Risk Assessment on the Movement of Honey Bee (*Apis mellifera*) Colonies into Nova Scotia and Introduction and Establishment of Small Hive Beetle (*Aethina tumida*)

Prepared for
Nova Scotia Department of Agriculture

Prepared by
Andony Melathopoulos
(University of Calgary)

January 2016

EXECUTIVE SUMMARY

This risk assessment has been developed in order to align the Nova Scotia Department of Agriculture's policy on the movement of honey bee (*Apis mellifera*) colonies into Nova Scotia (NS) from Ontario (ON), Quebec (QC) and other Atlantic Canada provinces with the probability of introducing and establishing small hive beetle (SHB, *Aethina tumida*). The assessment was developed from the current scientific understanding of SHB biology and ecology and hence is based on a series of assumptions that are listed and detailed in the assessment. The assessment also focuses on the consequence of two possible responses to the 2015 discovery that SHB has expanded beyond a 2011 quarantine zone located in southern tip of ON: 1) close the NS border to importation of honey bee colonies from outside the province under the authority of Bee Industry Act and Import Protocols (OPTION 1: *Border Closure*) or 2) continue importation for the pollination of commercial wild blueberries but with regulatory restrictions (e.g., restricting importation from zones that pose a high risk of SHB introduction, intensive monitoring and inspection of imported colonies, ensuring imported colonies leave NS after pollination) (OPTION 2: *Restricted Importation*).

This assessment follows the qualitative risk assessment methodology used by the Canadian Food Inspection Agency's (CFIA) *Risk Assessment on the Importation of Honey Bee (Apis mellifera) Packages from the United States of America* (2014). The CFIA assessment was based on criteria set by the World Organization for Animal Health (OIE) (2011), in which overall risk is determined by breaking risk down into the probability of: 1) pest entry, 2) exposure and 3) that the pest will be significant consequence to the importing jurisdiction. Consequently the assessment focuses on: 1) the risk that SHB would be introduced under each scenario (i.e., border closure or restricted importation), 2) the likelihood that if SHB were introduced into NS it

would establish among the province's honey bee stocks (exposure) and 3) the extent of the damage to the NS beekeeping industry if SHB were established. The main risk factors considered in this assessment are: 1) the current distribution of SHB in ON and their likely pattern of spread, 2) the conditioning effect of restrictions on colony movement from ON to provinces such as NB and 3) the pollination needs of NS's wild blueberry industry.

The assessment concludes that Option 1 (*Border Closure*) reduces both the risk of SHB entry and exposure compared to Option 2 (*Restricted Importation*), but the reduced consequence of SHB damage among beekeepers from Option 1 will have low-moderate negative consequences to wild blueberry producers because of the reduced supply of honey bee colonies for pollination.

Summary of the risk estimate for SHB associated for two options for moving honey bee colonies into Nova Scotia.

Hazard	**Entry Probability**	**Exposure Probability**	**Consequence Estimate**	**Risk Estimate**
Option 1: Border Closure	Extremely Low – Very Low	Negligible	Low - Moderate	Negligible
Option 2: Restricted Importation	Small - Moderate	Low to Small	Low - Moderate	Negligible – Low

STATUS OF THE DOCUMENT

Process Initiation and Dates

Request from: Steven Tattrie, Manager, Animal and Crop Protection, Nova Scotia Department of Agriculture

Date received on 4 December 2015

Risk Assessment Versions and Dates:

Draft #1: Internal review (12 January 2016)

The draft document was released to:

Steven Tattrie, Manager, Animal and Crop Protection, Nova Scotia Department of Agriculture

Rick Hoeg, Senior Program Administrator, Pests and Regulations, Nova Scotia Department of Agriculture

Jason Sproule, Apiculturalist, Nova Scotia Department of Agriculture

Draft #2: Draft risk assessment released for editing (19 January 2016)

The draft document was released to:

Steven Tattrie, Manager, Animal and Crop Protection, Nova Scotia Department of Agriculture

Rick Hoeg, Senior Program Administrator, Pests and Regulations, Nova Scotia Department of Agriculture

