2.2 Definition and Measurement of Diversification

Diversification “may be defined as the presence of multiple production enterprises with distinct marketed outputs in a single management unit” (Johnson, 1967 cited by Sumner and Wolfe, 2002, p. 447). While all of the definition of diversification presented by the authors surveyed resembled that cited by Sumner and Wolfe above, those activities that may be considered as forms of diversification remain unclear. For example, the secondary data used by White and Irwin (1972) involved pre-determined measures of specialization and therefore it is unclear whether off-farm activity was counted as an enterprise. Pope and Prescott (1980) chose to limit their study to on-farm sources of income to avoid biased results since United States Department of Agriculture data showed that smaller farms had a tendency to obtain more of their income from off-farm sources in contrast to larger farms (Ibid). Sumner and Wolfe (2002) opted for a farm-based definition composed of income from livestock, crop, government payments, and other farm income. However, Weiss and Briglauer (2002) focused much of their attention on the fact that that previous studies on the relationship between farm size and diversity failed to considers off-farm income as a form of diversification. While it was found that the existence of additional off-farm income reduced the degree of diversification, it was not clear whether inclusion or exclusion of off-farm income led to more significant results (Ibid). Similarly, Mishra et al. (2004) found fault with previous studies neglecting to control for off-farm income. Although off-farm sources of income are common in many farming households, the focus of the current study is to examine profits from beekeeping operations, specifically those implying bees as the main productive units. The current research will follow the approaches adopted by Pope and Prescott (1980), and Sumner and Wolfe (2002) in favour of limiting diversification to on-farm sources of income. Since the proposed research is concerned with profit from beekeeping activity, diversification will only include on-farm activity related to bees such as honey and honey products, commercial pollination, and bee breeding.

An appropriate measure of diversification is essential in order to effectively analyze the relationship between diversification and farm size. Prior research in this area suggests that more than one measure of farm diversification should be employed, the choice of which appears to be particular to each specific case. Of the five studies on diversification surveyed, only two employed more than one measure of diversification. First, Pope and Prescott (1980) used four different measures of diversification including an index of maximum proportions, a simple count of on-farm enterprises, a Herfindahl index and an entropy index in conjunction with ordinary least squares regression for their analysis. Second, Weiss and Briglauer (2002) employed three measures of diversification: a modified concentration ratio, a Berry index, and an entropy measure. Conversely, White and Irwin (1972) focused on the concept of specialization as defined U.S. Census of Agriculture data, and therefore required no measure of diversification. Sumner and Wolfe (2002) developed their own diversification index: "Diversification = [Cash farm sales - Milk sales] /Cash farm sales" (p.448). Mishra et al. (2004) used a mean-variance approach in conjunction with an entropy index and no other measure of diversification.

In addition to these farm-specific case studies, further literature has been devoted to measurement of diversification in non-agricultural industries. In *On Measuring Economic Diversification* Hackbart and Anderson (1975) sought to find a method for measuring economic diversification by applying a Shannon entropy function sectoral employment shares (Ibid). The entropy measure provides a precise definition of economic diversification as well as a direct measure for comparing diversity in different regions or over time (Ibid). However, two self-identified pitfalls of the measure proposed by Hackbart and Anderson (Ibid) are that it does not address "what constitutes an optimal diversification pattern", nor does it "establish a causal relationship between economic diversification and economic development policy variables" (p.378).

In *A Generalized Index of Diversification in U.S. Manufacturing* Gollop and Monahan, 1991) aimed to formally incorporate a continuous measure of product heterogeneity into a Herfindahl-based index. Gollop and Monahan (Ibid) posit that a good diversification index should vary directly with the number of different products produced; vary inversely with the increasingly unequal distribution of products across the line; vary directly with the dissimilarity or heterogeneity of products; have scope, apply equally well to plants, firms, and industries, and; be bounded between zero and unity. The ideal form in this case is a Herfindahl index, which measures corporate diversification (Ibid). Gollop and Monahan (Ibid) note that incorporation of a continuous measure of product heterogeneity into an index of diversification added more than 50% to the value of the indexes than if product heterogeneity had been ignored (Ibid).

For the proposed research, an ideal measure of diversification should vary directly with the number of different goods and services offered, and vary inversely with the increasingly unequal distribution of products across the line (Ibid). Using an entropy measure may be problematic for this study given that it is a logarithmic function and some of the survey data used may contain zeros as values; the logarithm of zero is undefined. The index proposed by Hackbart and Anderson (1975) may not be attainable given data constraints. After carefully considering the approaches employed for measuring diversification in similar studies, it has been determined that an index based on size or output would also pose complications because both size and output are represented by other variables under scrutiny. A Herfindahl index, similar to the one employed by Gollop and Monahan (1991) will be helpful in measuring the share of profits from each apiary enterprise within each beekeeping operation. Another useful diversification index is the one used by Sumner and Wolfe (2002) to provide a measure of diversification in relation to the dominant enterprise in a beekeeping operation: honey.

## 2.3 Farm Size and Diversification Discourse

The purpose of this study is to determine whether size and diversification affect apiary profits. If size and level of diversification of a farm operation are linked, this may also have implications for profits. Diversification in farming allows farmers to exploit “cost advantages that emerge from the existence of joint production facilities” (Weiss and Briglauer, 1972, p.3). However, the debate over the relationship between farm size and diversification is split.

There is a growing body of literature suggesting that size may be a determinant of farm diversification beginning with White and Irwin’s 1972 article *Farm Size and Specialization*. This study represents a first look at how farm size and diversification (versus specialization) are related contrasting with prior studies that treated them as distinct forces. Using Census of Agriculture data at five-year intervals, farm size classifications and measures of specialization, White and Irwin (Ibid) looked for relationships between size and degree of specialization (or lack of specialization) of farms across the United States. Though evidence was weak, it was found that larger farms tend to be more specialized (Ibid). The study concluded that increased size and specialization are strongly related for some types of farm enterprises such as cash grain, field crops, poultry, and livestock, but not for others (Ibid). White and Irwin (Ibid) also concluded that no particular enterprises were any more important to large farms.

Beginning with the premise set out by White and Irwin (1972), Pope and Prescott (1980) assumed that larger farms tend to be more specialized. *Diversification in Relation to Farm Size and Other Socioeconomic Characteristics* was a closer examination of farm size in relation to trade-offs between risk reduction and benefits from diversification (Ibid). The survey’s purpose was to analyze the relationship between farm size and characteristics, socioeconomic variables, and diversification (Ibid). The analysis by Pope and Prescott (Ibid) did not yield any significant relationship between larger farms and an affinity for diversification.

*Farm Diversification as an Adjustment Strategy on the Urban Fringe of the West Midlands* is an examination of the development of farm diversification outlining some of the characteristic features associated with the development of farm diversification (Ibery, 1991). The purpose of farm diversification proposed by Ibery (Ibid) is that to maintain or increase incomes farmers seek economies of scale, either through intensification, specialization, or by increasing farm size (Ibid). "This study restricts the definition of farm diversification to farm-centred activities and excludes income generated from, and labour involved in off-farm activities" (Ibid, p.209). Ibery (Ibid) found that diversification tends to increase as the size of the farm increases.

Sumner and Wolfe (2002) picked up where the debate had apparently trailed off more than twenty years earlier with *Diversification, Vertical Integration and Regional Pattern of Dairy Farm Size*. They began by pointing out that "Past research indicates that there is a tradeoff between diversification and farm size…" in reference to White and Irwin (1972, p.447). The study is mainly concerned with empirical questions of patterns and size distribution of U.S. dairy farms as well as how diversification and other farm characteristics relate to these patterns. Sumner and Wolfe (Ibid) concluded that diversification accounted for little variation in farm size.

*Determinants and Dynamics of Farm Diversification* shed more light on the relationship between farm size and diversification by taking into account off-farm activities and changes in farm size over time (Weiss and Briglauer, 2002). The purpose was to examine the determinants and dynamics of farm production (in Upper Austria) on the level and the dynamics of on-farm diversification. Using panel data, Weiss and Briglauer (Ibid) employed three measures of diversification similar to those used by Pope and Prescott (1980). The findings showed a positive relationship between farm size and diversification.

In 2004, Mishra et al. produced a paper entitled *Factors Affecting Farm Enterprise Diversification*. The purpose was to examine factors associated with farm enterprise diversification in the United Sates in 1996 and 2000. The study looked at the potential impact of commodity program payments on diversification to identify farm business, operator, and farm household characteristics associated with on-farm enterprise diversification (Ibid). Farm size measured by the value of the agricultural products sold was found to be significantly and inversely related to farm diversification.

Taking a slightly different approach, Aubert and Perrier-Cornet (2010) identified explanatory factors for diversification of wineries in France in *La diversification des activités dans les exploitations viticoles françaises*. Resources, skills, and environment in which the farm evolves are chief factors in determining diversification of enterprise (Ibid). The most important factors in deciding to diversify were skills and input resources of the farm (Ibid). Aubert and Perrier-Cornet (Ibid.) also found a positive link between diversification, production characteristics, and location. Availability of input resources was found to be a necessary and sufficient condition for diversification potential as well as a possible indicator of expansion (Ibid). This paper suggests that productive inputs are positively linked to the decision to diversify. Aubert and Perrier-Cornet's (Ibid.) findings can be interpreted as evidence that larger farms tend to be more inclined to diversify the line of goods and services they offer.

Table 2 shows that out of seven studies surveyed, two found that larger farms are likelier to be more specialized whereas three more studies found that larger farms are likelier to diversify, and two studies found no significant relationship. It appears that the debate lies slightly in favour of larger farm operations favouring diversification.

