Potential Economic Impact of European and American Foulbrood on Alberta's Beekeeping Industry

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Potential Economic Impact of European and American Foulbrood on Alberta's Beekeeping Industry
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Executive Summary

Alberta plays an integral role in the Canadian beekeeping industry and has been leading western Canadian honey production since 1961. The existence of diseases such as American foulbrood (AFB) and European foulbrood (EFB) can cause significant economic losses for the beekeeping industry in Alberta. The losses are due to the additional costs of replacing infected hives, bees and brood, potential loss in revenue due to total loss or reduction of honey production and hive rental income, costs for sterilizing hives with irradiation and the labour costs associated with implementing best management practices for prevention and controlling the spread of the disease.

A partial budget modelling approach was used for the economic impact analysis. Only costs and potential revenue losses that were deemed incremental were estimated. Three scenarios were analyzed. Scenario 1 considered a spring outbreak with burning of infected brood frames. Scenario 2 addressed a spring outbreak with irradiation of infected brood frames while Scenario 3 focused on a fall outbreak resulting in death of infected hives, bees and brood followed by burning of infected brood frames.

For each of these scenarios the potential economic impacts were first estimated on a per-hive basis before determining the industry-wide impacts at the baseline and outbreak levels of AFB and EFB incidence. Results from the National Honey Bee Health Survey were used as a basis for determining the baseline and outbreak levels of AFB and EFB. Table 1 below summarizes the direct potential economic impacts estimated.

Table 1: Summary of Direct Potential Economic Impacts of AFB and EFB

Direct Potential Economic Losses	American Foulbrood			European Foulbrood		
	$/Hive	Baseline	Outbreak	$/Hive	Baseline	Outbreak
Spring Outbreak with Burning of Infected Brood Frames (Scenario 1)	$655.59	$450,171	$18,465,903	$607.29	$252,227	$35,370,144
Spring Outbreak with Irradiation of Infected Brood Frames (Scenario 2)	$583.03	$356,758	$14,706,721	$569.00	$220,735	$30,871,855
Fall Outbreak Resulting in Death of Infected Hives, Bees and Brood followed by Burning of Infected Brood Frames (Scenario 3)	$383.56	$244,422	$10,127,959	$383.53	$158,504	$22,227,228

Depending on the scenario, the economic impacts ranged from $384 per hive to $656 per hive in the case of AFB. The corresponding value for EFB ranged from $384 per hive to $607 per hive. The difference in estimated impacts were due to the costs of replacing the burned frames and treatment of hives with antibiotics. From an industry-wide perspective, the estimated impact for AFB ranged from the baseline level of $0.24 million to an outbreak level of $18.47 million. The corresponding value for EFB ranged from $0.16 million to $35.37 million.

It is critical for Alberta beekeepers to continue following the recommended best management practices for AFB and EFB and thereby maintain the prevalence or incidence levels at the baseline of less than one per cent.

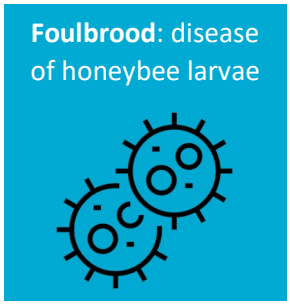
Introduction

The beekeeping sector is a vital component of Alberta's agriculture industry. The major enterprises within Alberta's beekeeping industry are honey production and pollination. A business analysis of beekeeping operations in 2016 across the province indicated that a third enterprise - selling of bees (queens, bee nuclei or nucs and hives) was emerging. In 2019, Alberta beekeepers managed 303,500 honeybee colonies, accounting for 39 per cent of the total number of Canadian honeybee colonies.

Pollination - Honeybees have been used to pollinate crops to improve yield and seed production for centuries. In Alberta, commercial use of honeybees to pollinate crops began in 1995 with the introduction of transgenic canola. Other crops for which bees have been used for pollination are borage, alfalfa and clover, etc. Over the last few years, the number of hives supplied for pollination purposes has more than tripled from about 20,000 hives in 1996. On average, approximately 55,000 to 75,000 bee colonies are rented annually for pollinating crops such as hybrid seed canola to ensure high yield canola seed for farmers. The number of pollinating hives continues to increase because the area for transgenic canola and other crops such as blueberries continues to expand (Laate, 2017).

While the Alberta beekeeping industry has been thriving, the presence of diseases like European and American Foulbrood can have a considerable negative impact on the economic prosperity of the industry. This report examines the economic impact of European and American Foulbrood on the Alberta beekeeping industry as well as providing background on the industry.

American and European Foulbrood - Honeybees are subject to a range of diseases some of which affect adult bees while others affect the immature stages of bee development (larvae and pupae). The latter are referred to as "brood diseases". **"Foulbrood" refers to two diseases impacting honeybee larvae**, **American foulbrood** (AFB) and **European foulbrood** (EFB).The names bear no relationship to the geographical distribution of the diseases as both occur in Alberta. The economic impact of these diseases to the beekeeping industry is considerable.



American foulbrood is considered the most destructive brood disease in North America/Alberta. However, recently EFB has become more virulent in Alberta; it often spreads rapidly and has become difficult to eradicate unless prompt measures are taken. While in the past, honeybee colonies have spontaneously recovered from EFB on their own, there have been an increasing number of colonies in Alberta unable to rebound from this disease. As a result, EFB has caused economic hardship for beekeepers, especially when it presents in the spring when many producers are building up their colonies for the season.

