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Research Priorities

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Contents

Preamble

Compared to other parts of North America, beekeeping is relatively new to the Canadian province of Newfoundland and Labrador (NL). Historically, Leander L. Davis appears to have been the first person to keep honey bees in Newfoundland, at Harbour Grace, circa 1929. However, modern-day beekeeping in the province owes its origins largely to the pioneering efforts of Wally Skinner who started beekeeping in 1974 (Hicks 2014). As of March 2018, there were about 500 honey bee colonies in the province managed by approximately 50 beekeepers. Beekeeping has clearly taken off as both a hobby craft and commercial activity with seven or eight beekeepers having a commercial focus. They sell honey, beeswax, pollen, and other products as well as offering pollination services to small fruit producers. It is the spring climatic conditions that have been the single most limiting factor in terms of expanding the apicultural industry here. However, with new technologies and methods, NL beekeepers expect to overcome the climatic challenge in the near future. We are optimistic that we can significantly expand the number of beekeepers and colonies in the province over the next 10 years so that we can improve not only our domestic market share of bee-related products but also offer various products for export nationally and internationally. In order to accomplish these goals, we need to retain our status as a relatively disease-free refuge for honey bees.

Based on input from its Scientific Advisory Committee (SAC), the Newfoundland and Labrador Beekeeping Association (NLBKA) has identified several research priorities concerning honey bees and wild pollinator species in NL. Broadly, these address:

1. the population biology of relevant native and honey bee species, and their pathogen profiles;

2. pollination studies;

3. NL honey bee genetics and breeding;

4. forage capacity;

5. annual colony loss and management monitoring; and

6. apiculture marketing.

The purpose of the present document is not only to identify the NLBKA's research priorities, but also to encourage the development of research proposals consistent with these priorities. The order of presentation does not imply ranking according to scientific merit. Excerpts from supporting references in Appendix 7.3 may be consulted.

1. Population studies, pathogen profiles and monitoring

1.1. Native bee species

Background. With the exception of limited, desk-top, data-mining using archival sources (e.g., by Cory Scheffield) and fieldwork by Laura Siegwart Collier, a biology student at Memorial University who collected *Vaccinium* pollinators in the Torngat region, very little is known about the native bee species in either Labrador or the island portion of the Province.[1] The full diversity of *Bombus* and non-*Bombus* native bee species is at present unknown, as well as their distribution and abundance. Thus far research efforts point to the presence of *B. Sandersoni*, *B. frigidus*, *B.mixtus*, *B. ternarius*, *B. sylvicola*, *B. melanopygus, B. polaris, B. balteatus, B. hyperboreus, B. terricola,* and *B. Bohemicus* in Labrador (Williams et al., 2014).

The re-introduction of *Apis mellifera* colonies to Upper Lake Melville and other parts of Labrador poses an attendant risk of pathogen spillover *fr*om *A. mellifera* to *Bombus* species. (see Colla et al. 2006; Fürst, et al. 2014; Graystock, et al. 2013a; Graystock, et al. 2013b; Graystock, et al. 2015; Manley, et al. 2015; and McMahon, et al. 2015). Climate change related research also requires the establishment of baseline inventories of the native bee species of Labrador.[2] On the Island, there is a pressing need for inventory work given the rapid growth in commercial and hobby apiculture. Again, we need to better understand possible pathogen spillover between *A. mellifera* and *Bombus* species there.

1.2 Health status of native bees in Labrador

Background. To-date there are no data available concerning the pathogen, disease, and pest profiles of native bees in Labrador. At the same time, there is a re-emerging interest in beekeeping in parts of Labrador. *A. mellifera* colonies have been kept in the Upper Lake Melville area and possibly the Labrador Straits in the past, but they were short-lived. No baseline pathogen research was conducted prior to their introduction. From a biodiversity, ecological, and ecosystem service perspective, it is not responsible to encourage new beekeeping in Labrador without knowing more about the health of the native bees. New pathogens, diseases and pests could be unwittingly introduced with possible negative consequences for native bee health. However, without baseline data on existing pathogens, long-term monitoring of native bee health and responsible management of *A. mellifera* re-introduction are greatly impaired if not impossible.

Research needed. The existing pathogen, disease, and pest profiles of native bees in Labrador require investigation for long-term monitoring, climate change research, as well as risk assessment related to the re-introduction of *Apis mellifera* colonies there. As noted above (section 1.1.) research elsewhere in North America and Europe provides evidence of pathogen spillover between *A. mellifera* and *Bombus* species. We have an opportunity to prevent or at least mitigate this problem in Labrador, but a baseline profile of pathogens, diseases and pests must be established before any risk assessment can be conducted and management strategies developed.

[1] See Williams, et al., 2014; Shelly Moores, personal communication with Peter Armitage, 21 Feb. 2017; Luise Hermanutz, personal communication with Peter Armitage, 13 Feb. 2017.
[2] E.g., See research conducted by The Woodard Lab, http://www.woodardlab.com/ in particular their *Bombus polaris* and climate change study. http://www.dispatch.com/content/stories/science/2016/10/16/01-researchers-hope-bombus-polaris-can-shed-light-on-climate-change.html

1.3. Pathogen profiles in Island honey bees

Prior to 2016, NL honey bees were surveyed for pathogens in 2004 (Rogers unpublished), 2007 (Williams and Rogers unpublished), 2009 (Williams, et al. 2010), and 2010 (Shutler, et al. 2014). *V. destructor* and *A. Woodii* were not detected during the 2004 survey, however, *Nosema apis* was detected in 2007 (Williams 2010: 3). During the 2016 season, provincial apiarist, K. Kennedy, sampled several apiaries for various pathogens as part of the Canadian National Honey Bee Health Survey. She also conducted a rolling 100% sample of all honey bee packages imported from Western Australia (WA) in April 2016. Colonies were sampled for *Nosema*, *Varroa*, tracheal mite, American foulbrood, European foulbrood, chalkbrood, Acute Bee Paralysis Virus, Black Queen Cell Virus, Chronic Bee Paralysis Virus, Deformed Wing Virus, Israeli Acute Paralysis Virus, Kashmir Bee Virus, and Sac brood virus. Kennedy reported on the results of the testing to the NLBKA at its Annual General Meeting on 5 November 2016. It appears that no testing has been done to-date with any NL honey bees as far as Cloudy Wing Virus, Invertebrate Iridescent Viruses, the “B” strain of Deformed Wing Virus (DWV-B), the Lake Sinai Viruses, and Slow Paralysis Virus are concerned, although the latter two viruses were to have included in the 2017 Canadian National Honey Bee Health Survey (National Bee Diagnostic Centre 2016; see also Bromenshenk, et al. 2010; Daughenbaugh, et al. 2015; McMahon 2016). The strategy of the National Honey Bee Health Survey is outlined in Appendix 7.1. Results of the National Honey Bee Health Surveys are published in report format by the National Bee Diagnostic Centre (NBDC). A brief methods statement is provided with the reports (e.g., see NBDC 2015).