Table 2. Literature summary on the relationship between farm size and diversification

| Author(s), year | Study Focus | Relationship between farm size and diversification | Conclusion |
|---|---|---|---|
| White & Irwin, 1972 | U.S. Census of Agriculture Data over five years | Larger farms are more specialized | Big farms specialize |
| Pope & Prescott, 1980 | Mix of U.S. farms and socio-economic characteristics | Larger farms not necessarily more specialized, even if economies of scale are possible | Inconclusive |
| Ibery, 1991 | England | Diversification increases with farm size | Big farms diversify |
| Sumner & Wolfe, 2002 | Size and distribution of dairy farms in the U.S. | Diversification/specialization accounts for little variation in size | Inconclusive |
| Weiss & Briglauer, 2002 | Longitudinal panel study of various Austrian farm types | Positive relationship between farm size and diversification | Big farms diversify |
| Mishra et al., 2004 | Policy factors in the U.S. impact of farm diversification | Farm size (measured in output value) is inversely related to diversification | Big farms specialize |
| Aubert & Perrier-Cornet, 2010 | Factors facilitating diversification in the French viticulture industry | Farms with more input resources tend to be more apt at diversification | Big farms diversify |

## 2.4 Research Gaps

The relationship between profits, farm size, and diversification is of particular importance to this research because of the effects these variables have on profits. While it is generally taken for granted that larger operations tend to generate more output through the logic of economies of scale, it is not known whether this relationship is significant for beekeeping operations. Similarly, the concept of economies of scope generally accounts for the increased efficiency from producing several outputs that use the same inputs. Although it is not the purpose of this study to identify the presence of economies of scale or scope, the effects of size and enterprise diversity on profits may offer some insight into more profitable management practices for apiaries.

First, it must be determined how profits are affected by the size and level of diversification of a farming operation. Does the size of an apiary have the greatest effect on its profits, or is it the level of diversification that accounts for changes in revenue? These questions have never been posed for apiaries.

Second, beekeeping is an ideal example of a multi-product firm that uses the same, principal input, namely honeybees. Yet, heretofore no one has sought to examine the relationship between beekeepers' profits and diversity, or number of apiary enterprises. Beekeeping also offers an ideal farm type in which to investigate the relationship between farm size and diversification. Despite the growing body of literature scrutinizing the relationship between farm size and diversification, apiaries have yet to be studied in this respect.

Last, research on the economics of beekeeping in Canada is limited. This study represents an opportunity to learn how Canada's apiary profits fluctuate with the size and diversity of operations, especially given the challenges Canadian beekeepers are now facing.

## 2.5 Summary

Apiarists are professional decision-makers, constantly weighing their output options in a volatile environment; most of which is a function of seasonality and anticipated crop values. While honey production and pollination services may seem like substitutes in the short run, they are in fact complementary in the longer run.

Farm size and diversification are two key concepts that not only define the parameters of this study, but are also an important focus in their own right. Farm size can be defined and measured in different ways; for this study apiary size will be quantified in terms of productive units: honeybee colonies. Diversification can also be defined in a number of ways based on the type of operation under consideration. For this study, diversification will be limited to enterprises in which honeybees are the primary productive input.

The current paper seeks to examine whether the size and number of products and services apiaries offer affect their profits as well as whether size and diversification are interrelated. It is hoped that this goal will be achieved through comparisons between different types of beekeeping operations, using a range of different methods and information.

# 3. BEE-LINE: DATA AND METHODS

The Canadian honey beekeeping industry's consolidation over the last two decades offers an ideal context in which to investigate the relationship between apiary profits, farm size, and diversification. The economic characteristics and practices of beekeepers can offer more insight into what is currently taking place in Canadian apiculture. It is therefore a main objective of this research to survey beekeepers about their operations and learn about their management techniques.

## 3.1 Data Collection

This particular research is concerned with the effects of farm size and level of diversification on apiary profits. Since most the required data for this research is not available from any public source, a survey specifically intended for this study is necessary. The primary data collection tool for this study is a survey questionnaire administered to Canadian beekeepers about their operations during the 2010 beekeeping season (Appendix A).

### 3.1.1 Survey Questionnaire Overview

The 2010 Beekeeping Survey was a collaborative effort between researchers in the Economic Working Group of the Natural Sciences and Engineering Research Council of Canada's Canadian Pollination Initiative (NSERC - CANPOLIN) at the University of Guelph's Department of Food, Agricultural and Resource Economics and the University of British Columbia's *Apis mellifera* Proteomics of Innate resistance (APIS) project. The survey was designed using Snap 10 Professional survey software, version 10.

The 2010 Beekeeping Survey questionnaire included eleven sections mainly looking at economic and demographic characteristics of Canadian beekeepers. The introductory part of the survey asked beekeepers to classify their status as a beekeeper (full time, hobby, part-time), the products and services they offered, the number of years they have been keeping bees, their age, level of education, and whether they were the sole operator of their apiary. Section One of the survey covered questions on location and number of colonies. Section Two focused on income and revenue with questions on proportion of income from beekeeping, as well as quantities and value of apiary outputs. Section Three included two questions on hired labour value and time. Section Four, which focused on honey production, asked respondents about the crops their bees foraged on, and types of contracts used. Section Five was similar to Section Four in that it posed the same questions only in relation to pollination services. The sixth section focused on pest prevention and management practices as well as colony losses and their suspected causes. Section Eight, designed specifically for the University of British Columbia's APIS project was on queen sourcing. Section Nine consisted of only one question asking respondents about the vehicles they owned. The final section of this survey consisted of follow-up and contact information questions for clarification of questionnaire responses, and also if respondents were interested in obtaining a report of the study findings.

The questionnaire counted a total of 42 questions to which respondents were free to answer, or not be they completing the questionnaire electronically, or in print. Depending on the answers given to certain questions, subsequent questions may have been skipped, or redirected to a more specific set of questions. For example, at the beginning of Section Five on pollination respondents were asked if they used any of their colonies for commercial pollination in 2010; if the answer was "yes", the questionnaire was redirected to a more specific set of questions on this topic concluding with a question about the biggest obstacles the beekeeper faced in getting started with this particular enterprise. However, if the respondent answered that they did not use any of their colonies for pollination, they were instead asked about the most important reasons behind their decision not to offer pollination services before proceeding to the subsequent section on the survey. While this re-directing of questions was programmed into the electronic survey, and occurred automatically, in the print version of the questionnaire (found in Appendix A), instructions on which question to proceed to next were written next to the answer choices.

### 3.1.2 Sample Recruitment, Survey Distribution, and Population Sample

Announcements in French and English inviting beekeepers to participate in the 2010 Beekeeping Survey including a simple web address were sent out electronically to provincial apiarists, regional beekeeping and producer associations, and national organizations such as the Honey Council of Canada to be featured in their electronic, and printed newsletters and on their websites. The advertisements also included information on how to obtain a printed version of the survey by mail for those beekeepers who preferred this format. The decision to offer surveys in print as well as electronically was to ensure that beekeepers without Internet access were not excluded from the sample. Due to time constraints, telephone, or in-person interviews were not possible.

The NSERC-CANPOLIN website (http://www.uoguelph.ca/canpolin/index.html) was the primary tool for administering the survey. The on-line survey was made available on June 20$^{th}$, 2011 and closed on December 1$^{st}$, 2011. Reminders and requests to re-post, or update the survey announcement were sent to the aforementioned beekeeping organizations in late September as this signals the end of the busy season for most beekeepers in Canada. In-person recruitment also took place at the British Columbia Honey Producers' Association in late October as well as the Ontario Beekeepers Association's annual general meeting in November.

The Honey Council of Canada (2011) reports that there are approximately 7,000 beekeepers in Canada operating a total of 600,000 colonies of honeybees, 80% of which are commercially operated while the remainder is run by hobbyists. The Prairie provinces of Alberta Saskatchewan and Manitoba are the major honey producers in Canada. Approximately 475,000 colonies are located in the Prairies, which produce 80% of Canada's honey crop. A representative sample should include a significantly larger proportion of commercial beekeepers than hobbyists. Similarly, the majority of survey respondents should be from Alberta Saskatchewan and Manitoba in order to be representative of the current distribution of Canadian honeybee colonies. One question on the survey asked respondents in which postal code the majority of their colonies are located for the purpose of identifying this demographic characteristic. There is no data currently available on the average number of colonies per beekeeper in Canada. Nevertheless, it is important to obtain a wide range of apiary sizes to effectively test the relevance of apiary size and diversification on profits.

## 3.2 Research Questions and Hypotheses

This study seeks to determine whether the size and diversity of an apiary affects its profits. The question that motivates this research is whether there is any relationship between apiary profits, size, and level of diversification. First, to gain some insight into apiary diversification, two indexes will be calculated: a Herfindahl and an index of diversification. Second, simple linear regression will be employed to determine whether changes in apiary profits are related to size or diversity of operations. The same method will also be used to determine whether changes in farm size can explain the diversity of apiary enterprises.

Diversification indexes will be employed to gain some insight into the level of diversification of some of the cases surveyed. For this, information on total apiary revenue (in sales dollars), as well as sales by apiary activity will be used to calculate these indexes. Total revenue is defined as the total sales value generated by each lucrative activity in which honeybees are the main productive input such as honey, pollination, queen breeding, nuc and package breeding, and pollen, wax, or jelly production.

First, a Herfindahl index, like that employed by Gollop and Monahan (1991) will provide a measure of the degree of concentration for each observation in the sample which contains sufficient revenue and enterprise information. For the Herfindahl index, the dollar value in sales from each apiary product or service is converted into a proportional share of the whole apiary's revenues, squared, then summed with the other squared shares to obtain an index value. Where E represents apiary enterprises, i is $i^{th}$ enterprise, and $s$ is the enterprise's profit share, equation (1) shows the Herfindahl index that will be used:

$$H_d=\sum^{E}_{i=1} s_i^2 \tag{1}$$

The Herfindhal generates an index value between zero and unity. The resulting index is a measure of concentration; if that number is greater than 0.25, this suggests that there is a high level of concentration in one particular apiary enterprise. If the Herfindahl index is below 0.25, this suggests that the operation is more diversified.