AFB is caused by a highly contagious spore-forming bacteria which weakens and, in most cases, kills honeybee colonies. AFB also contaminates beekeeping equipment which then must be destroyed or irradiated to prevent the spread to additional colonies. Antibiotics may be used to stop AFB from multiplying, but have no affect on the persistent spores, which may live for 40

years. Therefore, beekeepers must take precautions to prevent an infection from establishing itself in a beekeeping operation.

EFB is caused by non-spore forming bacteria which infects the gut of the larvae (developing honeybees). The diseases can out-compete the immature bees for food, resulting in larval death which will drastically weaken and even kill a colony if left unmanaged. If a disease kills all the larvae, there will not be a sufficient number of bees later in the season to collect nectar and produce honey. EFB is often referred to as an opportunist, as it tends to cause disease only when honeybees are under conditions of stress. Colonies may be stressed by seasonal conditions, nutrition, and pesticide exposure, all of which will help EFB gain a foothold and start killing the larvae. EFB can also be treated with antibiotics, but antibiotics will not rid the colony of EFB, it will only prevent the bacteria from infecting developing larvae. Therefore, similar to AFB, EFB disease management is imperative to prevent an infection from establishing itself in a beekeeping operation.

Table 2 illustrates the attributes of AFB and EFB as well as the methods that can be implemented to control the spread of these diseases.

Table 2: Attributes and Control Methods of American Foulbrood and European Foulbrood

Attributes of AFB and EFB	
Commonalities	**Differences**
• Both are bacteria which can affect larvae but AFB also affects the pupae. • Both have a foul smell. • The larvae ingest the bacteria or spore to make it vegetative. • Both diseases can be managed. • Both can be controlled using antibiotics. • Both are highly contagious. • Both can leave a scale (dried larvae/pupae depending on bacteria) in the brood cell.	• EFB affects larvae while AFB also affects larvae but leaves spores which also affect the pupae (pre-pupae and pupae). • AFB stresses bees and EFB is a stress disease so both can exist in one hive. • When the larvae are drawn out of the comb with a toothpick and exhibit a rope-like appearance, they are affected by AFB. • With AFB, capped cells appear sunken. • Larvae killed by AFB are typically brown, those killed by EFB may be yellow-greyish and sometimes brown, making it hard to differentiate from AFB without laboratory confirmation. • EFB scale appears twisted around the brood cell, where AFB scale appears flat on the bottom edge or will show a dried pupal tongue scale.
Control Methods of AFB and EFB	

• Isolate the hives and ensure that there are no other bees in the area.
• Then burn/irradiate any infected bee equipment
• Use integrated pest management methods:
  ○ Shake into new equipment.
  ○ Re-queen from resistant stock
  ○ Integrate a five year frame rotation, it does not have to be done all at once
  ○ Antibiotic treatment of remaining hives or use antibiotics in conjunction with other methods.	

Source: Alberta Agriculture and Forestry, “Honey Bee Pests and Diseases - Best Management Practices 2020”

Alberta Beekeeping Industry Statistics

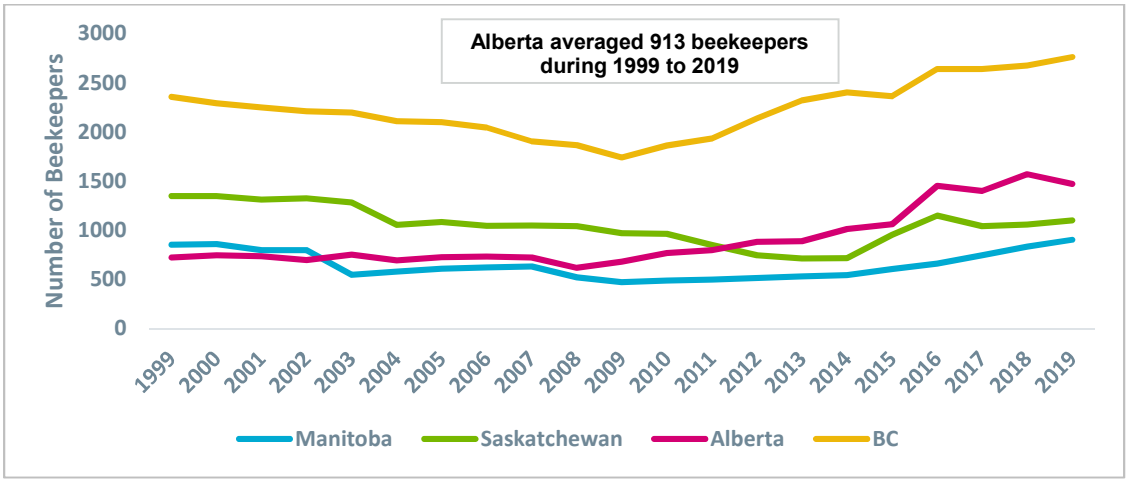
Alberta plays an integral role in honey production in Canada. Following are details regarding Alberta's position within the Canadian and Western Canadian context including the number of beekeepers, number of honeybee colonies, honey production, honey prices, farm cash receipts, and queen bee and honeybee import statistics.

Number of Beekeepers

The number of Alberta beekeepers increased by 103 per cent from 1999 to 2019

The number of Alberta beekeepers increased by 103 per cent during the period covering 1999 to 2019, averaging 913 beekeepers. In 2019, Alberta totalled 1,474 beekeepers comprising 14 per cent of the total number of beekeepers in Canada. As illustrated in Figure 1, British Columbia led Western Canada in the greatest number of beekeepers followed by Saskatchewan, Alberta, and Manitoba.