The Association's current Pathogen Testing Report can be consulted in the Appendix 7.2.

Research needed. The SAC has not yet identified additional pathogen-related research of benefit to the province’s honey bees and beekeeping, especially given that testing by the Government of Newfoundland and Labrador and the NBDC is conducted on an annual basis. However, research to develop a complete profile of endemic honey bee viruses in NL may facilitate long-term monitoring and assessment of the risk of pathogen spillover between *Apis* and non-*Apis* bee species.

The NLBKA welcomes further scientific research with respect to our endemic pathogens, particularly if it will advance NL apiculture by helping beekeepers monitor or manage resultant disease. The SAC will ask the NBDC and the Government of Newfoundland and Labrador’s provincial apiarist for relevant information when the need arises. The SAC will communicate with the NBDC to ascertain its capacity for the long-term storage of testing samples, and whether or not researchers may have access to such samples for research purposes.

2. Pollination studies

2.1. Background.

Honey bees are used widely throughout North America and Europe for the commercial pollination of a variety of crops including blueberry and cranberry. The provision of pollination services is a major source of income for many beekeepers, and is a determining factor in the economic success or failure of many beekeeping enterprises. In 2008 and 2009, Hicks (2011) conducted research on the impact of *Bombus impatiens* and *Apis mellifera* pollination on commercial blueberry fields. The honey bee component was confined to 2009 at which time eight colonies were placed in two fields at stocking rates of 4 hives/3 ha, and 4 hives/2 ha respectively (ibid.: 110). Climatic conditions at the time of the field research are not described. Hicks concluded that

> the stocking rates of *Bombus impatiens* and *Apis mellifera* observed in this study failed to increase fruit set compared to un-supplemented areas and thus does not support their use by farmers in eastern Newfoundland. However, increasing the stocking rates may increase pollination, but presently it is unknown if that would result in greater fruit production. As the bee fauna throughout Newfoundland is not well known, additional studies should be initiated to determine whether supplementation with introduced bees in those areas is worthwhile (ibid.: 116).

Hicks conducted a follow-up study with *Apis mellifera* in June-July 2015 but the results were inconclusive because climatic conditions were not conducive to honey bee foraging activity. In 2014 and 2015, Sircom (2016) conducted pollination research on four commercial cranberry farms on the Island of Newfoundland. She concluded that

> [n]o relationship between bee abundance and yield can be demonstrated in this study. Clearly bees are needed, but it appears that the native bees present are in high enough abundance to meet the plants' pollination needs. On all farms, bees were depositing enough pollen to ensure nearly complete pollination, but variation in stigma loading was not correlated with yield. Something else, such as temperature, moisture, or soil fertility, has a greater effect on yield than the variations in bee abundance, activity, or stigma loading observed here (ibid.: 30).

Research needed. Further work is required on a priority basis to determine whether pollination by *Apis mellifera* colonies increases the productivity of blueberry, cranberry crops, strawberries and other flowering crops in NL. Such research should be multi-year to take into account climatic variables peculiar to the province as well as annual variations in native pollinator species. This would also allow re-appraisal of *Apis mellifera* stocking rates recommended for blueberries and cranberries on mainland North America.

2.2. Native bee species vs. crop pollination.

It is well recognized that various native bee species can play an important role in commercial crop pollination. However, their effectiveness may be seriously compromised in areas where floral diversity is greatly diminished and the application of insecticides and herbicides widespread and frequent (Carvell, et al. 2007; Pywell, et al. 2006; Pywell, et al. 2005). In early 2017, the Cranberry Association of Newfoundland and Labrador announced its intention to ask the provincial government to allow the importation of 750 quads of *Bombus impatiens* to pollinate cranberry bogs. The NLBKA vigorously opposed this proposal citing numerous concerns including the risk of pathogen spillover from these bees to native bee species and honey bees, and the fact that *Bombus impatiens* is not native to the province. There is a high risk that *Bombus impatiens* could become established here, and henceforth out-compete native species like *Bombus terricola*.[3]

Research needed. There is a general lack of knowledge regarding native bee species indigenous to the Island of Newfoundland. To the best of our knowledge, bumble bees make up only about 20% of the bee species on the Island. Moreover, there is a significant number of bee species other than bumble bees that are likely to be important pollinators of cranberry, blueberry, and native plants. However, many lay people are unable to identify these bees, and many would not even see them as bees. Therefore, it is premature to conclude that there are not enough native species to pollinate cranberries, when the full spectrum of pollinator species available in cranberry fields has not been documented. Research is needed to generate a comprehensive inventory of pollinator species able to pollinate cranberry and blueberry crops in Newfoundland, and if possible, rank them in terms of importance to fruit set and other crop productivity variables.

2.3. Nesting ecology of the key native Bombus species

Commercial beekeepers can meet a large portion of the cranberry pollination demand by providing production colonies. However, cranberry producers elsewhere in Atlantic Canada pollinate their crops using a blend of *Bombus* and *Apis* pollinators, meaning that NL cranberry producers may continue to lobby government for *Bombus* imports. In its cautionary statement about the international traffic in *Bombus sp*. for pollination purposes, the International Union for Conservation of Nature (IUCN, nd) Bumble Bee Specialist Group considers

> that the commercial movement and deployment of bumble bees for pollination should be governed by the precautionary principle to prevent unintended harm. Local bumblebee species and subspecies should be targeted for commercial development and produced within their native ranges.