Jason Sproule, Apiculturalist, Nova Scotia Department of Agriculture

Draft #3: Final draft document released

CONTENTS

LIST OF ABBREVIATIONS

CFIA	Canadian Food Inspection Agency
cm	centimeter
e.g.	for example
et al.	and others
E.U.	European Union
ha	hectare
i.e.	that is
kg	Kilograms
km	Kilometer
m	Meter
NB	New Brunswick
NS	Nova Scotia
NSDA	Nova Scotia Department of Agriculture
OIE	World Organization for Animal Health
OMAFRA	Ontario Ministry of Agriculture Food and Rural Affairs
ON	Ontario
PEI	Prince Edward Island
QC	Quebec
SHB	Small Hive Beetle
US	United States of America
%	Percent
~	Approximately
>	Greater than
<	Less than

1 BACKGROUND

1.1 SMALL HIVE BEETLE

The small hive beetle (SHB, *Aethina tumida* Murray) is a sap beetle (Family: Nitidulidae) that originates in southern Africa and was introduced into the U.S. in 1996. It has since developed into an endemic pest of honey bee colonies not only in the U.S., but in Mexico, Egypt, Australia (Neumann and Ellis 2008) and southern Italy ([EFSA] European Food Safety Authority 2015b). In spite of episodic introductions into Canada (Alberta and Manitoba) in the mid-2000s through bulk bees imported from Australia (now restricted) and raw bees wax from the U.S. (Lounsberry et al. 2010), Canada remained free of SHB until 2008.

After introduction, SHB continued to spread within the US. In 2010 its establishment in Hawaii, a major source of queens for beekeepers across Canada, resulted in the inspection of queens imported into Canada. To date there are no known introductions of SHB from Hawaii on caged queens. More significant, however, was the spread and establishment of SHB across all the U.S. states bordering Canada. Increased SHB pressure in these states has resulted in the beetle being introduced at three regions close to the U.S.-Canada border:

1. the southwestern corner of Quebec in 2008 (Giovenazzo and Boucher 2010),
2. Essex County on the southern tip of Ontario in 2010 (Kozak 2010) and
3. the Fraser Valley of British Columbia in 2015 (Lee 2015))

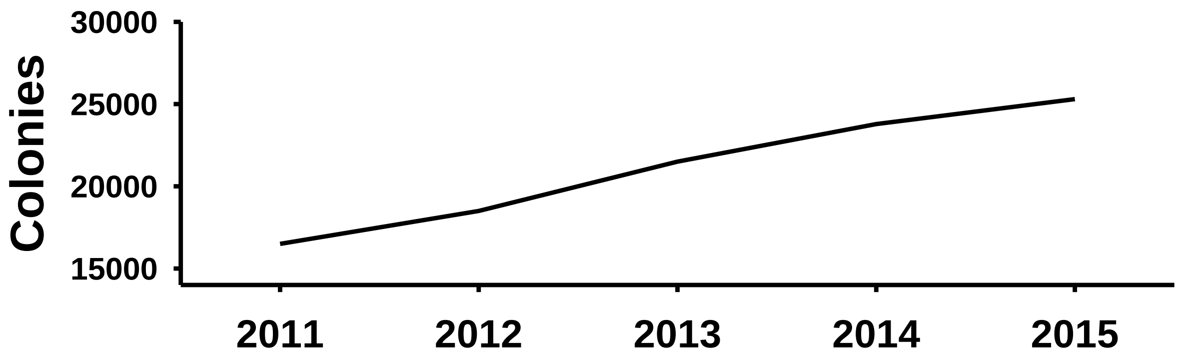
The eastern Canadian infestations were maintained within regulated quarantine zones, until 2015, when SHB in Ontario was detected at multiple locations in the Niagara region, well outside the original Essex County quarantine ([OMAFRA] Ontario Ministry of Agriculture Food and Rural Affairs 2015). Although the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) had found SHB outside the quarantine zone each year since the quarantine was introduced, these infested colonies were either destroyed or moved into the quarantine zone, with the additional provision that there could be no further colony movements in or out of these apiaries until SHB was deemed eradicated. But in 2015 OMAFRA announced a new provincial SHB management strategy that enabled the movement of colonies from apiaries positive for SHB (19 November 2015, Ontario Beekeepers Association, Annual General Meeting).

1.2 CURRENT CONTEXT

1.2.1 Nova Scotia

There are approximately 400 beekeepers operating in NS, 36 of which are considered commercial (>50 hives). The bee industry farm gate value in 2014 is approximately $4.5 million ($1.5 million from honey and $3 million from pollination services). The value of honey bees to Nova Scotians, however, is complicated by the importance of honey bees to the pollination of agricultural crops, the key crop being wild blueberry, which in 2015 had farm gate value of $32.5 million but is estimated to be over $100 million when the berry processing and other associated activities are included (*Peter Burgess, Perennia, personal communication*). Approximately 80% of NS's 25,000 colonies are used in the pollination of blueberries, and although there has been a tremendous growth in colony stocks over the past five years through the NS Pollinator Enhancement Program (~50% increase, Figure 1), there remains a need to annually import approximately 5,000 colonies from ON (historically from the Niagara region) to meet the province's pollination needs.