The second index of diversification that will be employed to measure enterprise concentration (and ensure that the findings are consistent) will be a modified version of Sumner and Wolf's (2002) diversification index:

$$\text{Diversification} = [\text{Cash farm sales - Milk sales}] /\text{Cash farm sales} \tag{2}$$

This diversification index will be adapted slightly to account for an apiary's main enterprise, honey:

$$\text{Divers} = (\text{Apiary sales - Honey sales}) \div \text{Apiary sales} \tag{3}$$

Similar to the Herfindhal index, this measure will produce a value between zero and one to indicate the degree of an operation's diversification. However, the significance of the values for the Divers index are opposite those generated by the Herfidahl: the diversification "index ranges from close to zero for specialized farms to well over 0.25 for farms [where the given enterprise] is only part of a diversified farming operation" (p.448).

These indexes will provide some indication of how diversified some apiaries in the sample are. The next step will be to use this information to test three hypotheses using a linear regression model.

Profit per colony is measured by subtracting total apiary costs from total sales and dividing the difference by the number of honeybee colonies. Size is defined as the number of honeybee colonies in operation in May of 2010.Number refers to the number of products and services offered for which honeybees are the primary input, let

$$\text{Profit} = \alpha + \beta_1 \text{Size} + \beta_2 \text{Number} \tag{4}$$

represent the relationship between apiary profit, size, and diversity.

Hypothesis 1: Profit Per Colony and Farm Size

$H_0$: There is no relationship between profit per colony of an apiary and its size.

Hypothesis 2: Profit Per Colony and Number of Apiary Enterprises

$H_0$: There is no relationship between profit per colony of an apiary and the number of products and services it offers.

Hypothesis 3: Farm Size and Enterprise Diversification

$H_0$: There is no relationship between the size of an apiary and its level of diversification. Where Size and Number are defined as before, let

$$\text{Number} = \alpha_0 + \alpha_1 \text{ Size} + \varepsilon \tag{5}$$

be the linear model to determine whether the number of apiary enterprises is attributable to the size of the operation. A Similar linear regression will be performed using the modified Divers index summarized above:

$$\text{Divers} = \delta_0 + \delta_1 \text{ Size} + \varepsilon \tag{6}$$

To supplement findings on the effect of apiary enterprises on profit, information on constraints beekeepers face in diversifying their operations may offer more insight into the profitability of apiaries. Pollination services will be used as an example of an additional apiary enterprise beekeepers could offer to earn extra income. Both barriers in getting started as well as deterrents will be considered by asking beekeepers who offer this service as well as those who do not.

### 3.3 Summary

This study is concerned with how relationships between the size and level of diversification of an apiary affect its profits and how this relates to current trends in consolidation of Canada's beekeeping industry. The 2010 Beekeeping Survey is the first of its kind in Canada in that it focuses on the economic practices of apiarists by looking at the size and diversity of their operations. Two diversification indexes will offer insight into the level of diversification represented in Canada's apiaries. In order to learn the effects of apiary size and diversification on profits, simple linear regression will be employed. Since the relationship between farm size and diversification continues to be debated, this study will contribute to the discourse using linear regression analysis will be employed to determine whether changes in the later can be explained by the former. Challenges and barriers to apiary enterprise diversification will also be explored using the example of commercial pollination services; this will offer more insight into where private and public innovation may be useful.

# 4. THE BEE'S KNEES: RESULTS AND DISCUSSION

The 2010 Beekeeping Survey was open from June 20th through December 1st, 2011 and covered a wide range of questions from general demographics to specific sales and costs figures from apiary enterprises across Canada. Questions that are of particular interest to this study relate to the profits, size, and enterprise diversity of Canadian beekeeping operations. The following section presents the survey's findings, examines the relationships between apiary profits, size, and enterprise diversification and looks at barriers and challenges to enterprise diversification.

## 4.1 Sample Description

Since there currently exist no publically available demographic details on Canada's honey beekeepers, it was important for this inquiry to capture some of those details to give an impression of who Canada's apiarists are and what they do. Although a total of 33 completed surveys were submitted on-line and by mail, the number of responses per question varied. Those questions receiving the lowest number of responses were those on apiary costs and sales while questions about general demographics received the highest response rate.

### 4.1.1 Beekeeper Sample Characteristics

In Canada, 80% of honey beekeepers are full-time commercial apiarists, the majority of which can be found in Alberta, Manitoba, Ontario and Quebec; however, not much else is know about this diverse group of farmers. Beekeeping status was the only demographically-related question on the 2010 Beekeeper Survey with a response rate of 100%. Out of 33 respondents, 12 indicated that they were either full time or commercial beekeepers, while 21 identified themselves as part time or hobbyist beekeepers. This ratio is actually the opposite of what the Honey Council of Canada (2011) reports.

As Table 3 indicates, the majority of survey respondents were between the ages of 40 and 59 years; this group accounted for 65% of the 32 survey participants who answered this question. The over 70 age category, though an option in the survey is absent from Table 3 because none of the respondents selected this as their age category. The age distribution found in the survey sample reflects the national average of farm operators: 54% of farmers in Canada are between the ages of 35 and 54 (Statistics Canada, 2006).

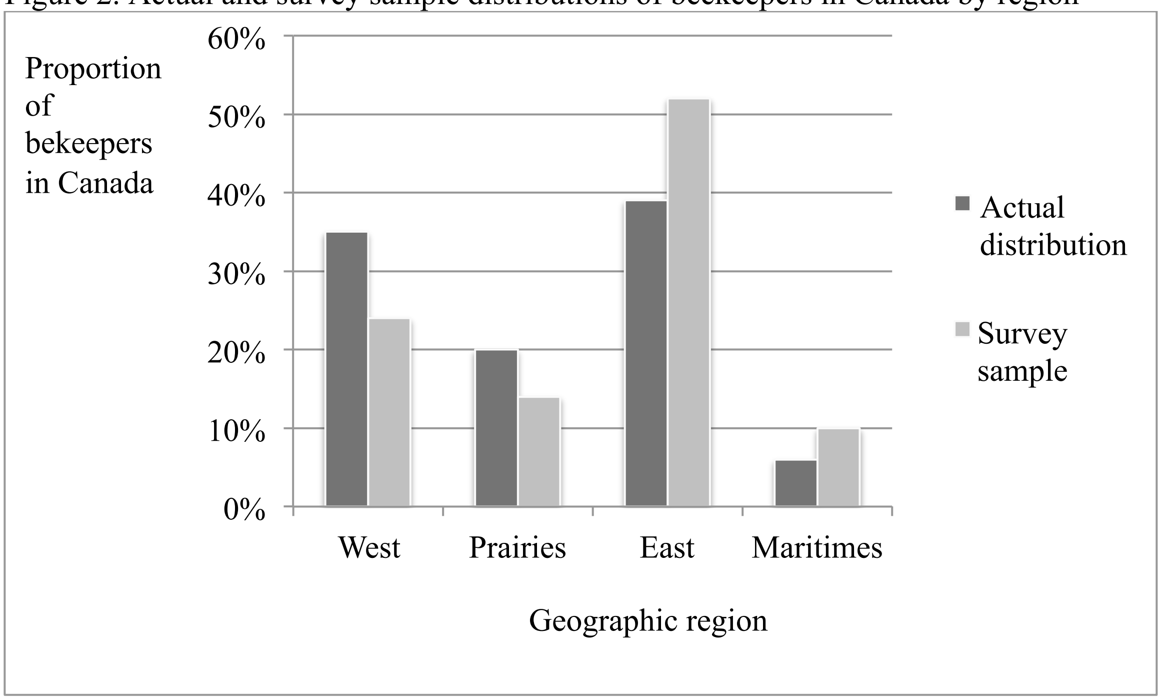
Table 3. Beekeeper characteristics (n = 32)

| Characteristics | Number (share) |
|---|---|
| Age | |
| 20-29 | 1 (3%) |
| 30-39 | 5 (16%) |
| 40-49 | 10 (31%) |
| 50-59 | 11 (34%) |
| 60-69 | 5 (16%) |
| Education | |
| Less than high school | 5 (16%) |
| High school diploma | 4 (12%) |
| College / cégep / trade school diploma | 10 (31%) |
| Undergraduate degree | 8 (25%) |
| Post graduate degree | 5 (16%) |

Out of 32 beekeepers who chose to identify their highest level of education, the majority reported having completed a college degree (31%) and 41% possessed university diplomas. The national average of Canadian farm operators who hold university degrees is 10% according to the 2006 Census of Agriculture (Statistics Canada, 2006).

Due to the low response rate of the survey, it was difficult to obtain a sample that was geographically representative of the distribution of beekeepers in Canada. Figure 2 shows the regional distribution of beekeepers who completed the survey compared to the actual distribution of beekeeper throughout Canada according the Canadian Socioeconomic Database of Statistics Canada (CANSIM) (2010). The ten provinces were grouped based on their geographic location: the Maritimes include Prince Edward Island, New Brunswick, Nova Scotia, Newfoundland and Labrador; the East consists of Ontario and Quebec, the Prairies include Manitoba and Saskatchewan, and the West is made up of Alberta and British Columbia.

Figure 2. Actual and survey sample distributions of beekeepers in Canada by region




Source: CANSIM, 2010

In comparing the survey sample distribution with the actual distribution of Canadian beekeepers, it is clear that the survey sample is not perfectly representative of the actual distribution. The provinces of Ontario and Quebec are overrepresented in the sample while the Prairies and West should take up a larger share. Nonetheless, the sample of beekeepers that completed the 2010 Beekeeping Survey is similar to the actual distribution in terms of regional rankings for highest number of beekeepers and honey production (CANSIM, 2010).

### 4.1.2 Apiary Characteristics

The information on apiary characteristics such as size and number of products and services offered in Canada is also limited. Data obtained from CANSIM (2010) indicates that there were just over 7,200 honey beekeepers in Canada operating some 617,264 colonies. Therefore the survey sample of 33 beekeepers and 29,247 colonies in total represents 0.4% of Canada's beekeepers and 0.5% of their honeybee colonies. 32 of the 33 respondents reported the number of colonies they operated in 2010; these numbers ranged between 1 and 17,000 with an average of 886 colonies and a standard deviation of 3008.