Research needed. The nesting ecology of the most abundant and widely distributed *Bombus* species on the Island of Nfld. should be established with a view to assessing the feasibility of commercially producing a local native species for commercial pollination purposes. The research should include a risk assessment of commercial production related to out-competition with other native *Bombus*

[3] See letter from NLBKA president, Catherine Dempsey, to Honourable Steve Crocker, Minister of Fisheries and Land Resources, Government of NL, 24 February 2017. http://nlbeekeeping.ca/data/documents/2017-02-24- response-to-Minister-re-cranberry-assoc-final.pdf.

species and magnification of endemic *Bombus* pathogens, pests and diseases.

3. Genetics and breeding

3.1 Newfoundland honey bee origins

The local strain, as it presently exists, has many desirable traits: it is a winter hardy and very gentle bee; its numbers build gradually in the spring but take off explosively when the weather improves; it is economical in its consumption of winter stores, yet it is also a good honey producer. The genetics of this somewhat promiscuous strain date back to the mid-1970s, combining a *Ligustica* base with some Carniolan, Buckfast, and Russian Primorsky ingredients stirred in.

Pioneering beekeeper, Wally Skinner, and his daughters Alison van Alten and Andrea Skinner have played the primary role in shaping the genetics of these bees.[4] Until recently, Andrea and Paige Marchant, co-owners of the Newfoundland Bee Company, have been the sole purveyors of nucleus colonies and queens to other beekeepers in the province. Gerard Smith of G & M Family Farm started selling nucs and queens in 2015 and his stock derives mostly from the Skinner strain, although he purchased some bees from another pioneering beekeeper, Aubrey Goulding, several years ago. Goulding started beekeeping in 1984 and obtained bees from New Zealand and Nova Scotia (Hicks, 2014: 13). He sold nucs intermittently over the years but has not been a major supplier to other beekeepers in the province. Trevor Tuck of Tuck's Bee Better Farm started selling queens derived from the Skinner strain starting in ca. 2015-2016.

Wally Skinner first purchased honey bees from Al Flemming in Nova Scotia ca. 1974 (Hicks 2014: 13). These were derived from imported U.S. packaged bees, likely Carniolans with some Buckfast genetics from Weaver Apiaries of Texas, that were being used on the John L. Bragg blueberry farm operations in Nova Scotia (Oxford Frozen Foods).[5] Skinner began overwintering his bees after 1985 when the provincial government imposed import restrictions (Hicks 2014: 13). Henceforth, queen and egg imports to the province would require a government permit. At some point early on, Skinner purchased a queen from Jerry Draheim (Pugwash, Nova Scotia area).[6] He also purchased queens a couple of years from Silas Thompson in Grand Falls-Windsor. Now retired from beekeeping, Thompson obtained his bees from other parts of Canada (Quebec, Ontario and Nova Scotia) as well as from Australia and New Zealand (Hicks 2014: 14). In the mid-2000s, Wally and/or his daughter, Andrea, imported eggs derived from Ontario bee stock as well as the Ontario Russian bee breeding program with the view to enhancing the disease resistance of their strain.[7] Finally, the Skinners imported 10 Hawaiian queens in 2008 (Williams 2010: 3). It appears that they have not purchased

[4] Wally Skinner personal communication with Peter Armitage, 10 January 2017. See also Hicks (2014).

[5] See Flemming's beekeeping biography. "Al thinks he has got some good bees: mainly Carniolans with some Buckfast genetics from Weaver Apiaries of Texas that pre-date Nova Scotia's flirtation with Brother Adam's bees, and the residue of Philip Bishop's rigorous selection." http://www.nsbeekeepers.ca/profilesDetail.php?3

[6] See http://www.nsbeekeepers.ca/profilesDetail.php?13

[7] "The Russian bees did not come from Quebec.Ontario imported them from the U.S. There was a M.Sc. project by Geoff Wilson under the direction of Medhat Nasr. We had a Russian bee breeder in Ontario for years named Francois Petit who handled all the imported Russian stock" (Alison van Alten email to Peter Armitage, 12 January 2017).See also http://www.chathamdailynews.ca/2010/06/18/russian-honeybees-found-to-have-greater-resistance-to-disease and https://www.ontariobee.com/outreach/2004Research.

bees from the late Tom Northcott, Aubrey Goulding or any other beekeepers on the Island of Newfoundland, who obtained their bees separately. In April 2016, Trevor Tuck and Chris Lester imported 130 packages of bees from Western Australia. Pending confirmation by Western Australian sources, it is assumed that these bees are virtually pure *Apis mellifera ligustica* stock (Chapman and Oldroyd 2008).[8]

Research needed. The above description of the history of our current honeybee strain is incomplete and imprecise and does not constitute a genetic profile *per se*. Research is underway to develop an accurate genetic profile of our local honey bee strain to provide guidance for future breeding programs.[9] Whatever varroosis resistance was bred into this strain through the efforts of the Skinner family, it is likely to have receded significantly over the last ten years because hygienic behaviours and other forms of resistance are not stable over multiple generations.[10] Genetics research could also guide breeding with respect to improving winter hardiness and other traits, guide individual or collective beekeeper breeding strategies, and assist commercial beekeepers in out-of-province marketing of queens and other clean-bee products.

For additional information on this topic see Appendix 7.3.1.

3.2 Early season mating and nucleus colony development

Winter is long and difficult for beekeepers in NL; the months of May and June hardly qualify as spring months given the frequently cool temperatures and rain that are common at that time of the year. Climatic conditions are probably the single-most important limiting condition affecting honey bee survival and honey production in the province (see Canadian Association of Professional Apiculturists 2017: 5-6). Typically, nucleus colonies are not ready for sale here until the middle of July, compared to at least a month earlier in southern Ontario. The reason for this is because of inadequate numbers of sexually mature drones and difficulty mating virgin queens in June due to frequently cool, wet climatic conditions. Government restrictions in the past have made it impossible for beekeepers, particularly novice ones, to import nucleus colonies or packages from the Mainland, such that they could build their colonies more quickly for winter. These restrictions are strongly endorsed by the NLBKA because they are the best weapon against the inadvertent introduction of *Varroa* and other pathogens, pests, and diseases into the province. Restrictions are likely to continue into the future as long as the province's pathogen profile remains unchanged.