Figure 1: Western Provinces Number of Beekeepers (1999 – 2019)



Source: Statistics Canada. Table 32-10-0353-01 Production and value of honey

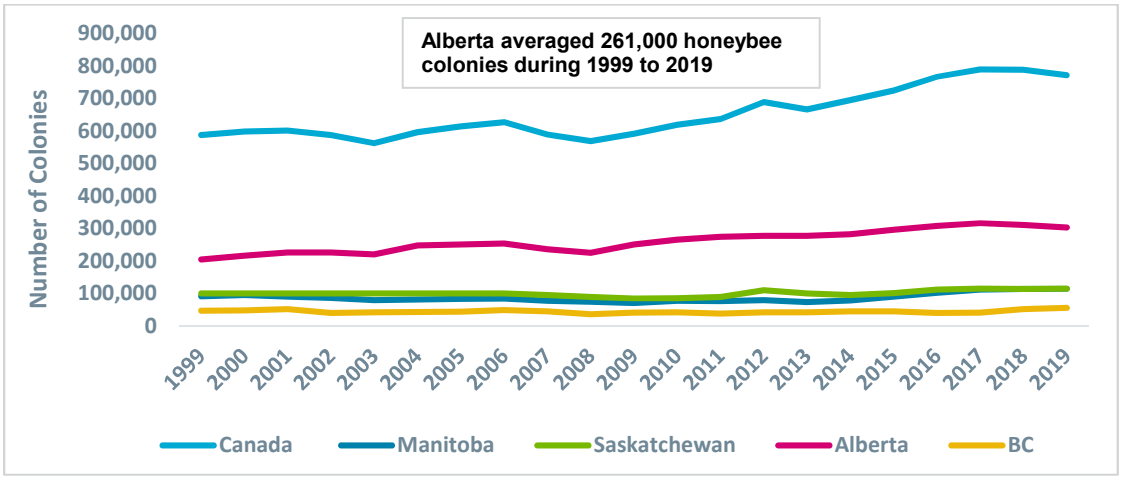
Number of Bee Colonies

In 2019, Alberta comprised 39 per cent of total Canadian bee colonies

As depicted in Figure 2, after more than a decade of steady growth in total honeybee colony numbers, the number of Canadian colonies declined 2.1 per cent from a year earlier to 773,182 in 2019. The contraction was primarily due to sustained weather unfavorable to honeybees including a cold wet spring in many parts of Canada.[1] During the period covering 1999 to 2019, Alberta averaged about 261 thousand colonies and led Western Canada comprising 39 per cent of total Canadian bee colonies in 2019.

[1] Statistics Canada, https://www.agr.gc.ca/eng/horticulture/horticulture-sector-reports/statistical-overview-of-the-canadian-honey-and-bee-industry-2019/?id=1594646761058

Figure 2: Canada and Western Provinces Number of Bee Colonies (1999 – 2019)



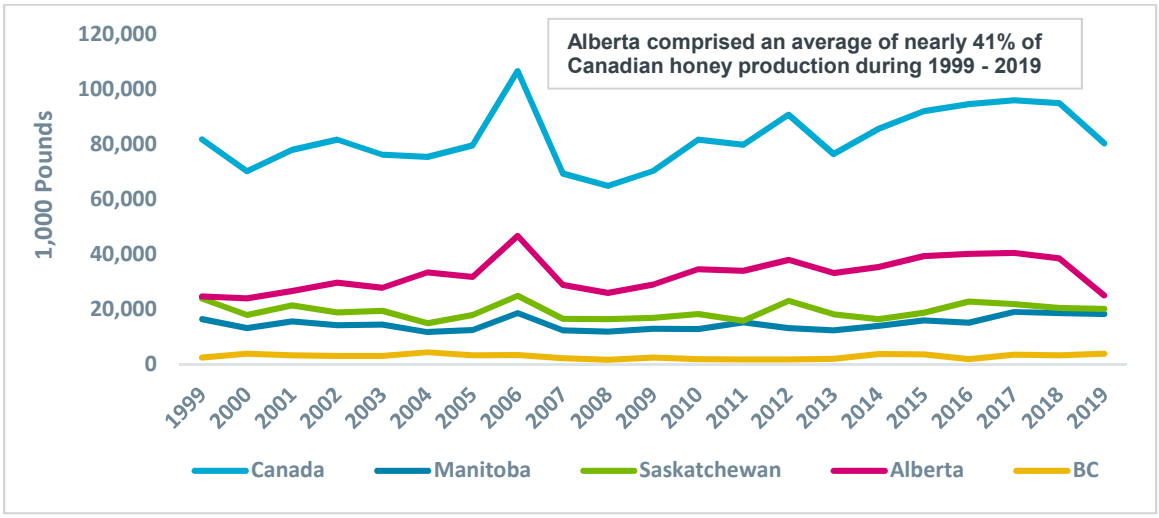
Source: Statistics Canada. Table 32-10-0353-01 Production and value of honey

Honey Production

Alberta comprised an average of nearly half of total Canadian honey production

Canada produced an average of 82.2 million pounds of honey per annum during the period covering 1999 to 2019. **Alberta is a significant player in the Canadian honey industry comprising an average of nearly 41 per cent (33 million pounds) of total Canadian honey production** during the same period. As highlighted in Figure 3, following Alberta were Saskatchewan, Manitoba, and British Columbia.