Enterprise diversification is an important factor in this study since beekeeping is a type of farming that lends itself particularly well to diversification and as such may present opportunities for increasing apiary profits. 29 of the beekeepers who completed the survey provided enough information to determine which products and services they offered, however, only 24 indicated in which province their honeybee colonies were located. Apiary enterprises, for this study were limited to goods and services in which honeybees were the main productive input; these include honey, queens, nucs and packages pollination, and wax, pollen, and jelly. Table 4 offers a summary of apiary activities by region based on the survey sample; it shows that beekeeping operations in the Eastern and Prairie provinces are the most diversified within the sample.

Table 4. Regional distribution of apiary enterprises (n = 24)

| Apiary enterprise | Maritimes (4%) | East (62%) | Prairies (13%) | West (21%) |
|---|---|---|---|---|
| Honey | 1 | 15 | 3 | 5 |
| Queens | | 3 | | |
| Nucs | | 5 | 2 | |
| Pollination | | 2 | 1 | |
| Wax, pollen, and jelly | | 2 | 2 | 1 |

Table 5 provides a summary of the different combinations of products and services offered by survey respondents. All of the beekeepers that provided information on apiary enterprises offered honey. The greatest number of apiary enterprises any single beekeeper in this survey was engaged in was four.

Table 5. Apiary enterprises (n=29)

| | Apiary products and services | | | | | |
|---|---|---|---|---|---|---|
| Number of Enterprises offered by apiaries | Honey | Pollination | Queens | Nucs | Wax, pollen, jelly | Number of beekeepers (share) |
| One | 11 | 0 | 0 | 0 | 0 | 11 (38%) |
| Two | 4 | 0 | 1 | 1 | 2 | 4 (14%) |
| Three | 9 | 5 | 2 | 7 | 4 | 9 (31%) |
| Four | 5 | 3 | 5 | 5 | 2 | 5 (17%) |

### 4.2 Descriptive Results

The goal of this research is to determine whether there is a relationship between apiary profits and size of the operation as well as the diversity of enterprises. The first relationship to be examined is that between profit per colony and size, followed by the link between profit per colony and enterprise diversification. Last, the relationship between apiary size and diversification is also considered. Table 6 gives an overview of survey statistics for apiary size, enterprises and profit.

Table 6. Summary statistics for apiary size, enterprises, and profit measures

| | Observations | Percentage of sample | Mean | Maximum | Minimum | Standard deviation |
|---|---|---|---|---|---|---|
| Number of colonies | 32 | 97% | 914 | 17000 | 1 | 3052.81 |
| Number of apiary enterprises | 25 | 76% | 2.2 | 4 | 1 | 1.15 |
| Profit per colony | 14 | 42% | $599.53 | $2323 | $2.5 | 659.21 |

#### 4.2.1 Apiary Profits, Farm Size, and Diversification

Diversification can be measured either by how concentrated an operation is with the production of one product or service, or it can measure by how diversified the operation is. For this study one of each of these indexes is employed. First, an adaptation of Sumner and Wolfe's (2002) diversification index, Divers, is calculated for honey; honey is not only the main enterprise for most apiaries, but it is also the only product that all apiaries in the sample offer. The Divers index value ranges between zero and unity where values below 0.25 indicate a specialized farm whereas values well above 0.25 suggest a diversified operation. As Table 6 show, most of the cases in this sample have a diversification index well above 0.25 suggesting that these farms are well-diversified. However, the indexes calculated for honey in cases 1, 6, and 7 are sufficiently close to zero suggesting that these operations mainly specialize in honey.

Table 7. Diversification indexes (n = 11)

| | Cases with revenue reported for more than one apiary enterprise | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Indexes | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Divers = (apiary sales - honey sales) /apiary sales | 0.037 | 0.29 | 0.34 | 0.38 | 0.06 | 0.12 | 0.73 | 0.08 | 0.86 | 0.49 | 0.12 |
| $H_d=\sum_{i=1}^{E} s_i^2$ | 0.92 | 0.58 | 0.55 | 0.51 | 0.90 | 0.78 | 0.46 | 0.84 | 0.40 | 1 | 0.80 |

The second index employed is a Herfindahl, which measures the concentration of a given enterprise within an operation based on profit shares. The Herfindahl indexes calculated for these apiaries all exceed 0.25, which suggests that in most apiaries, profits tend to be concentrated in one enterprise: honey, except for Case 7 where most of the sales in that operation came from pollination fees. To be sure, a low value in the first line of Table 7 should be met by a high value in the second line of the table to ensure consistency of results. These indexes show that although many of the farms sampled offer more than one apiary product or service, their profit shares tend to be mainly concentrated in honey production. With these enterprise characteristics in place, the discussion now turns to the results of the linear regressions examining the relationships between apiary profits, size, and diversification.

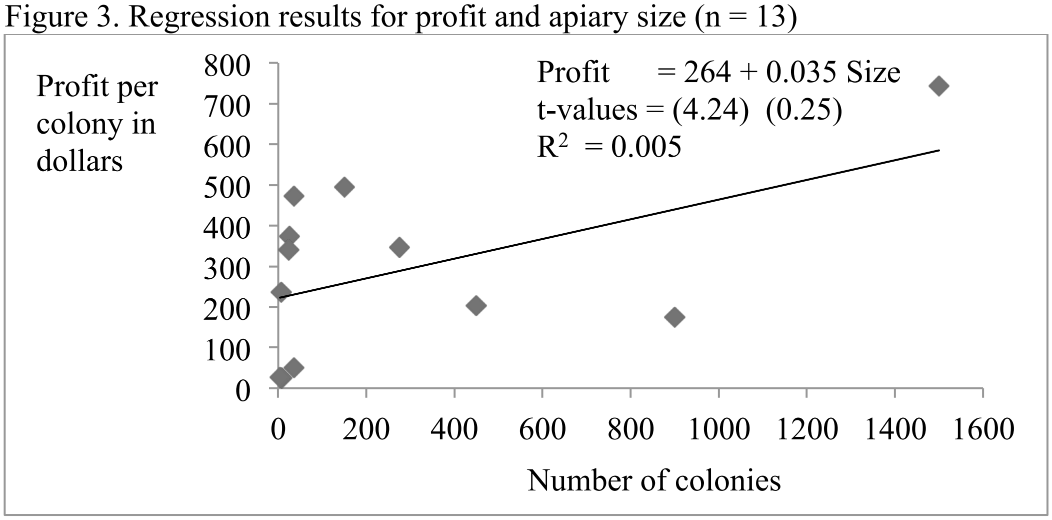
The following equation, wherein Profit, Size, and Number are as previously defined summarize the results of the linear regression for with 13 observations and a coefficient of determination, $R^2$ equal to 0.64:

$$\text{Profit} = -55.107 - 0.002\text{Size} + 127.892\,\text{Number} \qquad (7)$$
$$\text{Standard errors} = \quad (83.04) \qquad (0.01) \qquad (29.25)$$

Hypothesis 1: Profit Per Colony and Farm Size

Profit is defined as profit per colony, calculated by subtracting total apiary sales from total costs and dividing by the number of colonies. Question number 16 on the 2010 Beekeeping Survey asked respondents to list their annual dollar sales values in 2010 for the following apiary activities: honey, nucs, queens, pollination fees, as well as wax, pollen and jelly. These sales values were added up to obtain total apiary sales. Question number 18 on the survey asked respondents to report annual costs for purchased queens, bee packages, feed, pollen patties, transportation, disease prevention and treatment, custom work, lease payments, and overhead; these costs were summed to find total cost. Total costs were subtracted from total sales to find profit. The number of colonies was obtained in question 9 of the survey: “How many colonies did you operate at the beginning of May 2010”. As Figure 3 indicates, none of the variation in apiary size explains changes in profit per colony. Thus, the first hypothesis, “There is no relationship between the profit per colony of an apiary and its size” would not be rejected.

Figure 3. Regression results for profit and apiary size (n = 13)

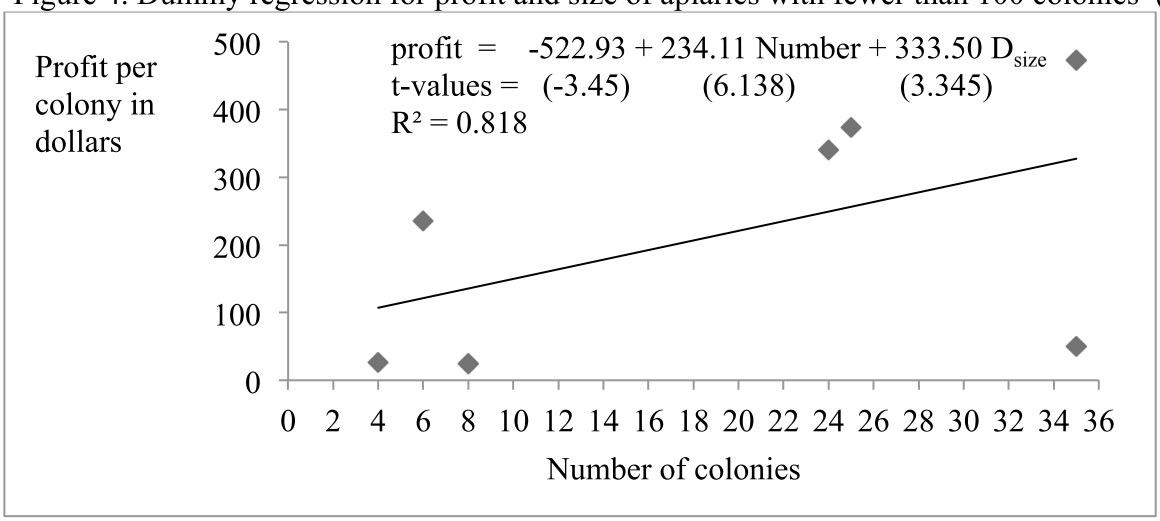



Note: This particular regression included an outlier with 1,700 colonies, which was omitted from the above figure.