Research needed. Beekeepers in NL would benefit greatly from having nucleus colonies available at least three weeks earlier in the season. This would provide additional time to draw comb and build colony strength in preparation for winter. Quicker access to nucs requires that virgin queens be

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[8] Details concerning Western Australian breeding programs are currently unknown. It is not known whether all 130 colonies were re-queened, and if so what strain the new queens are derived from, or how they were mated (e.g, by drones from the Skinner strain or Western Australian colonies).

[9] In the summer of 2016, Memorial University (Grenfell) professor, Julie Sircom, contacted beekeepers in the province to request samples of their honey bees. Her purpose is "to look at a suite of microsatellites and mitochondrial DNA that will give the big picture of diversity, i.e., the number of loci at each microsatelliteas a measure of inbreeding and 'genetic distance' among different areas of the province, as well as information on matrilines" (email to Peter Armitage, 21 November 2016).

[10] See https://content.ces.ncsu.edu/comparison-of-russian-and-italian-honey-bees.

mated earlier. Therefore, methods need to be developed to enable early season production and mating of virgin queens (possibly via instrumental insemination) so as to promote the production of nucleus colonies earlier in the beekeeping season.

4. Colony loss and management survey

Beekeeping communities benefit from the collection of data regarding honey bee health and management. Systematic and methodologically robust data collection can provide credible information that can facilitate understanding potential health problems and guide beekeepers in developing management solutions to them. Furthermore, beekeeper data can be used to monitor the development of the apicultural industry, ascertain beekeeper needs (both commercial and hobby), aid community-wide planning, and better represent beekeepers to the public and governments.

Several beekeeping organizations and/or management entities in Canada systematically collect data from beekeepers using survey methodologies, including B.C.'s Apicultural Program, the Canadian Association of Professional Apiculturalists, and the Ontario Beekeepers' Association.[11] Both the B.C. and Ontario surveys include commercial and hobby beekeepers, while CAPA's survey relies on data collection by provincial apiarists and focuses almost exclusively on commercial beekeepers.

Beekeepers in Newfoundland and Labrador need a systematic survey of colony health and management that includes both commercial operations and hobbyists. The CAPA-based survey administered by the provincial apiarist does not provide sufficient data for our management requirements, and in the past has experienced low participation which frustrates monitoring and management objectives. To this end, the NLBKA initiated in 2017 a "Colony Loss and Management Survey" under the direction of Association member, Dr. Steve Walsh. The survey collected information about many aspects of beekeeping to determine how many colonies were kept and lost throughout the beekeeping season (June 2016-June 2017). The objective of the survey is to build a database for assessing health of Newfoundland and Labrador honey bees, and the management practices which may affect their health. A census survey consisting of 43 questions covering demographics, hive design, forage-habitat, summer period (June 1-October 31 2016), winter period (November 1 2016- May 31 2017), queen practices and geographic location was mailed to 45 persons: 38 current , 6 former and 1 non-member. Only beekeepers who had apiaries for one year or more were included; no beekeepers were listed in Labrador.

The Colony Loss and Management Survey requires an institutional commitment by the NLBKA. Walsh will continue to administer the survey on behalf of the Association, and is currently undertaking revisions based on 2017 results as well as determining database computer software solutions that will provide appropriate analytical capacity (e.g., temporal and regional comparisons) and long-term data management.

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[11] For B.C. see Paul van Westendorp. 2017. "Beelines." *BeesCene*. 33(3): 7; for CAPA see Annual Colony Loss Reports http://www.capabees.com/category/extension/overwintering-losses/; for the OBA survey see OBA news release 30 Oct. 2017, "Ontario Beekeepers Report Dramatically Lower Honey Production in 2017" https://www.ontariobee.com/sites/ontariobee.com/files/document/OBA_Honey_Production_Media_Release_October_30_2017.pdf; See also Ontario Ministry of Agriculture, Food and Rural Affairs Apiary Program survey http://www.omafra.gov.on.ca/english/food/inspection/bees/2016winterloss.htm

5. Honey bee forage capacity

Background. Until relatively recently, the quality, quantity and location of honey bee forage has not been a major concern for beekeepers in NL. Beekeeping remains in its infancy with about 50 beekeepers managing approximately 500 colonies at last count. Seven or eight people have nascent commercial operations that are producing honey and other products for domestic sale and are offering pollination services to small fruit growers on the Island of Newfoundland. At least one commercial operator has established out-apiaries for the purpose of producing mono-floral honey products (e.g., fireweed in the Cormack region). There is anecdotal evidence that lack of forage is an issue for some beekeepers in some parts of the Island in terms of limiting the number of colonies that can be pastured at certain locations. However, with expanding commercial operations on the horizon and a rapid increase in hobby beekeepers, there is potential for beekeepers to exhaust local bee pastures (Al-Ghamdi, et al. 2014; McRory 2015; Vautour 2014). Beekeepers know in general terms that their bees obtain much of their nectar and pollen from a limited number of plant species, e.g., alder, pussy willow, maple, dandelion, clover, fireweed, goldenrod and bog aster. However, there are no data available to the beekeeping community concerning the abundance and distribution of these species that would allow for systematic planning and management of apiary locations and numbers. Furthermore, little is known about the nutritional qualities of local alder species and other plants that may be of potential value to honey bees (e.g., coltsfoot, pin cherry, hawkweed). In his recent study of the beekeeping industry in NL, Walke (2015: 22) reports that one of his respondents identified the need for an adequate land base and floral source as a major challenge to the sustainability of his operation. "Another respondent also mentioned carrying capacity (maximum population sustainable given the available food resources) of his region as a concern" (ibid.).

Research needed. Beekeepers in NL need forage-related research conducted that will address three aspects of forage – *what* type of forage, *where* it is found, and *when* it can be accessed by honey bees. Research data on honey bee forage could assist beekeepers in planning apiary locations, lobbying governments to enhance forage in some areas, monitoring of forage capacity in some regions, etc. (see Decourtye, et al. 2010; Goulson, et al. 2015).

What — the forage species in the province that can be accessed by honey bees. We need a proper inventory of our bee forage species. This topic also includes the nutritional quality and quantity of this forage, and the carrying capacity of an available forage area (i.e., the number of colonies it will support) (see Girard, et al. 2012).

Where — the geographic location of these forage species (concentrations in particular areas). Priorities are to (a) help beekeepers find suitable apiary locations, and (b) manage apiary placement in potentially congested areas such as the Northeast Avalon. NLBKA may wish to make recommendations to various municipalities, developers, and the provincial Department of Highways re. lawn mowing schedules, re-vegetation strategies along roadsides, etc. so as to optimize forage in certain locations.