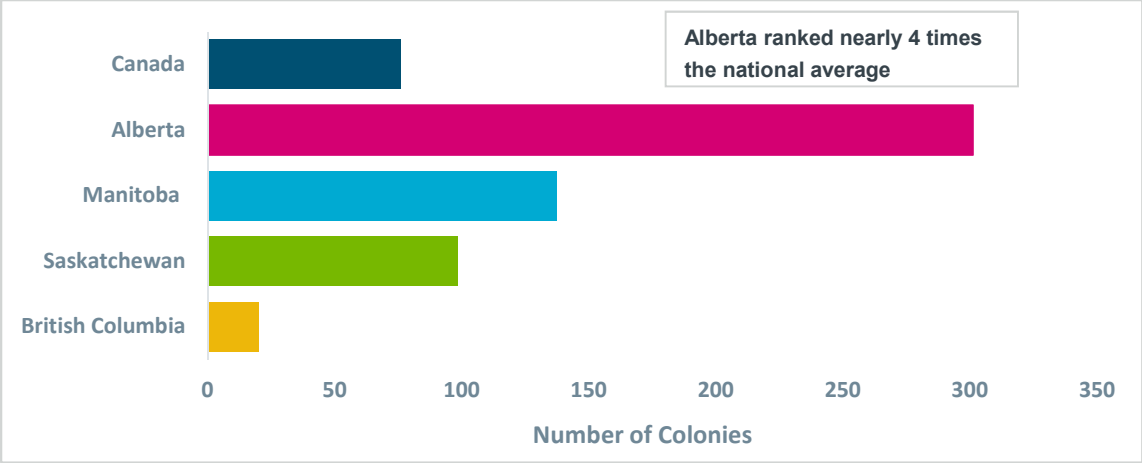
Figure 3: Canada and Western Provinces Honey Production by Quantity (1999 – 2019)



Source: Statistics Canada. Table 32-10-0353-01 Production and Value of Honey

As indicated in Figure 4, during the period covering 1999 to 2019, Alberta ranked nearly four times the Canadian average of about 76 bee colonies per beekeeper with an average of 301 colonies per beekeeper.

Figure 4: Canada and Western Provinces Number of Colonies per Beekeeper (1999 – 2019)



Source: Statistics Canada. Table 32-10-0353-01 Production and Value of Honey

Average Yield per Colony

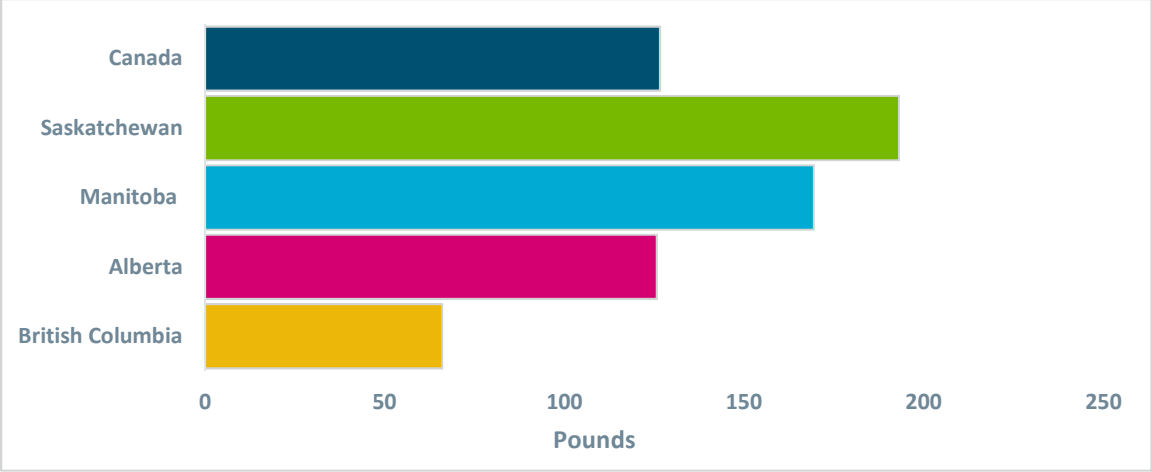
Alberta averaged 125.7 pounds per colony

(1999 – 2019)

Based on data from Statistics Canada, Canadian honey yield during the period covering 1999 to 2019 averaged126.5 pounds.

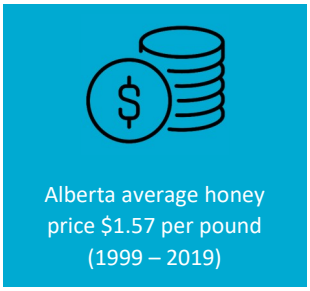
As noted in Figure 5, Alberta fared slightly below the Canadian average ranking behind Saskatchewan and Manitoba with an average of 125.7 pounds during the same period.