However, to verify whether this conclusion applies to apiaries of all sizes, the same analysis was performed using a dummy variable ($D_{Size}$) to distinguish between small and larger-sized operations. The sample was broken up into two groups based on the number of colonies they manage and a second regression was performed. For the size grouping dummy variable, apiaries with fewer than 100 colonies were assigned a value of one while larger operations were assigned a zero.

As the coefficient of determination in Figure 4 shows, apiary size does matter and smaller operations appear to be more profitable than their larger counterparts. Therefore, the null hypothesis should be rejected.

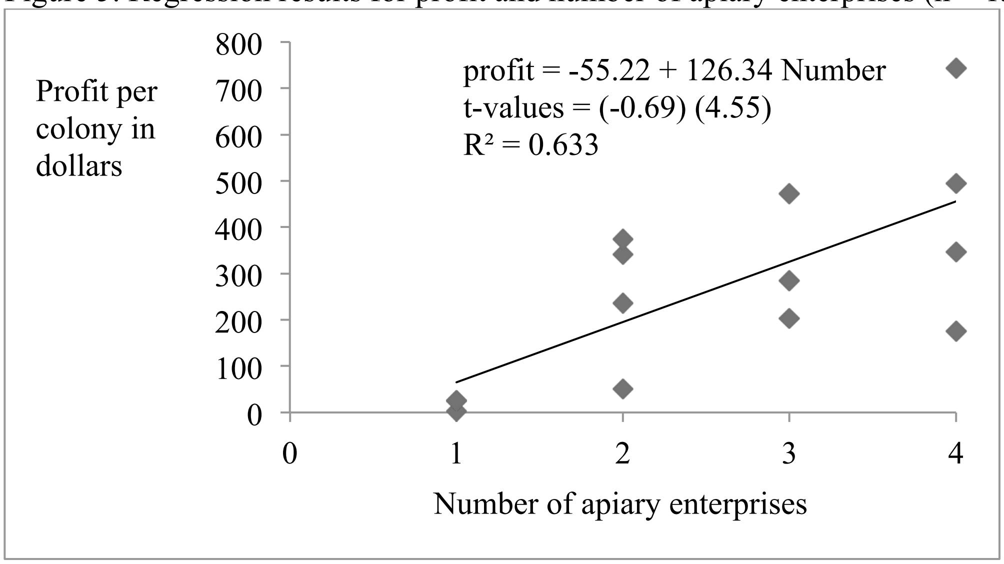
Figure 4. Dummy regression for profit and size of apiaries with fewer than 100 colonies (n = 7)




Hypothesis 2: Profit Per Colony and Number of Apiary Enterprises

Profit is defined as profit per colony, calculated in the same manner previously described. Number of apiary enterprises is determined by counting the number of products and services for which survey respondents reported sales on the 2010 Beekeeping Survey. Question 16 of the questionnaire asked respondents to list their annual sales values for 2010 for the following apiary activities: honey, nucs, queens, pollination fees, as well as wax, pollen and jelly. Figure 5 shows that changes in the number of apiary enterprises explains the variation in profits. Based on the linear regression, the second hypothesis, “There is no relationship between the profit per colony of an apiary and the number of products and services it offers.” would be rejected with at a 95% confidence interval.

Figure 5. Regression results for profit and number of apiary enterprises (n = 13)




Hypothesis 3: Farm Size and Enterprise Diversification

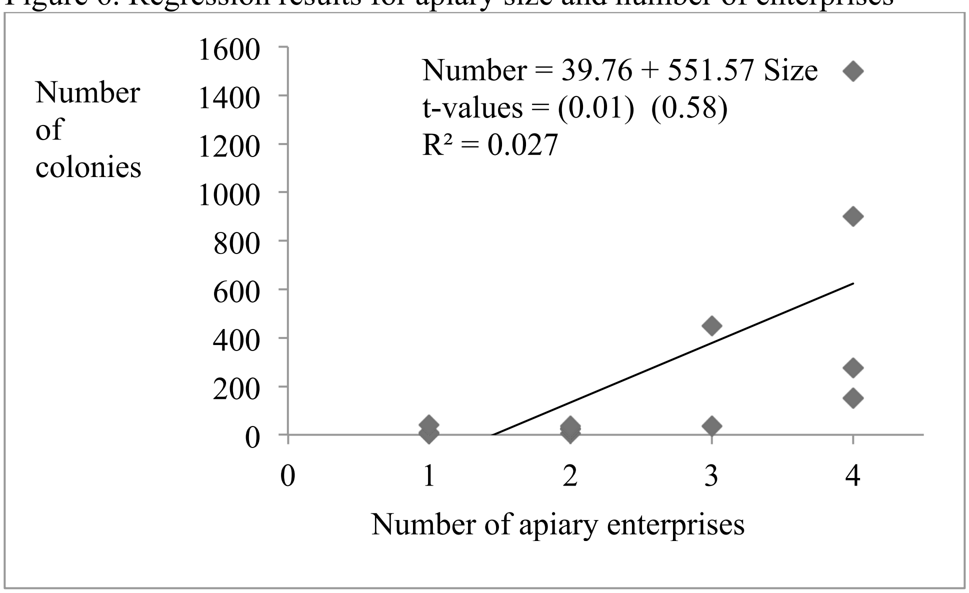
To test the third hypothesis posed in this study, two linear regressions were performed: one between the diversification index and farm size, and the other between the number of products and services offered by an apiary and farm size. Using the diversification index, Divers, defined above, and farm size as previously described, the first linear regression produced a coefficient of determination of 0.1467. Where

$$\text{Divers} = 0.16 - 191100 \text{ Size} \tag{8}$$

The corresponding t-values for the intercept is 2.62 and 1.44 for Size. The null hypothesis should not be rejected based on a 95% confidence level. Based on this first regression, the level of an apiary's diversity, based on its Divers index, is not explained by its size.

The second linear regression performed was between the number of apiary enterprises and size, each defined in a manner consistent with previous measures for these variables. Figure 6 confirms that the findings from the preceding regression between the Divers indexes and size. In this case, even less of the variation in apiary diversification is explained by the size of the operation. Therefore, the third null hypothesis stating that there is no relationship between the size of an apiary and its level of diversification should not be rejected with a confidence level of 90%.

Figure 6. Regression results for apiary size and number of enterprises




The literature on farm size and diversification presented in the second section of this paper included seven studies examining the relationship between farm size and diversification. As Table 1 summarized, two studies found that larger farms tended to specialize rather than diversify; both of these studies looked at a variety of agricultural operations offering a range of products and services (White and Irwin, 1972, Mishra et al., 2004). However, three studies concluded that big farms were more likely to diversify: one of these (Ibery, 1991) looked at a mix of farms in the United Kingdom; another (Weiss & Briglauer, 2002) examined the same variety of farms, but over a five-year period in Austria; while the third (Aubert & Perrier-Cornet, 2010) looked at the French viticulture industry. Two further studies drew similar conclusions to the findings of this research, namely that none of the variation in apiary diversification is explained by the size of the operation. The first of these studies is the work of Pope and Prescott (1980), which looked at a mix of farm operations in the United States. The other study whose findings mirror those herein is the one by Sumner and Wolfe (2002), which looked at dairy farms in the United States. The findings produced by this study, using two different linear regressions to determine whether there is a relationship between farm size and diversification, most closely reflect those found by Sumner and Wolfe (Ibid).

Now that a relationship between enterprise diversity and apiary profits has been established, as well as a relationship between smaller operations and profitability, it is worth investigating some of the challenges to diversifying an apiary. The following section examines barriers to diversification using the example of pollination services.

### 4.2.2 Barriers to Diversification Into Pollination

It is important to examine an example of apiary enterprise diversification such as commercial pollination to learn more about barriers to enterprise expansion, which could potentially earn beekeepers more profit. Based on these findings, it will be possible to suggest ways of improving upon the economic viability of Canadian apiaries.

Two questions on this survey concerned the barriers to diversifying an apiary to offer commercial pollination services. The purpose of this set of questions was to provide more insight on why beekeepers may be reluctant to diversify their operations. First, respondents who identified themselves as providers of pollination services were asked to list and rank the three biggest obstacles they faced in getting started with this lucrative activity. Meanwhile, beekeepers who did not offer pollination were asked to list and rank the most important factors deterring them from diversifying into commercial pollination. These responses were then scored based on the ranked assigned to them. For example, if a beekeeper that stated that lack of demand for the service was the most important obstacle, or deterrent, this response was given a score of three points. Conversely, if a respondent gave the same answer as the second most important factor, the response was assigned was a score of two points, or one point for third most important factor. As Table 8 indicates, the biggest obstacles in getting started with pollination (for beekeepers who offered this service in 2010) were the challenges posed by transporting the hives and obtaining appropriate equipment to facilitate commercial pollination. On the other hand, among beekeepers that did not offer commercial pollination services, most stated that it is due to the small size of their operation or the fact that they are simply hobbyists.

Table 8. Barriers to commercial pollination

| Group of apiarists: | Apiarists who offer pollination services | Apiarists who do not offer pollination services |
|---|---|---|
| Questions asked: | "What were the three biggest obstacles you faced in getting started with commercial pollination?" | "What were the three most important reasons behind your decision not to provide commercial pollination"? |
| Most important factor cited | Transport and equipment constraints | Hobby status / small operation |
| Second most important factor cited | Cost outweighs benefits | Bee health and biodiversity |
| Third most important factor cited | Tie between “No demand”, “Lack of skills”, “Bee health and biodiversity” | No interest |

### 4.4 Summary

The 2010 Beekeeper Survey offers a great deal of insight into the economic practices of Canada’s apiculturist community. The survey sample was reasonably representative of the regional distribution of beekeepers across Canada though the proportions of part time and full time apiarists are reversed. This sample suggests that most beekeepers are in their 50s and hold a post-secondary degrees. Through linear regression, and hypothesis testing, it was determined that while apiary size explains changes in profit, smaller operations tend to be ore profitable. The investigation into the relationship between apiary profits and diversity of enterprises suggests that changes in profit per colony can be explained by the variation in the number of enterprises. An examination into the relationship between farm size and diversification, revealed no link between the number of colonies and either the index or diversification, or the number of apiary products and services offered.