When — the phenology of these forage species (i.e., the time of the year when they produce pollen and nectar).

Agricultural lands and pollination. Research related to improving pollinator habitat around agricultural lands could be of benefit to honey bees and native pollinators (see Blaauw and Isaacs 2014; Carvell, et al. 2006; Garibaldi, et al. 2014; Goulson, et al. 2015; Kennedy, et al. 2013; Morandin, et al. 2007; Pywell, et al. 2006; Pywell, et al. 2005; Rundlöf, et al. 2008; Wratten, et al. 2012). Research results could have positive policy implications for the development and management of agricultural lands in NL and be of interest to the NL Horticultural Council and other members of the NL Federation of Agriculture particularly those who produce crops dependent upon insect pollination. "It would be advantageous to conduct studies on the floral abundance and diversity within ecoregions in Newfoundland in order to better understand target locations for potential apicultural development as well as assess the carrying capacity of different areas on the island. That being said, local knowledge (from experienced farmers and beekeepers in particular) may be valuable and should not be overlooked" (Walke 2015: 22).

6. Apicultural market research

Background. According to Sanford and Hoopingarner (1992: 743), 500 colonies was the "traditional line between part-time and full-time beekeepers, for statistical purposes" in the United States. However, they thought that as many as 2,000 colonies would be required to support a single beekeeping family. Also for the U.S., Daberkow et al. (2009: 608) note that the "2007 Agricultural Census reported that nearly 28,000 farms reported having at least one colony. A recent study noted that only about 1,500 farms are considered commercial beekeepers (i.e., a year ending inventory of more than 300 colonies) who accounted for nearly 90 percent of all colonies in the U.S. in 2002 for an average of around 1,400 colonies per farm." According to Melhim, et al. (2010: 8-9), in Canada fully commercial beekeepers work more than 300 colonies and they are "full time, possibly migratory beekeepers who rely for their income on producing honey in commercial quantities, in the case of honeybee farms, and on rendering remunerated pollination service to both and non-local farmers, in the case of both honeybee and non-Apis bee farms."

Miels d'Anicet and Api Culture Hautes Laurentides Inc. are a successful commercial beekeeping entity in Quebec owned and operated by Anicet Derocher and Anne-Virginie Schmidt.[12] Their operation is based on approximately 1,500 colonies supporting a rural store, and sophisticated on-line marketing/sales of organic honey, pollen, propolis, beeswax, and body care products. Breeding and queen-rearing varroosis resistant stock are also important ingredients in the success of the Derocher-Schmidt enterprise. Owned and operated by Tom Cosman and Mary Ann Whidden, Cosman and Whidden Honey in Greenwich, Nova Scotia, is another successful commercial beekeeping operation selling multiple bee products as well as pollination services. They run approximately 2,000 colonies each year.[13] Veteran Nova Scotian beekeeper, Tony Phillips, says that one person can make a frugal living running 300 to 500 colonies per year without the need to hire seasonal back-up labour. However, all of the larger beekeeping operations engage seasonal labour.[14]

With respect to pollination contracts, the Nova Scotia Beekeepers Association recommends

[12] See https://mielsdanicet.com/fr-ca/a-propos/elevage-de-reines-abeilles/.
[13] See http://www.novascotiahoney.com/index.htm.
[14] Tony Phillips personal communication with Peter Armitage, 13 March 2017.

"hive stocking rates for fruit crops" of three colonies per acre.[15] At these rates, about 1,500 honey bee colonies would be required to pollinate the approximately 500 acres of land in cranberry production on the Island of Newfoundland.[16] According to Statistics Canada, the amount of land in blueberry production in NL declined from 1,918 acres in 2006 to 1,062 acres in 2011.[17] Close to 3,200 honey bee colonies would have been required to pollinate all of the 1,062 acres of blueberry fields in the province in 2011.

Currently, in the absence of pollination contracts, all commercial beekeepers in the province sell their honey and other products domestically, through health and specialty food stores, craft fairs, and directly to upscale restaurants in St. John's. In December 2016, retail honey prices in specialty stores in St. John's varied from a high of $107.14/kg (56g jar) to a low of $27/kg (1 kg container).[18] There appears to be little in the way of out-of-province sales, and no beekeeper sells to industrial honey packers. As noted by Walke (2015), "the sale and use of honeybees for research purposes is a more important opportunity than commercial sale off the island....Marketing honey bees for research purposes and to provide other breeding programs and mite-free locations may prove to be a more lucrative development direction."[19]

Research needed. In theory, income from the provision of pollination services to blueberry, cranberry and other fruit producers on the Island of Newfoundland could contribute significantly to the economic viability of several commercial beekeeping operations in the province, when mixed with income from the sale of honey, pollen, beeswax, nucleus colonies, queens, and other bee products. However, opportunities for growth in commercial beekeeping appear limited unless blueberry and cranberry acreage expands significantly, and/or other aspects of beekeeping can be developed and marketed in innovative ways.

Market research is concerned with a number of questions:

• What quantity of lands must be put into cranberry and blueberry production in order to support expanded commercial beekeeping?

• Do we have the bee forage capacity to support a large number of beekeepers including commercial and hobby people? (see forage capacity research priority).

• Where are cranberry and blueberry farming operations located in relation to existing commercial beekeepers? (see forage capacity research priority).

• Where are the best locations for apiary placement, by commercial and hobby beekeepers, in order to maximize honey production? (see forage capacity research priority).

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[15] See http://www.nsbeekeepers.ca/newBeekeepersDetail.php?Pollination-Standard-12. See also, Eaton and Nams (2012: 1308-1309). They recommend placing up to 4 hives per hectare in wild blueberry fields in Nova Scotia where densities of non-Apis bee species are low.

[16] Re. Acreage in cranberry production, see http://www.acoa-apeca.gc.ca/eng/Agency/MediaRoom/NewsReleases/Pages/4398.aspx.

[17] See 2011 Census in Agriculture. http://www.statcan.gc.ca/pub/95-640-x/2011001/p1/prov/prov-10-eng.htm.

[18] Peter Armitage price survey, December 2016.