Figure 5: Canada and Western Provinces Honey Average Yield per Colony (1999 – 2019)



Source: Statistics Canada. Table 32-10-0353-01 Production and Value of Honey

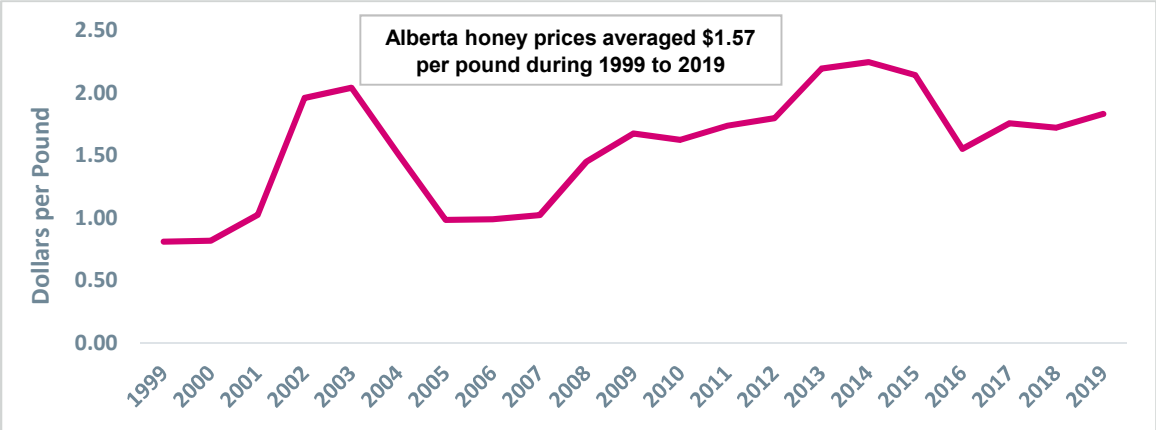
Honey Prices



Alberta producer prices received per pound of honey varied considerably over the last 20 years as shown in Figure 6.

During the period covering 1999 to 2019, the average honey price in Alberta was $1.57 per pound. In 2019 the Alberta honey price totaled $1.83 per pound.

Figure 6: Honey Price in Alberta - Dollars per pound (1999 - 2019)

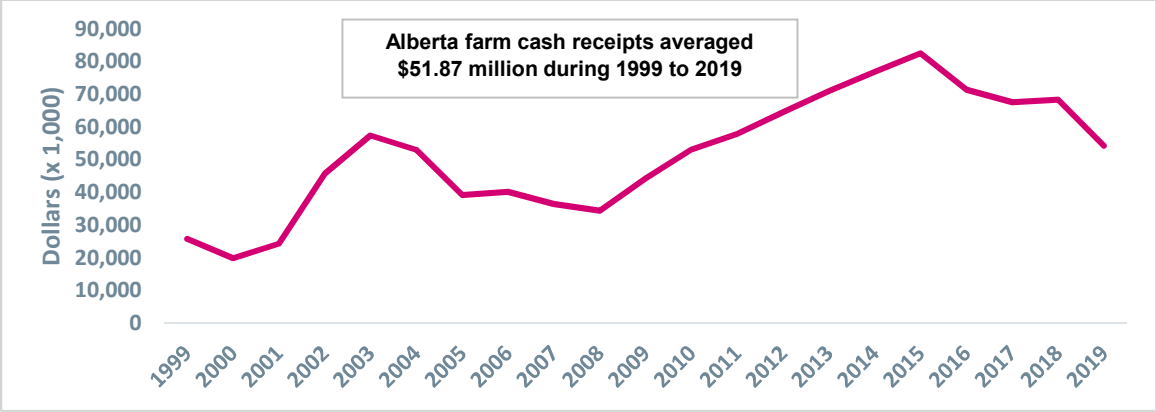


Source: Statistics Canada. Table 32-10-0353-01 Production and Value of Honey

Honey Farm Cash Receipts

As illustrated in Figure 7, Alberta farm cash receipts derived from honey production in 2019 totaled $54.4 million, down 34 per cent from the record high of $82.6 million set in 2015. Alberta's honey market receipts averaged $51.87 million during the period covering 1999 to 2019**.** In 2019, honey production was down across most regions in Alberta. This was largely due to adverse weather in the early spring and during the honey flow months.

Figure 7: Honey Farm Cash Receipts in Alberta (1999 - 2019)



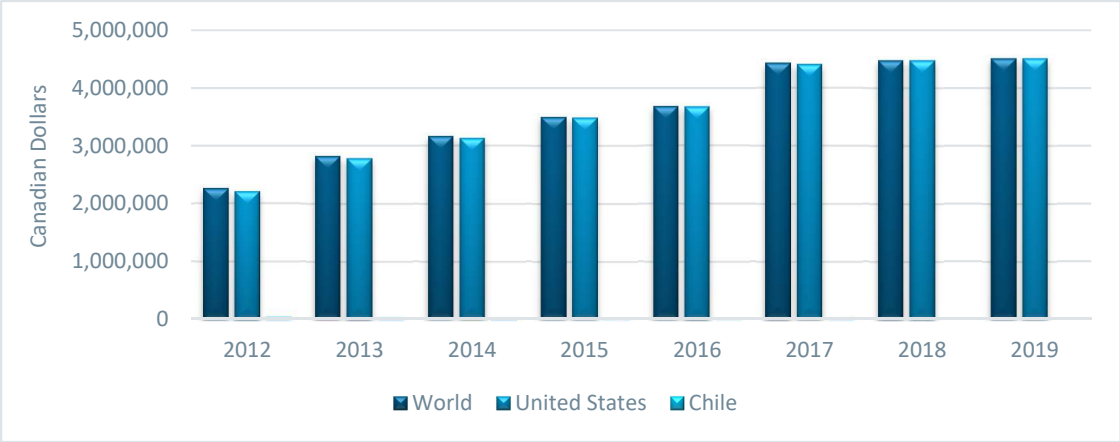
Source: Statistics Canada. Table 32-10-0045-01 Farm cash receipts

Honeybee Imports

Queen Bees

Alberta is reliant upon queen bee imports which are critical for the beekeeping industry's sustainability. In 2019, Alberta accounted for about 56 per cent of total Canadian live queen bee imports. As highlighted in Figure 8, Alberta's live queen bee imports rose by 17 per cent during the past seven years. During the period covering 2012 to 2019, Alberta imported an average of 132,072 live queen bees with nearly all imports originating from the United States.