Figure 1. The number of colonies in NS over the last 5 years.



The movement of honey bees in NS is regulated by the *Bee Industry Act* (2005), which: a) requires all apiaries in the province to be registered, b) anyone importing colonies into NS to obtain an import permit, c) empowers the Minister of Agriculture and Fisheries (or their designate) to declare a quarantine zone, d) compels beekeepers to report specific listed pests and diseases to the provincial Apiculturalist and e) empowers the provincial Apiculturalist or an Inspector to inspect colonies located in the province. The Bee Act informs the *Bee Industry Regulations*.

Under these Regulations the Nova Scotia Department of Agriculture (NSDA) has developed a *Bee Health Importation Protocol* (see Appendix for the 2015 version of the protocol). This protocol sets out the conditions in which bees can be imported into NS. Since small hive beetle (SHB) is currently not present in NS, the protocol states that:

1. no colonies from a SHB quarantine zone (or which have transited through a quarantine zone) are permitted into NS,
2. the permit applicant requires a Certificate of Inspection from the exporting province within 45 days of colonies being imported into NS,
3. 10% of the colonies per apiary (or 10 colonies, whichever is greater) must have their broodnests inspected for SHB
4. if colonies are exported from a province with an established SHB population, *an additional* 15% of the colonies per apiary (or 15 colonies, whichever is greater) must have a rapid top-bar inspection for SHB

5. a provision that enables NSDA to adjust their import requirements relative to associated risks for beekeepers who have had SHB in previous years
6. inspection of all queens imported from outside Canada from a country with SHB
7. a provision that the permit holder be made aware that their colonies can be inspected by the Provincial Apiculturalist while in NS
8. a provision that if SHB is detected in the permit-holder's colonies while in NS that the colonies will be ordered to moved back to the province of origin within 72 hours of detection under bee-tight mesh netting during the journey

1.2.2 Ontario

In 2014 there were approximately 112,800 honey bee colonies in ON operated by 3,200 beekeepers. Ontario, consequently, is the province in Eastern Canada with both the most beekeepers and bee colonies.

The proposed 2016 OMAFRA Small Hive Beetle Strategy (19 November 2015, Ontario Beekeepers Association, Annual General Meeting) has a number of key elements:

1. Beekeepers are required to submit a general movement plan to OMAFRA for colonies located either in SHB-positive apiaries or apiaries at a high risk of having SHB. These plans will focus on movements that reduce the risk of spreading SHB.
2. OMFRA may inspect SHB-positive colonies prior to movement to a non SHB-positive apiary as needed and based on risk,
3. SHB remains a reportable pest in Ontario,
4. Beekeepers are required to submit a best management plan (BMP) outlining how they plan to manage SHB and OMAFRA has supported considerable research and extension to help beekeepers adapt to manage SHB

1.2.3 Quebec, New Brunswick and Prince Edward Island

Combined, Quebec (QC), New Brunswick (NB) and Prince Edward Island (PEI) have fewer colonies and beekeepers than ON (QC – 51,979 colonies, NB – 8,989, PEI – 3,777 (2014)). But all of these provinces have expanding commercial wild blueberry production and some, such as NB, are wholly unable to meet their pollination needs without growers renting colonies from outside the province (requiring 20,000 colonies that have largely been imported from ON). Of these provinces, only QC has had introductions of SHB and these have been quarantined in the southwestern corner of the province since 2008. But SHB within the quarantine zone in QC have had difficulty surviving the winter (*Valerie Fournier, Associate Professor, University of Laval, personal communication*) and reinfestion appears to occur entirely through SHB flight from infested colonies on the U.S. side of the border (Giovenazzo and Boucher 2010).

Given the changed approach to SHB in ON, QC has indicated that imported colonies will require an inspection certificate stating colonies are SHB-free following the inspection of: 1) 100% of colonies by rapidly scanning the colony's top bars and 2) 10% of these colonies' for SHB in broodnests. QC will also require a declaration from the permit holder, signed by the Provincial Apiculturalist in the beekeeper's home province, indicating that their entire operation has been free of SHB for the past two years. The province has additionally signalled that it will permit the transit of colonies through QC as long as those colonies travel in closed vans or are wrapped with fine bee-proof mesh.