[19] Of course, the economic potential of NL bee exports can only be realized if the province is able to control effectively the importation of live bees and used beekeeping equipment, both prerequisites for the maintenance of the relatively-free pathogen, pest, and disease status. Dean Harron, then vice-president of the Thunder Bay Beekeepers' Association, claims that his region lost its *Varroa*-free status in ca.2014 when a maverick beekeeper imported five infested colonies. Every apiary was infested within three years. Harron had a bee export business prior to the recent arrival of *Varroa*, but this was destroyed once the pest took hold there (Dean Harron personal communication with Peter Armitage, 11 January 2017).

• Where are the best locations for apiary placement, by commercial and hobby beekeepers, in order to maximize honey production? (see forage capacity research priority).

• What market conditions (market prices for small fruits) must exist in order for it to be financially viable for cranberry and blueberry producers to purchase pollination services from commercial beekeepers, in the absence of government subsidy?

• How many pollination contracts do commercial beekeepers require in order to achieve economies of scale; so that per colony rental fees approach those on the Mainland of Canada, and are therefore more affordable for berry producers in NL (approx. $165 per production colony).

• What other crops would benefit from honey bee pollination in NL; strawberry, raspberry, squash, pumpkin, zucchini, greenhouse crops, what else? What is the cost-benefit of pollination services for such crops? Can producers of such crops afford honey bee pollination services?

• Given NL's unique status as being free of *Varroa* and a variety of other pathogens, pests, and diseases, what markets are there nationally and internationally for live bee exports? What is the potential economic value of these exports? What if anything is required with respect to honey bee breeding (genetics) in order to enhance the marketability of our honey bees in relation to national or international customers?

• What is the potential for the production of certified organic honey and other bee products in the province? What is the economic feasibility of going organic? Are there areas in the province free of pesticides and herbicides where honey bees can be pastured for organic honey production? What are the costs and regulatory challenges related to organic certification?

• What are the domestic and out-of-province markets for NL honey bee products? At what point does the domestic market become saturated with product, given the current price range of this product and the consumer demographic willing to pay top dollar for it? What are the characteristics of the demographic willing to pay top dollar for our product? Are beekeepers in NL willing to sell product to more price-sensitive demographics at lower prices? What are the minimal prices below which commercial beekeeping is not economically viable?

For excerpts from supporting references see Appendix 7.3.3.

7. Appendix

7.1 Strategy of National Bee Diagnostic Health Survey (2013 - 2017)

To index bee health, samples are collected from across Canada-with a goal of collecting from 0.5% of registered hives. Each apiary-level sample will be a composite from 10 randomly selected colonies (~100 bees/colony) for a total of ~1000 bees. Most of these bees will be shipped live to the NBDC-TAC in miniature battery boxes. Another portion of these bees will be preserved in alcohol and sent to the same location.

Samples will be analyzed for American Foul brood and resistance strains, European Foul brood, Nosema count and species identification, Varroa mite infestation levels, tracheal mites as well as exotic pests. In addition, samples will be tested for seven honey bee viruses including: Acute Bee Paralysis Virus, Black Queen Cell Virus, Chronic Bee Paralysis Virus, Deformed Wing Virus, Israeli Acute Bee Paralysis Virus, Kashmir Bee Virus, and Sac brood Virus. By the third year (Summer 2016), samples will additionally be tested for hybridization with African races of honey bees and in the fourth year (Summer 2017), two additional viruses: Lake Sinai Virus and Slow Paralysis Virus, as well as chemical residue analysis will be added to the panel. Visual evaluations in the field are also performed to detect various pests, pathogens and queen conditions. Samples are collected between July and August, before fall treatment of colonies for Varroa or Nosema. See https://www.gprc.ab.ca/research/initiatives/nbdc/projects/current/nat_survey.html

Note. Ideally, record keeping related to pathogens found in *Apis mellifera* colonies in NL would encompass details of sampling methods (geographic area, age and sex of bees, time of the year, etc.) as well as details of the scientific protocols used by the agencies doing the testing. In the latter, methodological details are crucial as false positives or negatives may occur. In addition, as experimental methods evolve and become more sensitive, previously negative results may turn positive. Thus, replicate DNA samples from each testing survey should be stored for future consideration or potential repeat tests. It is paramount that at least a limited number of people in NL (e.g., from academia and/or provincial Department of Fisheries and Land Resources) have a complete understanding of the science and logistics involved to appropriately evaluate the results of pathogen monitoring. Monitoring data should be freely available upon request to any of the stakeholders and/or be posted on a public website.

7.2. NLBKA report on Pathogen Testing 2017

Pathogen testing results of Newfoundland and Labrador's domestic honey bee stocks – 2017 NLBKA report to the membership

The NLBKA Board is pleased to provide our membership with a summary of the pathogen testing results as they appeared in the 2016-17 Canadian National Honey Bee Health (CNHBH) survey. Testing was completed in 2016 at the National Bee Diagnostic Center (NBDC) (Beaverlodge, Alberta) on samples obtained from five commercial apiaries (10 sampled colonies per apiary). This was the first time our province participated in this annual Canada-wide survey. Sample collection, handling and shipping were performed under the guidance of the NL Provincial Apiarist. The detailed results of the survey can be viewed here: https://www.gprc.ab.ca/doc.php?d=2016NHBHS

Mites and other parasites

The survey confirmed that we are the only Canadian province – and actually one of very few places in the world – that remains *Varroa destructor*-free. This is great news because it is well known that infestation with the *Varroa* mite is a serious predisposing/aggravating factor for a number of other diseases in honey bees. It is noteworthy that the incidence of *Varroa* is extremely high in neighboring provinces (91% in Quebec, 71% in NS, 45% in NB and 88% in PEI). Dissection and molecular testing did not detect tracheal mites and microscopic analysis did not identify any *Tropilaelaps* parasites in our samples. Also, by visual inspection, our colonies were shown to be free of the small hive beetle and wax moth.