Figure 8: Alberta Imports of Live Queen Bees by Country of Origin and Value (2012 – 2019)



Source: Statistics Canada

Honeybee Packages

Almost 100 per cent of bee packages are imported into Canada. According to Statistics Canada, Alberta imports of bee packages fluctuated considerably from 2000 to 2016. New Zealand was the primary exporter of live honeybee packages to Canada, comprising 77 per cent of total Canadian honeybee package imports in 2016.

Bee Nuclei (Nucs)

Survey of Alberta Beekeepers in 2019 shows that about 88 per cent of nucs purchases were from British Columbia, eight per cent from Alberta and the remaining four per cent were from other Canadian provinces.

Economic Impact of Foulbrood

The presence of diseases like foulbrood can cause significant economic losses for the beekeeping industry in Alberta. Depending on the severity of infection, infected colonies may be weakened or die. The economic losses are due to the additional costs of replacing infected hives, bees and brood, potential loss in revenue due to reduced honey production and hive rental income, costs of

sterilizing hives with irradiation and labour costs associated with implementing best management practices for prevention and control of the spread of the disease.

Three scenarios were analyzed to determine the economic impact of AFB and EFB. For each of these scenarios the potential economic impacts were estimated on a per hive basis before determining the industry-wide impacts at the baseline and outbreak levels of AFB and EFB incidence. The scenarios analyzed are as follows:

- Scenario 1 - Spring outbreak with burning of infected brood frames.
- Scenario 2 - Spring outbreak with irradiation of infected brood frames.
- Scenario 3 - Fall outbreak resulting in death of infected hives, bees and brood, followed by burning of infected frames.

Results from the National Honey Bee Health Survey were used as a basis for determining the baseline and outbreak levels of AFB and EFB. The baseline was based on the use of visual inspections of brood combs to detect diseased larvae while the outbreak level was based on detection by molecular methods. Specifically, the molecular method that was used to detect the presence of AFB was bacteria culture, and for EFB was conventional polymerase chain reaction (PCR). Table 3 shows the 2014 to 2017 National Honey Bee Health Survey results for AFB and EFB in Alberta.

Table 3: National Honey Bee Health Survey Results for AFB and EFB in Alberta, 2014-2017

Year of Report	Visual Inspection Baseline Level		Molecular Detection Outbreak Level	
	AFB	**EFB**	**AFB**	**EFB**
2014	0.45%	0.17%	15.40%	36.60%
2015	0.50%	0.60%	16.00%	37.00%
2016	0.50%	0.10%	22.00%	45.00%
2017	0.20%	0.20%	13.00%	30.00%
Average	**0.41%**	**0.27%**	**16.60%**	**37.15%**

Source: Grande Prairie Regional College National Bee Diagnostic Centre

As shown in Table 3, AFB and EFB incidence based on visual inspections averaged less than 0.5 per cent. However, the presence of the bacterium when detected by molecular methods averaged approximately 17 per cent for AFB and 37 per cent for EFB. These high percentages associated with the molecular detection indicates that the potential for AFB and EFB outbreaks in Alberta is significant if conditions become favourable.

Key Data and Assumptions

Table 4 shows the data and assumptions used for the estimation. The information was sourced from Alberta Agriculture and Forestry (AF), Statistics Canada and peer-reviewed academic research papers.

Table 4: Key Data and Assumptions

Type of Information	Per Unit
Number of Hives and Yield Information	
Total number of hives in Alberta - 2015-2019 Average	307,476
Average number of hives used for pollination (55,000 – 75000 hives)	65,000
Hives used primarily for honey production - %	78.9%
Hives used primarily for pollination - %	21.1%
Average honey yield per hive, 2015-2019 Average - (lbs)	123
Average honey production per pollinating hive (lbs)	90
Loss in honey yield per hive if AFB or EFB occurs in Spring - %	100%
Loss in honey yield per hive if AFB or EFB occurs in Fall -% [2]	40%
Loss in rental income per hive if AFB or EFB occurs in Spring - %	100%
Loss in rental income per hive if AFB or EFB occurs in Fall - %	40%
Stock Replacement	
Percentage of infected hives replaced using splits and queens	75%
Percentage of infected hives replaced using packages and nucs	25%
Quantity of honey required for bees to build wax on a new brood frame – lbs [3]	1.60
Prices	
Price of honey - 2015-2019 Average - $/lb	$1.80
Average rental income per hive from pollination in 2019	$158
Value of a split - $ [4]	$94.95
Price per queen purchased	$39
Bee package (2 lb equivalent)	$224
Nuc with 4 frames and a queen in Alberta in 2019	$252
Yellow or Black Assembled Frame and Foundation (minimum 100) - $/frame	$3.15
Labour Costs	
Average wage rate for Apiary Technicians (NOC 8431 or 8253) - $/hour	$19.50
Inspection of brood frames (2 people working 8 hours each per 100 hives) - $/hive	$3.12
Cleaning and removing empty dead-out equipment from apiary sites - $/hive	$1.63
Decontaminating boxes and equipment by scorching with a propane torch - $/hive	$0.65
Labour and other costs if hives are burned not irradiated - $/hive	$0.65
Antibiotic Treatment Costs	
Tylosin (Tylosan) cost per hive - 3 treatments	$0.58
Tylosin (Tylosan) cost per hive - 6 treatments (Spring and Fall)	$1.17
Oxytetracycline cost per hive - 3 treatments	$0.55
Oxytetracycline cost per hive - 6 treatments (Spring and Fall)	$1.11
Irradiation costs - ($/hive)	
Super or Nuc box (with or without frames inside) - $/each	$6.00
Frames (2 frames per wrapped package) - $/package	$3.50
Transportation costs for irradiation treatment (to and from the IOTRON facility in BC) - $/hive	$5.20