The survey also examined obstacles and barriers to diversification into commercial pollination. The biggest challenges to enterprise diversification into commercial pollination were found to be transportation and equipment constraints as well as small size of operation or hobbyist status. These findings give some indication of what beekeepers face in trying to expand, or diversify an existing operation, and potential areas the beekeeping industry as well as policy could address to further promote the profitability of beekeeping in Canada.

# 5. HEAD FULL OF BEES: LESSONS AND RECOMMENDATIONS

The purpose of the CANPOLIN Economic Working Group was to examine those economic and social aspects associated with pollination in Canada to determine how the value of pollinators and pollination can be translated into policy. For this, a research visit to France in August of 2011 was conducted to learn about the beekeeping industry and policy initiatives from a larger research community in the European Union (EU). The purpose of this section is to highlight some industry, policy, and environmental innovations from the EU, which may be of interest to the Canadian beekeeping community for improving upon its economic viability.

## 5.1 Industry Initiatives

Organization among beekeepers can serve to promote and legitimize their activities as lucrative enterprises. The most notable initiative observed from the EU is the creation of a professional group of beekeepers specializing in pollination services. In the early 1990s, French beekeepers offering pollination services began setting up regional groups for apiarists and professional pollinators known as the GRAPP (Groupement des Apiculteurs et Pollinisateurs Professionnels). The GRAPP now has three chapters: one in the Midi-Pyrénées region, one in Rhône-Alpes, and one in the Mediterranean (Mediterrané). The founding purpose of the GRAPP was to promote pollination services by bolstering the legitimacy of this activity, and communicating the benefits of pollination to crop growers. Each of these three chapters has evolved independently from the others, and as such, have been able to focus more on the needs of their members while promoting issues they feel are important in their area. The GRAPP has also served as a business center where beekeepers can coordinate their services with the needs of growers. Promoting commercial pollination not only benefits growers, but also allows honey producers to be more selective of those crops on which their bees forage making it possible to obtain better quality honey they can sell at premium prices.

The beekeeping industry can also improve upon its economic viability by engaging in more discussion with complimentary industry groups such as grower associations and other potential clients. At a meeting between beekeepers and growers of the Chambre régionale d'agriculture Rhône-Alpes in Lyon in August of 2011 it became clear that dialogue between these groups was important to improving upon the economic success of their enterprises. For example, beekeepers stated that they could improve the effectiveness and transparency of pollination services if they had better access to information on how to set fees for hive rentals, and information from growers on how to optimize the quality of pollination services offered. For their part, growers requested more information on efficiency of honeybees for pollination, and the effects of antibiotics and pesticides on bees. Similar meetings, or a census among beekeepers and growers in Canada could help to identify needs regarding commercial pollination and render this and other apiary activities more profitable.

Extension services represent another tool that can assist beekeepers in updating their management techniques and accessing reliable information. Some beekeepers at the Chambre régionale d'agriculture Rhône-Alpes meeting expressed an interest in obtaining expert hive management and pollination advice. Extension services should offer beekeepers more information on colony management, optimal pollination stocking rates, harmful substances, and potential risks to bees. One way in which such information could be gathered and disseminated would be to establish an electronic reference library for growers and beekeepers. Similarly, a technical and economic reference list, or chart for growers and beekeepers, could serve to facilitate contract agreements. Such extension services in Canada could be made available electronically through provincial agricultural ministry websites or field offices.

## 5.2 Policy Initiatives

Currently in Canada, there are no federal or provincial programs targeted directly at promoting development in the beekeeping industry. Policy initiatives from the EU that could be implemented in Canada are centred on technical training, enterprise development, and subsidies.

As the 2010 Beekeeping Survey confirmed, equipment and transportation constrains were cited as the biggest obstacles to getting started with pollination. Difficulty in obtaining affordable equipment and transportation was also identified as an important constraint in France. Equipment for movement of hives such as loaders, skids, tows, and scales is available to beekeepers at low rental rates (France AgriMer, 2009). French beekeepers are also eligible for partial reimbursed of costs associated with movement of hives for pollination. The French government has also made subsidies available for purchasing new colonies and equipment by new apiarists or those wanting to expand an existing operation (up to a certain number of colonies) (Ibid).

Lack of skills is also a restricting factor which may deter some beekeepers from expanding their operations to include additional products or services. To address apiarist skills development, policy should seek to make training more accessible to those who need it. In an effort to recruit new beekeepers, the French government has made training available and offered subsidies for apiarists wanting to update their hive and farm management skills (Ministère de l'alimentation, de l'agriculture et de la pêche, 2010). Such policies can also be used to recruit and train new beekeepers in Canada poised to succeed ageing beekeepers.

In Europe, just as in Canada, high over winter death rates and pathogens are two problems that continue to negatively impact apiary profits. To alleviate some of the financial burden from colony losses, French beekeepers can retrieve a proportion of their annual colony losses (Ibid). A similar program, either based on income tax or insurance may also be beneficial for Canadian beekeepers whose colonies have been negatively affected by *varroa mite* or high over-winter losses.

## 5.3 Environmental Initiative

An exemplary initiative from the European Union which uses managed bees to raise awareness about environmental issues is the Urban Bees project. In an effort to raise awareness about the plight of bees and their relevance to human life as an indicator species, hives have been placed at various locations in cities where they can be seen and heard, but not be accessed by people. The purpose is to emphasize the role of pollinators as indicator species, and at the same time have a way of assessing the environmental quality in urban areas by monitoring hive health. A website (www.urbanbees.co.uk) was recently launched where the public can learn more about the role of bees in the environment. A similar public awareness campaign in Canada could serve to characterize the impacts of climate and land use change on managed bees. Such an initiative in large Canadian cities could be led either by universities, or by municipalities in partnership with relevant government departments specializing in agriculture and the environment.

## 5.4 Summary

There are a number of ways in which Canada's beekeeping industry can continue to improve upon its economic viability, either through industry or policy action. Beekeeper-led initiatives tend to emphasize organization and promotion of the benefits of the services they offer. Canadian beekeepers could benefit from forming similar specialized associations to France's GRAPP to gain legitimacy, raise awareness, and deliver services more effectively. Engaging in regular dialogue with complementary industries like growers who may benefit from pollination could also contribute to strengthening economic viability in Canada's beekeeping industry. Policy initiatives appear to be better for addressing the availability of equipment and skills development. Potential policy initiatives to improve the net benefits of the pollination market should focus on equipment, training, and compensation of colony losses. Finally, efforts should be made to raise public awareness about the benefits bees provide and the environmental impacts of their decline.

# 6. BUZZKILL: CONCLUSIONS AND LIMITATIONS

## 6.1 Summary of Research and Findings

The global decline of honeybees, the most efficient pollinators of food crops, has far-reaching consequences. In Canada, the livelihoods of beekeepers are affected by this trend as higher than normal over-winter losses and *varroa* mites continue to negatively affect colonies making apiculture an increasingly expensive farming activity. The Canadian beekeeping industry has consolidated over the last two decades as fewer beekeepers take on a greater number of colonies. In an effort to ameliorate the economic viability of beekeeping in Canada, it is important to examine the enterprise management strategies of beekeepers. The purpose of this research has been to identify the differences in profits per colony between different sizes of apiaries and levels of diversification in Canada.

Beekeeping, like most farming activity, is about choices and trade-offs between outputs. Apiarists are faced with a wide range of productive choices such as honey, pollination services, breeding, and other wax and pollen products. However, these production choices are often a function of seasonality and anticipated crop values. Other apiary characteristics are also believed to have an impact on production choices and their returns. This study looked at whether there is any relationship between apiary profits and number of colonies as well as number of products and services offered. This study also contributed to the discourse on farm size and diversity by considering the apiary, a previously unexamined farm type that is particularly well-suited to offering a variety of products and services using a single productive input.

This study on the economic practices of beekeepers has offered more insight into what is currently taking place in Canadian apiculture. The Canadian honey beekeeping industry's consolidation over the last two decades offers an ideal context for investigate the relationship between apiary profits, farm size, and diversification. The main objective of this research was to survey beekeepers about their operations and their enterprise management techniques. In order to test the relationship between apiary profits, size, and diversification simple linear regression was employed. Two indexes of diversification were also calculated to measure the degrees of diversity and concentration for the apiaries surveyed. First, a modified index of diversification, similar to that proposed by Sumner and Wolfe (2002) indicated how diversified an operation is based on a value between zero and one where a larger value indicated a more diversified apiary. Second, a Herfindahl index measuring the degree of concentration of the operation was also calculated; in this case, a high value indicates a more specialized operation. To analyze the relationship between apiary profits, size and diversity, information on sales, costs, and number of colonies was collected using a cross-Canada survey for beekeepers.

The 2010 Beekeeping Survey was the primary data collection tool for this study. The survey sample was geographically representative of the distribution of beekeepers across Canada. The majority of the sample resided in the provinces of British Columbia, Alberta, Ontario, and Quebec, which coincide with where most of Canada's beekeeping activity takes place. Beekeeping survey respondents were, on average, 50 years old and possessed a post-secondary degree. Linear regression was employed to examine three sets of relationships involving profit per colony, apiary size, and enterprise diversity. First, it was determined that although apiary size was a generally weak explainer of variations in profits, smaller operations were found to be more profitable than those comprising more than 100 colonies. Second, the variation in number of goods and services offered by an apiary was found to account for 63% of the variation in profits based on the results of the linear regression. The third relationship examined, that between farm size and diversification, showed no link between the number of colonies and either the index of diversification, or the number of apiary products and services offered. The survey also examined challenges to diversifying an apiary using the example of commercial pollination. Survey participants were asked either why they chose not to offer commercial pollination, or what were the biggest obstacles they faced in starting out with this service. The most commonly cited barriers to enterprise diversification into commercial pollination related to transportation and lack of equipment. These findings gave an indication of the challenges beekeepers face in trying to expand or diversify an existing operation, and potential areas that industry and policy initiatives should address.