Viral testing

Our samples were tested for the presence of 7 viruses: Acute Bee Paralysis Virus (ABPV), Black Queen Cell Virus (BQCV), Chronic Bee Paralysis Virus (CBPV), Deformed Wing Virus (DWV), Israeli Acute Bee Paralysis Virus (IAPV), Kashmir Bee Virus (KBV), and Sacbrood Virus (SBV). Apiaries were scored as "Positive" for any detection level of the virus or "Negative" for the absence of the virus.
Visual inspection of the 50 NL colonies showed no outward manifestations (clinical signs) of viral diseases. However, there was "molecular detection" of viral genes for SBV (40% incidence) and BQCV (80% incidence). It is important to note that the molecular biological test "polymerase chain reaction" (PCR), used for detection, is extremely sensitive and can detect the presence of a virus in a bee's tissues but unfortunately has no diagnostic value as far as any disease is concerned. In other words, the test may yield a wide range of positive values but, usually, there is no clear threshold value to warn the beekeeper of an underlying or impending viral disease. In fact, the scientific literature suggests that it is not uncommon for healthy honey bees to naturally harbour very low levels of viruses and co-evolve with them. To complicate matters even more, several parameters associated with the collection, storage and shipping of bee samples to a lab as well as parameters associated with the PCR test itself (technical details followed by each lab) may influence the test results. In view of this, the NLKBA strongly discourages members from having their colonies additionally tested for viruses on their own initiative and expense as it is unlikely that they will receive back test results of any practical value for their bee stock management. Currently, we consider the PCR test results for viral diseases to play an advisory but not a diagnostic role in the management of our bee stocks and we use the official NBDC results, presented in the national 2016 CNHBH survey, as our guide.

Bacterial diseases

Microbiological assays based on bacterial culture of adult bee samples did not detect American foulbrood (AFB) in any of our colonies. On the other hand, application of the sensitive PCR test showed molecular detection of European foulbrood (EFB) in two of the five sampled apiaries but there was no report of clinical signs of disease. The 2016 CNHBH report noted that "positive detection of EFB by PCR does not conclusively diagnose an active condition within the apiary."

Fungal diseases

Microscopic analysis detected spores of *Nosema spp*. in four of five apiaries tested but the average spore count/bee was well below the threshold (one million spores/bee) recommended for treatment. Use of the sensitive PCR test found three of the five sampled apiaries positive for *N. ceranae*, and one apiary positive for both *N. ceranae* and *N. apis.* Again, there was no report of clinical disease in any of the apiaries tested. Also, there was no detection of the chalkbrood fungus.

Conclusions and Recommendations

Overall, the health status of our domestic honey bee stocks remains strong as there was no detection of overt disease or infestation for any of the pathogens or pests tested. However, we strongly recommend that our members remain vigilant and familiarize/educate themselves with respect to disease symptoms, especially for pathogens that were "molecularly" detected (SBV, QCBV, *Nosema spp*. and EFB). Several books and on-line sites can be quite helpful as guides. For example, CAPA's *Honey Bee Diseases & Pests* publication (http://www.capabees.com/capa-honey-bee-diseases-and-pests-3rd-edition/); the internet site "Beeware" from Australia (http://beeaware.org.au); and the "Bee Health" app that can be downloaded on cellphones and used in the field: (https://play.google.com/store/apps/details?id=ca.ab.gov.beehealth&hl=en). To prevent possible transfer of diseases and pests, best practices in obtaining supplies and materials from reliable NL sources must be followed. It is also strongly recommended that signs of clinical disease be reported to the Provincial Apiarist and NLBKA in a timely manner and advice be sought as to what remedies can be applied. As a network of hobbyists and commercial operators, the NLBKA remains committed to providing any help possible to our membership and the Provincial Apiarist in order to promote the biosecurity and efficient monitoring of our domestic bee stocks. *Prepared by the NLBKA Research Committee on behalf of the NLBKA Board of Directors, Jan. 2018.*

7.3. Excerpts from Supporting References

7.3.1. NL honey bee genetics:

"Subject to correction from the Newfoundland Bee Company breeders, I have observed the following traits in their Newfoundland bee line since 2009. And what a beautiful bee they have created. First: a very gentle bee. When you open the hive on a hot day they just stroll around. No agitation, no guard bees lining up and looking at you. Nada. Second: gradual spring builders; fine for our gradual spring climate, but explosive breeders when the weather gets right (I think that is the Russian). Third: some colonies kick out the drones on the first cool night in September while others do it three or four weeks later (Must be the Carniolan coming out). Fourth: I regularly come out into spring with an excess of honey stores before the big breeding cycle comes on (Perhaps a bit of Russian?). Whatever you may conclude, this is what we have and it is Great! We have Wally Skinner and his successors Andrea and Paige to thank. We are very fortunate!" — Dan Price, past-president, NLBKA

"No genetic profile of Newfoundland's honeybee population has been conducted to date. It is therefore difficult to assess any actual long term or short term risk of inbreeding within Newfoundland's honeybee colonies. However, it is clear that some beekeeping operations stand at a disadvantage when faced with very low colony numbers, geographic isolation, high winter mortality, and the absence of a guaranteed supply of bees from within the island. As a result, cooperation among Newfoundland's beekeepers in the design of a breeding scheme or breeding program may be highly beneficial in order to ensure the sustainability of individual operations." — Stephan Walke 2015: 13

7.3.2. Honey Bee Forage Research

"We perceive another serious risk to *Apis mellifera* and pollination in New Brunswick is due to starvation, with the vast majority of the province's woodlands containing scant summer blossoms. When pollination is complete — and wild blueberry pollination is the largest crop we have in New Brunswick — we rely on the goodwill of local farmers to allow us to place our colonies on their property, out of the way. The modern-day shift in agriculture practices is one of the causes for concern. The increase in corn plantation is virtually of no benefit to honeybees....Also, farmers tend to mow their alfalfa and clover crops as they come into blossom, when they are at their peak of nutritional value, thus depriving the bees of the vital pollen and nectar they need for overwinter survival....There is an opportunity perhaps to resolve the starvation problem by having all government highways and those types of projects incorporate the seeding of roadway shoulders with seeds from perennial flowers that are normally considered weeds. I would suggest dandelion, purple vetch, Dutch clover and other flowers that bloom at different times of the year. Not only would it provide forage for bees, it would stabilize the land and provide food for small, seed-eating wildlife. There are also tracts of abandoned farmland becoming overgrown with alder bushes. These lands could also be planted with the above crops, and also sweet clover." — Paul Vautour, Maritime Delegate to the Canadian Honey Council 2014