Scenario 1 assumed that in the event of a spring outbreak the bees were not killed; only infected brood frames were burned. Beekeepers used the shook swarm or shaking method which involves

[2] Tibor I. Szabo (1983)

[3] Whitcomb, W Jr. (1946)

[4] Bernier M. and P. Giovenazzo (2018)

shaking all the bees onto new frames with foundation in disinfected hive boxes[5]. At the outbreak level, all hives (both affected and unaffected) were treated with antibiotics to stop re-infection of bee colonies. No revenue was generated from infected hives used for both honey production and pollination (i.e., 100 per cent revenue loss).

Scenario 2 assumed that in the event of a spring outbreak the bees were not killed; only infected brood frames were disinfected with electron beam or gamma irradiation. Beekeepers used the shook swarm or shaking method which involves shaking all the bees onto new frames fitted with foundation in disinfected hive boxes. At the outbreak level, all hives (both affected and unaffected) were treated with antibiotics to stop re-infection of bee colonies. No revenue was generated from infected hives used for both honey production and pollination (100 per cent revenue loss).

Scenario 3 assumed that in the event of a fall outbreak there would be death of colony bees so bee replacement is required (too late in the season for shook swarm method). All infected hives were burned. Approximately 75 per cent of the stock was assumed to be replaced through making splits and buying queens and the remaining 25 per cent through package bees and nucs. At the outbreak level, all remaining hives (unaffected) were treated with antibiotics to stop re-infection of bee colonies.

There was a 40 per cent honey loss and a 40 per cent pollination loss on the infected hives. As a result, revenue generated from affected hives used for honey production and pollination declined by 40 per cent. Based on the Survey of Alberta Beekeepers in 2019, average rental charge (blend of rental fees for blueberry and canola fields) was estimated at $158.17 (Emunu, J. P. 2020). The rental fees for blueberry fields ranged from $80 to $125, while for canola fields fees ranged from $170 to $199.

Analysis and Results

Economic impacts from a project, program, or policy can be categorized into primary or direct impacts and secondary impacts which is the combination of indirect and induced impacts. This analysis focused on estimating only the direct impacts. A partial budget modelling approach was used for the economic impact analysis. Only potential costs and losses in revenue that were incremental in the event of disease incidence were estimated. Table 5 shows the number of hives impacted by AFB and EFB based on the five-year (2015-2019) average of 307,476 hives.

Table 5: Number of Hives Impacted by AFB and EFB

	American Foulbrood - AFB		European Foulbrood - EFB	
	Baseline	Outbreak	Baseline	Outbreak
Average foulbrood incidence (%)	0.4125%	16.6000%	0.275%	37.1500%
Number of hives affected by foulbrood	1,268	51,041	822	114,227
Hives used primarily for honey – 78.9%	1,000	40,251	649	90,080
Hives used primarily for pollination – 21.1%	268	10,790	174	24,148

[5] Agriculture and Forestry, Government of Alberta 2020. Honey Bee Pests and Diseases - Best Management Practices 2020.

Depending on the severity of foulbrood incidence, the number of hives that could potentially be impacted by AFB ranged from 1,268 hives (baseline) to an outbreak level of 51,041 hives. The corresponding value for EFB as shown in Table 5 ranged from 822 hives to 114,227 hives.

As indicated previously, Alberta beekeepers rent out about 55,000 to 75,000 honey bee colonies annually to pollinate crops such as hybrid canola seed, blueberries, etc. Based on an average 65,000 hives, hives used primarily for honey production were estimated at 78.9 per cent of the total number of hives affected by AFB and EFB respectively while the remaining 21.1 per cent constituted hives impacted by AFB and EFB used primarily for pollination.

Table 6 shows the results of the economic impact of a spring outbreak with burning of infected brood frames (Scenario 1).

Table 6: Impact of a Spring Outbreak with Burning of Infected Brood Frames - Scenario 1

Direct Potential Economic Losses	American Foulbrood			European Foulbrood		
	$/Hive	Baseline	Outbreak	$/Hive	Baseline	Outbreak
Cost of replacing burned infected brood frames (18 frames for AFB and 10 frames for EFB)	$108.61	$137,751	$5,543,445	$60.34	$49,628	$6,892,201
Costs associated with treating all hives with antibiotics	$1.14	$0	$349,914	$1.11	$0	$341,196
Value of lost honey from infected hives used for only honey production	$221.69	$221,736	$8,923,204	$221.69	$143,793	$19,969,701
Value of lost honey production from infected hives used for pollination	$162.21	$43,493	$1,750,261	$162.21	$28,205	$3,917,000
Lost rental income from infected hives used for pollination	$158.17	$42,409	$1,706,654	$158.17	$27,502	$3,819,410
Labour cost for inspecting hives to identify infected brood frames	$3.12	$3,957	$159,248	$3.12	$2,566	$356,389
Labour and other costs associated with burning infected combs	$0.65	$824	$33,177	$0.65	$535	$74,248
Total Economic Impact	**$656**	**$450,171**	**$18,465,903**	**$607**	**$252,227**	**$35,370,144**

As shown in Table 6, the economic impacts for AFB and EFB were estimated at $656 per hive and $607 per hive respectively. The difference in estimated impacts were due to the costs of replacing the burned frames and treatment of hives with antibiotics. For AFB all frames (nine frames per box or 18 frames per hive) were replaced while for EFB only the infected brood frames (10 frames per hive) were replaced. Since nearly all hives in Alberta are not treated every year, the baseline costs associated with treating unaffected hives with antibiotics was assumed to be zero.