Tools for improving upon the economic viability of Canada's beekeeping industry can be initiated by the beekeeping industry as well as through policy programs. First, beekeepers, though already organized regionally and as an industry, could also form groups to represent specific lucrative activities such as commercial pollination. Specialized groups serve to promote the benefits of their activities to potential clients while legitimizing these enterprises. Similarly, beekeeping organizations should also seek to engage in regular dialogue with industries that could benefit from apiary services such as growers of pollination-dependent crops. Dialogue with complementary industries can also assist beekeepers in providing needed goods and services and doing so more efficiently. Potential policy initiatives to improve the net benefits of the pollination market should focus on equipment, training, and compensation of colony losses. Special attention is needed to link the cause of consolidation in Canada's beekeeping industry with appropriate solutions that will allow out apiarists to thrive.

## 6.2 Limitations

While the preceding analysis allowed for clear conclusions to be drawn regarding the relationships between apiary profits, size, and level of diversification, some constraints complicated this endeavour. The three main categories of limitations surrounding this research, scope, timing, and sample size, all pertain to the principal data collection tool: the survey questionnaire.

The 2010 Beekeeping Survey was a joint collaboration between members of the NSERC-CANPOLIN initiative at the University of Guelph and the University of British Columbia's APIS Project. Three individuals contributed to developing the survey at different stages and for different research purposes including apiary enterprise management, pollination practices, and honeybee disease prevention and treatment. As a result, the questionnaire was composed of a range of questions that was too broad.

The timing of the survey was also problematic in that its release coincided with the busy beekeeping season. The survey opened on June 20th, 2011 with announcements being sent out to beekeeping associations and provincial apiarists in early June. The busy season for beekeepers is usually during the spring and summer when bees collect nectar and pollen (Cheung, 1973). The late summer and early fall are also a busy times for beekeepers as this is usually when they begin to extract honey from their hives for packaging and processing into other goods. Thus, it is very likely that the response rate of the survey was lower than it would have been if the survey had been launched during the late fall or winter.

Although the 2010 Beekeeping Survey was initially set to close on October 1st, 2011, it was determined in early September that the survey should remain open until December 1st to increase the number of observations. However, this tactic only increased the number of responses by four surveys. The total sample consisted of 33 observations, but not all of the surveys submitted were complete. Questions regarding sales received particularly low response rates: less than 50% in some cases. The limited amount of information required to estimate apiary profits, namely costs and sales in dollars, made it difficult to accurately assess whether apiary profits vary with size and level of diversification of an operation.

### 6.3 Recommendations

Sample size was the biggest limitation for this study, therefore future research should re-examine relationships between apiary profit, size, and diversification using more observations. The relationship between apiary profits and diversification should also be investigated in greater detail.

The analyses found no relationship between changes in apiary profits based on size of the operation, even when the sample was divided between smaller and larger operations. A larger sample may help to clarify both the link between profit per colony and number of colonies, as well as whether larger apiaries as opposed to smaller ones exhibit different profit-size relationships.

The most significant finding underscored by this study was that beekeeper enterprise management techniques, or more specifically, the number of goods and services they offer, explains variations in profits. Although this implies that more diversified apiaries are likelier to generate higher revenue, further research is needed to determine whether a particular mix of enterprises, or allocation of colonies to certain enterprises can maximize profits. Future studies looking at apiary profits and diversification could also examine the effects of economies of scope in the beekeeping industry both as a way to reduce risk, and maximize profits since a relationship between profit and diversity of enterprise has been established.

Further research investigating the link between farm size and diversification should focus on farming operations with multiple enterprises using a single input such as beekeeping. Although the variation in an apiary's size could not be explained by looking at the number of enterprises, or its diversification index, it would be worth reproducing this analysis with a larger sample.

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UNIVERSITY of GUELPH

# 2010 Beekeeping Survey

We are pleased to invite you to participate in a study by the University of British Columbia and the University of Guelph on the economics of beekeeping in Canada. Our goal is to learn about beekeepers' production and pest management practices and their impacts on the economic viability of beekeeping operations and honey bee health. You are free to participate or not in this survey. Should you choose to participate, you are free to skip any questions you prefer not to answer. The survey should take approximately 20 minutes to complete.

If you have any questions or concerns regarding any ethical aspects of this survey, please contact:
Research Ethics Coordinator
University of Guelph
437 University Centre
Guelph, ON
N1G 2W1
Telephone: 519-824-4120 (x56606)
E-mail: sauld@uoguelph.ca

We welcome your questions and feedback on the survey:
hbsurvey@uoguelph.ca
(519) 824-4120 ext. 53428

**Thank you very much for your time and cooperation**.

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## To begin, a few questions about yourself.

**1.** **As which of the following do you identify yourself? Check all that apply.**

- ☐ Hobbyist Beekeeper
- ☐ Part-time Beekeeper
- ☐ Full-time Beekeeper
- ☐ Commercial Beekeeper - Honey
- ☐ Commercial Beekeeper - Pollination
- ☐ Queen Breeder
- ☐ Nuc and Package Producer
- ☐ Grain Producer
- ☐ Fruit Grower
- ☐ Vegetable Grower
- ☐ Livestock Producer

**2.** **How many years have you been keeping bees?**

**3.** **What is your age?**

- ○ Under 20
- ○ 20-29
- ○ 30-39
- ○ 40-49
- ○ 50-59
- ○ 60-69
- ○ 70+
- ○ Prefer not to answer

**4.** **What is your highest level of education?**

- ○ Less than high school
- ○ High school diploma
- ○ College / cegep / trade school diploma
- ○ Undergraduate degree
- ○ Post graduate degree
- ○ Prefer not to answer

**5.** **Are you the sole operator of your beekeeping farm?**

- ○ Yes
- ○ No

If you selected "No", how many people operate your farm <u>including</u> yourself?

[ ]

**6.** **Are you a certified organic beekeeper?**

- ○ Yes
- ○ No
- ○ Currently in transition

***Next, we'd like to know more about your beekeeping business. We have grouped these questions into sections for ease and clarity.***

## Section 1: Honeybee Colonies

**7.** **In what postal code are the <u>majority</u> of your colonies located?**

[ ]

**8.** **How many colonies did you operate at the beginning of May, 2011? Write a zero for none.**

[ ]

**9.** **How many colonies did you operate at the beginning of May, 2010? Write a zero for none.**

[ ]

**10.** **How many new colonies did you purchase between May 1st, 2010 and October 31st, 2010? Write a zero for none.**

[ ]

**11.** **How many new colonies were the result of splitting existing colonies? Write a zero for none.**

[ ]

**12.** **How many colonies did you operate at the end of October, 2010? Write a zero for none.**

[ ]

## Section 2: Income and Revenues

**13.** **What proportion of your farm income in 2010 was from beekeeping?**

- ○ Less than 20%
- ○ 20-39%
- ○ 40-59%
- ○ 60-79%
- ○ 80-99%
- ○ 100%
- ○ I don't know

**14.** **What proportion of your total income in 2010 (farm and off-farm income) was from beekeeping?**

- ○ Less than 20%
- ○ 20-39%
- ○ 40-59%
- ○ 60-79%
- ○ 80-99%
- ○ 100%
- ○ I don't know

**15.** **Please provide the quantities of the following outputs in specified units for the year 2010. Write a zero for none. Write "N/A" if the item is not applicable to your operation.**

| | |
|---|---|
| Quantity of honey (in kilograms) | |
| Number of nucs (nucs) | |
| Number of queens (queens) | |
| Number of colonies rented for commercial pollination (colonies per use). Please count multiple rentals per colony as unique colonies. For example, if the same colony was used 3 times, count it as 3 colonies. | |

**16.** **Please provide the sales totals in dollars for the year 2010.**
**Write a zero for none. Write "N/A" if the item is not applicable to your operation.**

Annual sales value of honey

Annual sales value of nucs

Annual sales value of queens

Annual value of pollination fees

Annual sales value of wax / pollen / jelly

Annual sales value of other commodities and services

**17.** **Please provide the purchased quantities of the following items in specified units for the year 2010.**
**Write a zero for no purchase and / or no expense. Write "N/A" if the item is not applicable to your operation.**

Quantity of queens purchased (queens)

Number of packages of bees purchased (packages)

Quantity of sugar feed purchased (in kilograms)

**18.** **Please provide the following costs in dollars for the year 2010.**
**Write a zero for no purchase and / or no expense. Write "N/A" if the item is not applicable to your operation.**

Total annual cost of purchased queens

Total annual cost of bee packages purchased

Total annual cost of sugar feed purchased

Total annual cost of pollen patties purchased

Total annual cost of transportation (fuel, freight, and tucking)

Total annual cost of disease treatment (chemicals, drugs, tool, etc.)

Total annual cost of custom work and repairs

Total annual cost of lease payments (equipment, machinery, vehicles, and land)

Total annual cost of overhead: licenses, insurance, interest, taxes, and forage access fees

## Section 4: Labour

**19.** **On average, how many hours of <u>hired</u> labour were used per month for the following activities in 2010?**
**Write a zero for none.**

| | |
|---|---|
| Preventing diseases and/or damages | |
| Treating disease and/or damages | |
| Securing Forage Access (searching, negotiating, moving hives, etc.) | |
| Maintaining and repairing colonies | |

**20.** **On average, how many hours of <u>family</u> labour (including your own) were used per month for the following activities in 2010?**
**Write a zero for none.**

| | |
|---|---|
| Preventing diseases and/or damages | |
| Treating disease and/or damages | |
| Maintaining and repairing colonies | |
| Securing Forage Access (searching, negotiating, moving hives, etc.) | |

**21.** **Please complete the following information for the two primary crop on which your bees foraged between early spring 2010 and the end of fall 2010 for the purpose of producing honey.**
**Write N/A if this question does not apply to you.**

**First crop** [ ]

Did you use a written contract (Y or N) [ ]

Location of crops (county and province) [ ]

Number of foraging colonies [ ]

Foraging access fee [ ]
Write a zero if you did not pay an access fee.
Write "IK" if you made a payment in-kind in exchange for foraging, followed by an estimated dollar value of the in-kind-payment.
(For example: IK, 100).