"…[w]e as beekeepers should be utilizing the bee pasture resource of an area to the maximum. Almost everywhere honey bees are kept in Ontario, at least 30-40 bee hives can be kept at two mile intervals. A beekeeper with one or a very few colonies should not expect to monopolize such a potential resource by claiming such an areas as his exclusive right to that bee yard area. There could be several small bee yards within this area. If a commercial beekeeper who is trying to make his living from the bees has established bee yards already, then the smaller beekeepers should respect that the resource is being well utilized there and respect that beekeeper's claim on that resource area. Too many bees in an area can make it non-productive for everyone. We do not have a very good mechanism in place currently to utilize the beekeeping potential resource of each possible bee yard location in Ontario. Conflict can occur between many small scale beekeepers over bee yard locations where there is plenty of resource for all of them in a relatively small area. It would be nice if the registered beekeepers could go on a restricted internet site and see where the registered bee yards are with the number of colonies at each site. That would allow beekeepers to come to agreements to work the resource to what it can withstand." — Doug McRory, Retired Provincial Apiarist (Ontario), 2015.

"Forage is the basis of a healthy colony's immune system. Yet, most areas of the state saw very low levels of abundant natural forage and rainfall this year adversely affecting the colonies' immunity." — Bill Castro 2017

"The species richness of wild bees and other pollinators has declined over the past 50 years, with some species undergoing major declines and a few going extinct. Evidence of the causes of these losses is patchy and incomplete, owing to inadequate monitoring systems.…Habitat loss, which has reduced the abundance and diversity of floral resources and nesting opportunities, has undoubtedly been a major long-term driver through the 20th century and still continues today….Although the causes of pollinator decline may be complex and subject to disagreement, solutions need not be; taking steps to reduce or remove any of these stresses is likely to benefit pollinator health. Several techniques are available that have been demonstrated to effectively increase floral availability in farmland. Similarly, encouraging gardeners to grow appropriate bee-friendly flowers and to improve management of amenity grass-lands can also reduce dietary stress. Retaining or restoring areas of seminatural habitat within farmland will improve nest site availability." — Dave Goulson, et al 2015

"In most cases, success in beekeeping depends on the availability of sufficient bee forage in terms of both quality and quantity of nectar and pollen grains. Hence, beekeeping is more dependent on the existing natural resource conditions of an area than any other livestock activities. In areas, where beekeeping is not suitable, other improved management skills and advanced technologies alone cannot make beekeeping successful. For this reason, availability of adequate bee forage is considered to be one of the most important elements in beekeeping industry." — Ahmed Al-Ghamdi, et al. 2014

"The results of this study suggest that colonies may suffer from a nutritional deficiency during their stay in large-scale blueberry crops in which weeds are intensively managed. This can affect honey bee colony brood development quite rapidly, although the effects are only observable a few weeks later by beekeepers in the field. Our findings reflect results from a recent study by Odoux et al. (2012) in which the authors demonstrated that weeds are a critical source of pollen for honey bees in agrarian environments….different plant species in an area can act together to attract and maintain a population of pollinators and thus contribute to enhancing the pollination of a monoculture." — Mélissa Girard, et al. 2012

"It is clear that adequate nectar and pollen resources are critical in maintaining honey bee health….A deficiency in quantity and quality of pollen and nectar can lead to demographic decrease of the colony; pollen deficiency leads to low colony populations, which in turn further reduces the number of bees available to collect pollen and nectar….Moreover, recent work shows the importance of pollen quality and diversity on the immune response of honey bees….The role of these two nutrients is so critical that beekeepers often must provide supplements in the form of sugar syrup or pollen supplement to prevent nutritional deficiency and colony failure. However, pollen supplements and syrup do not provide the same nutritive quality as natural pollen and nectar….This nutritional demand could be supplemented by crop producers and rural landowners through the protection and enhancement of additional flower resources in non-cropped areas." —Axel Decourtye, et al. 2010

One objective of the UK agri-environment schemes is to enhance the abundance and diversity of flowering plant species within arable systems through changes in management within or at the margins of fields. Field margins are a key feature of agricultural landscapes and there are well-documented agronomic and ecological reasons why they have become the focus of management options within the schemes….As predicted, uncropped margins sown with mixtures containing nectar- and pollen-producing plants were more effective in providing bumble bee forage than margins sown with a grass mix, allowed to regenerate naturally or managed as conservation headlands. Our results demonstrate that, using evidence-based habitat creation, uptake of selected options within ELS [Environmental Stewardship, Entry Level] in England could have a positive impact on bumble bees, including species of conservation concern." — Carvell, et al. 2006

7.3.3. Apicultural Market research

"In addition, significant potential exists to provide disease-free, chemical-free bees for research purposes….Given that Newfoundland's honeybees have not been exposed to many of the stresses on the mainland, one respondent identified the sale and use of honeybees for research purposes as a more important opportunity than commercial sale off the island. Here we encounter the issue of honeybee genetics interacting with disease resistance and therefore market potential." — Walke (2015: 18)

"Significant attention is being given to the use of genetic research and honeybee breeding in order to increase mite resistance (OPERA 2013, Rinderer et al. 2000; University of Guelph n.d.). Honeybee breeding has traditionally been focussed on maximizing commercially significant traits such as honey production, temperament, and colony growth (Delaney et al. 2009). Breeding for mite resistance in honeybees can involve a number of behavioural traits (Sammataro 2012) or even targets of mite growth rate (Fries 2012). However, breeding for resistance requires exposure to infestation pressure (Cauia 2010; OPERA 2013). Therefore, the sale of mite/disease-free honeybees to infested commercial operations outside the province will not be viable unless collaboration with mainland breeding programs is maintained and a focus on producing mite-resistant honeybee strains is upheld in Newfoundland. It would be wise to prioritize production goals and assess market feasibility for the potential sale of honeybees outside the province. Marketing honeybees for research purposes and to provide other breeding programs and mite-free locations may prove to be a more lucrative development direction." — Walke (2015: 18)

"It is clear that Newfoundland's pollination capacity is not matched to its agricultural productivity, either in terms of pollinator numbers or the logistics of their rental, distribution or transport. That being said, mutual interest from both beekeepers and crop producers has been identified. Therefore, boosting honeybee populations on the island and coordinating communication and cooperation between fruit producers and beekeepers could aid in increasing the sustainability of these industries as well as their provincial independence." — Walke (2015: 20)

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