From an industry-wide perspective, the estimated impact for AFB ranged from the baseline level of $0.45 million to an outbreak level of approximately $18.47 million. The corresponding value for EFB ranged from $0.25 million to approximately $35.37 million.

Table 7 shows the results of the economic impact of a spring outbreak with irradiation of infected brood frames (Scenario 2). The economic impacts for AFB and EFB were estimated at $583 per hive and $569 per hive respectively. Similar to the results of Scenario 1, the difference in estimated impacts were due to the costs of disinfecting frames with irradiation and treatment of hives with antibiotics. For AFB all frames (18 frames per hive) were irradiated while for EFB only infected brood frames (10 frames per hive) were irradiated.

Table 7: Impact of a Spring Outbreak with Irradiation of Infected Brood Frames - Scenario 2

Direct Potential Economic Losses	American Foulbrood			European Foulbrood		
	$/Hive	Baseline	Outbreak	$/Hive	Baseline	Outbreak
Costs of disinfecting frames with irradiation – (18 frames for AFB and 10 frames for EFB)	$31.50	$39,953	$1,607,792	$17.50	$14,394	$1,998,978
Costs associated with treating all hives with antibiotics	$1.14	$0	$349,914	$1.11	$0	$341,196
Value of lost honey from infected hives used for only honey production	$221.69	$221,736	$8,923,204	$222	$143,793	$19,969,701
Value of lost honey production from infected hives used for pollination	$162.21	$43,493	$1,750,261	$162	$28,205	$3,917,000
Lost rental income from infected hives used for pollination	$158.17	$42,409	$1,706,654	$158	$27,502	$3,819,410
Costs of sending infected brood frames for irradiation and returning to apiary	$5.20	$6,595	$265,384	$5.20	$4,277	$593,917
Labour cost for inspecting hives to identify infected brood frames	$3.12	$2,572	$103,511	$3.12	$2,566	$231,653
Total Economic Impact	**$583**	**$356,758**	**$14,706,721**	**$569**	**$220,735**	**$30,871,855**

From an industry-wide perspective, the estimated impact for AFB ranged from the baseline level of $0.36 million to an outbreak level of $14.71 million. The corresponding value for EFB ranged from $0.22 million to approximately $30.87 million.

Table 8 shows the results of the economic impact of a fall outbreak resulting in the death of infected hives, bees and brood, followed by burning of infected frames (Scenario 3).

Table 8: Fall Outbreak Resulting in Death of Infected Hives, Bees and Brood - Scenario 3

Direct Potential Economic Losses	American Foulbrood			European Foulbrood		
	$/Hive	Baseline	Outbreak	$/Hive	Baseline	Outbreak
Cost of replacing 75% of dead hives with splits and queens	$100.10	$95,216	$3,831,713	$100.10	$61,746	$8,575,189
Cost of replacing 25% of dead hives with package bees and nucs	$59.43	$18,843	$758,302	$59.43	$12,220	$1,697,043
Costs associated with treating unaffected hives with antibiotics	$1.14	$0	$291,828	$1.11	$0	$214,442
Value of lost honey from infected hives used for only honey production	$89.06	$89,083	$3,584,917	$89.06	$57,769	$8,022,871
Value of lost honey production from infected hives used for pollination	$65.17	$17,473	$703,171	$65.17	$11,331	$1,573,663
Lost rental income from infected hives used for pollination	$63.27	$16,964	$682,662	$63.27	$11,001	$1,527,764
Labour cost for inspecting all hives to identify dead hives	$3.12	$3,957	$159,248	$3.12	$2,566	$356,389
Cleaning and removing empty dead-out equipment from apiary sites	$1.63	$2,061	$82,942	$1.63	$1,337	$185,619
Labour costs associated with burning infected hives	$0.65	$824	$33,177	$0.65	$535	$74,248
Total Economic Impact	**$384**	**$244,422**	**$10,127,959**	**$384**	**$158,504**	**$22,227,228**

As shown in Table 8, the economic impact for both AFB and EFB was estimated at $384 per hive. This is because in most cases methods used for AFB are sufficient for EFB treatment. Since nearly all hives in Alberta are not treated every year, the baseline costs associated with treating unaffected hives with antibiotics was assumed to be zero.

From an industry-wide perspective, the estimated impact for AFB ranged from the baseline level of $0.24 million to an outbreak level of $10.13 million. The corresponding value for EFB ranged from $0.16 million to approximately $22.23 million.

Conclusion

The analysis shows that the beekeeping industry would experience substantial financial losses associated with an AFB or EFB outbreak in Alberta. The negative financial impacts are due to the additional costs of replacing infected hives, bees and brood, potential loss in revenue due to total loss or reduction of honey production and hive rental income, costs for sterilizing hives with irradiation and the labour costs associated with implementing best management practices for prevention and controlling the spread of the disease.

It is critical for Alberta beekeepers to continue following the recommended best management practices for AFB and EFB and thereby maintain the prevalence or incidence levels at the baseline of less than one per cent.

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