**Second crop** [ ]

Did you use a written contract (Y or N) [ ]

Location of crops (county and province) [ ]

Number of foraging colonies [ ]

Foraging access fee [ ]
Write a zero if you did not pay an access fee.
Write "IK" if you made a payment in-kind in exchange for foraging, followed by an estimated dollar value of the in-kind-payment.
(For example: IK, 100).

## Section 6: Pollination Services

**22.** **Did you rent any of your colonies for commercial pollination in 2010?**

- ○ Yes => Please proceed to question **24**
- ○ No => Please proceed to question **23**

**23.** **What were the three most important reasons behind your decision not to provide commercial pollination? Please start with the most important one.**

| | |
|---|---|
| Most important reason | |
| Second most important reason | |
| Third most important reason | |

**Please proceed to Section 7: Pest Prevention Practices**

**24.** **Please complete the following information for crops (up to four crops) on which your bees foraged between <u>early spring 2010</u> and the <u>end of fall 2010</u> for the purpose of providing pollination services in chronological order.**

| | |
|---|---|
| First crop | |
| Did you use a written pollination contract (Y or N) | |
| Location of crops (county and province) | |
| Number of rented colonies | |
| Average number of frames per colony | |
| Rental fee ($/colony) Write a zero if you did not charge a rental fee. Write "IK" if you received a payment in-kind in exchange for pollination services, followed by an estimated dollar value of the in-kind-payment. (For example: IK, 100). | |
| One-way distance traveled (in kilometers) | |

**If no more crops, please proceed to question 27.**

**25.** **Please complete the following information for crops (up to four crops) on which your bees foraged between <u>early spring 2010</u> and the <u>end of fall 2010</u> for the purpose of providing pollination services in chronological order.**

| | |
|---|---|
| Second crop | |
| Did you use a written pollination contract (Y or N) | |
| Location of crops (county and province) | |
| Number of rented colonies | |
| Average number of frames per colony | |
| Rental fee ($/colony) Write a zero if you did not charge a rental fee. Write "IK" if you received a payment in-kind in exchange for pollination services, followed by an estimated dollar value of the in-kind-payment. (For example: IK, 100). | |
| One-way distance traveled (in kilometers) | |

**If no more crops, please proceed to question 27.**

**26.** **Please complete the following information for crops (up to four crops) on which your bees foraged between early spring 2010 and the end of fall 2010 for the purpose of providing pollination services in chronological order.**

Third crop

Did you use a written pollination contract (Y or N)

Location of crops (county and province)

Number of rented colonies

Average number of frames per colony

Rental fee ($/colony)
Write a zero if you did not charge a rental fee. Write "IK" if you received a payment in-kind in exchange for pollination services, followed by an estimated dollar value of the in-kind-payment. (For example: IK, 100).

One-way distance traveled (in kilometers)

**27.** **Please complete the following information for crops (up to four crops) on which your bees foraged between early spring 2010 and the end of fall 2010 for the purpose of providing pollination services in chronological order.**

Fourth crop

Did you use a written pollination contract (Y or N)

Location of crops (county and province)

Number of rented colonies

Average number of frames per colony

Rental Fee ($/colony)
Write a zero if you did not charge a rental fee. Write "IK" if you received a payment in-kind in exchange for pollination services, followed by an estimated dollar value of the in-kind-payment. (For example: IK, 100).

One-way distance traveled (in kilometers)

**28.** **Please record the number of colonies and honey yield per colony for each of the following cases in 2010.**
**Write N/A if you don't know the answer.**

| | |
|---|---|
| Number of colonies NOT used for pollination | |
| Average honey yield per colony from colonies NOT used for pollination (in kilograms) | |
| Number of colonies used to pollinate one crop | |
| Average honey yield per colony from colonies used to pollinate one crop (in kilograms) | |
| Number of colonies used to pollinate two crops | |
| Average Honey yield per colony from colonies used to pollinate two crops (in kilograms) | |
| Number of colonies used to pollinate two or more crops | |
| Honey Yield per Colony from colonies used to pollinate two or more crops (in kilograms) | |

**29.** **Please indicate the method you used to secure your pollination agreement with growers in 2010. Check all that apply.**

- ☐ An informal agreement set year-by-year
- ☐ A formal written agreement set in advance
- ☐ Negotiated through a third party (i.e. broker)
- ☐ Other

Please specify:

**30.** **What were the three biggest obstacles you faced in getting started with commercial pollination and/or specializing in it? Please start with the biggest obstacle.**

| | |
|---|---|
| Biggest obstacle | |
| 2nd biggest obstacle | |
| 3rd biggest obstacle | |

## Section 7: Pest Prevention Practices

**31.** **Do you practice any of the following pest prevention methods? Check all that apply.**

| | *I currently practice this method* | *I have started within the last two years* | *I do not currently practice this method, but I would like to* | *I know of other beek eepers who practice this method* |
|---|---|---|---|---|
| 1. Re-queen with genetically-resistant stock | ☐ | ☐ | ☐ | ☐ |
| 2. Use pathogen and/or animal-specific traps or barriers | ☐ | ☐ | ☐ | ☐ |
| 3. Monitor level of pathogens throughout the year | ☐ | ☐ | ☐ | ☐ |
| 4. Use clean equipment | ☐ | ☐ | ☐ | ☐ |
| 5. Separate weaker colonies from strong ones | ☐ | ☐ | ☐ | ☐ |
| 6. Renew at least two frames per colony every year | ☐ | ☐ | ☐ | ☐ |
| 7. Protect colonies from cold and wet winds | ☐ | ☐ | ☐ | ☐ |
| 8. Other | ☐ | ☐ | ☐ | ☐ |

**32.** **Do you practice any of the following over-wintering methods? Check all that apply.**

☐ Wraps (e.g. Western, Dussen VD, or Tar paper)
☐ Davies BD method
☐ Cardboard sleeve
☐ Indoor over-wintering
☐ Other
Please specify:

## Section 8: Bee Losses and Mortality

33. Not including over-wintering losses, how many colonies did you lose and/or dispose of between early May and the end of October, 2010? Write a zero if you did not lose any colonies.

34. How many colonies did you lose over the winter of 2010 - 2011? Write a zero if you did not lose any colonies.

35. Rank the following factors in terms of the most relevant for your colonies' mortality over the summer of 2010.

| | *Most relevant (1)* | *(2)* | *(3)* | *(4)* | *(5)* | *(6)* | *Least relevant (7)* |
|---|---|---|---|---|---|---|---|
| Harsh preceding winter | O | O | O | O | O | O | O |
| Excessive pollination | O | O | O | O | O | O | O |
| Weak queens | O | O | O | O | O | O | O |
| Pesticides and/or insecticides | O | O | O | O | O | O | O |
| Mite infestation | O | O | O | O | O | O | O |
| Nosema | O | O | O | O | O | O | O |
| Poor Food Reserves | O | O | O | O | O | O | O |

Other relevant factors:

**36.** **Rank the following factors in terms of the most relevant for your colonies' mortality over the winter of 2010 - 2011.**

| | *Most relevant (1)* | *(2)* | *(3)* | *(4)* | *(5)* | *(6)* | *Least relevant (7)* |
|---|---|---|---|---|---|---|---|
| Harsh weather | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Excessive pollination | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Weak queens | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Pesticides and/or insecticides | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Mite infestation | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Nosema | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Poor Food Reserves | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Other relevant factors:

## Section 9: Queen Sourcing

**37. What is your primary source for queens?**

- ○ Self-produced
- ○ Local (same province) breeder
- ○ Other Canadian breeder
- ○ American import
- ○ Other import

**38. For breeding, or purchasing queens, rank the following traits in order of importance.**

| | *Most import ant (1)* | *(2)* | *(3)* | *(4)* | *(5)* | *(6)* | *(7)* | *(8)* | *(9)* | *Least import ant (10)* |
|---|---|---|---|---|---|---|---|---|---|---|
| Longevity | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| From local stock | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Cost | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Honey production | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Pollination | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Winter survival (cold tolerance) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Varroa sensitive hygiene | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Nosema resistance | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| American Foulbrood resistance | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Viral resistance | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Other important traits:

**39. Have you ever purchased queens specifically bred for hygienic behaviour, or other resistance traits?**

- ○ Yes
- ○ No

**40. Would you be interested in purchasing queens that demonstrate marked resistance to mites?**

- ○ Yes => Please proceed to question **42**
- ○ No => Please proceed to question **41**

**41.** **What would be some of your concerns in deciding whether to purchase queens that demonstrate marked resistance to mites? Check all that apply.**

- ☐ Actual (proven) survival rate
- ☐ Cost
- ☐ Forgone honey production
- ☐ Other

Please specify:

## Section 10: Vehicles

**42.** **Do you own any of the following vehicles? Check all that apply.**

- ☐ Small truck or full size pick-up
- ☐ Eighteen-wheel truck
- ☐ Forklift
- ☐ Tractor
- ☐ Other

Please specify:

## Section 11: Follow-up and Contact Information

**43.** **Would you like to be sent a summary of the survey findings?**

- ○ Yes
- ○ No

**44.** **May we contact you to clarify questions about your responses?**

- ○ Yes
- ○ No

**45.** **Are you interested in participating in future surveys on this topic?**

- ○ Yes
- ○ No

**46.** **If you answered "Yes" to <u>any</u> of the above three questions, please provide an e-mail, postal address, or telephone number where you can be contacted:**

## End of Survey
## Thank you for your participation.

**We welcome your questions and feedback on the survey:**
hbsurvey@uoguelph.ca