2 RISK ASSESSMENT

2.1 INTRODUCTION

2.1.1 Scope of the Risk Assessment

This risk assessment has been developed in order to align the Nova Scotia Department of Agriculture's (NSDA) policy on the movement of honey bee (*Apis mellifera*) colonies into Nova Scotia (NS) from Ontario (ON), Quebec (QC) and other Atlantic Canada provinces with the probability of introducing and establishing small hive beetle (SHB, *Aethina tumida*). The assessment focuses on the consequence of two possible responses: 1) close the NS border to importation of honey bee colonies from outside the province under the authority of Bee Industry Act and Import Protocols (OPTION 1: Border Closure) or 2) continue importation for the pollination of blueberries under conditions of increased restrictions (OPTION 2: restricted importation).

2.1.2 Methodology

Information for this assessment was gathered using a Google Scholar search of the terms "small hive beetle" and "*Aethina tumida*" and focusing on peer-review research and government regulatory documents ([OIE] World Organisation for Animal Health 2013, Canadian Food Inspection Agency 2014, [EFSA] European Food Safety Authority 2015a, b). From this initial literature search additional literature was obtained by working through the references cited in the key papers reviewing SHB management and biology (Neumann and Elzen 2004, Neumann and Ellis 2008, Cuthbertson et al. 2013, Neumann et al. 2013).

2.1.3 General Approach

This assessment follows the qualitative risk assessment methodology used by the Canadian Food Inspection Agency's (CFIA) *Risk Assessment on the Importation of Honey Bee (Apis mellifera) Packages from the United States of America* (2014). The CFIA assessment was based on criteria set by the World Organization for Animal Health (OIE) (2011), in which overall risk is determined by breaking risk down into the probability of: 1) pest entry, 2) exposure and 3) that the pest will be of significant consequence to the importing jurisdiction. The risk associated with SHB entry and exposure (i.e., establishment) was assessed against qualitative categories of likelihood that correspond to a probably range (Table 2).

Table 1. Categories of likelihood for entry and exposure

		Probability Range	
Likelihood	**Descriptive Definition**	**Minimum**	**Maximum**
Negligible	The event would be virtually unlikely to occur	10^{-7}	10^{-6}
Extremely Low	The event would be extremely unlikely to occur	10^{-6}	10^{-5}
Very Low	The event would be very unlikely to occur	10^{-5}	10^{-4}
Low	The event would be unlikely to occur	10^{-4}	10^{-3}
Small	The event would be minimally likely to occur	10^{-3}	10^{-2}

Moderate	The event would be fairly likely to occur	10^{-2}	10^{-1}
High	The event would likely occur	10^{-1}	1

Similarly, the consequence of a given level of SHB exposure was determined against the qualitative criteria in Table 3.

Table 2. Categories of consequence definitions

Consequence	Description
Negligible	The probability and the costs and losses associated with the economic factors are insignificant.
Very Low	The probability and the costs and losses associated with the economic factors are minor.
Low	The probability and the costs and losses associated with the economic factors are low.
Moderate	The probability and the costs and losses associated with the economic factors are intermediate
High	The probability and the costs and losses associated with the economic factors are severe.
Extreme	The probability and the costs and losses associated with the economic factors are catastrophic.

Based on the risk of entry and exposure, a combined entry × exposure assessment was made using the matrix outlined in Table 4.

Table 3. Matrix of entry × exposure probability

ENTRY PROBABILITY	**High**	Negligible	Extremely Low	Very Low	Low	Small	Moderate	High
	Moderate	Negligible	Negligible	Extremely Low	Very Low	Low	Small	Moderate
	Small	Negligible	Negligible	Negligible	Extremely Low	Very Low	Low	Small
	Low	Negligible	Negligible	Negligible	Negligible	Extremely Low	Very Low	Low
	Very Low	Negligible	Negligible	Negligible	Negligible	Negligible	Extremely Low	Very Low
	Extremely Low	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Extremely Low
	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
		Negligible	**Extremely Low**	**Very Low**	**Low**	**Small**	**Negligible**	**High**
					EXPOSURE PROBABILITY			

This combined entry × exposure assessment was then related to the consequence assessment using the matrix outlined in Table 5, such that the overall risk associated with the two options outlined in this assessment could be determined: OPTION 1 (*Border Closure*) or OPTION 2 (*Restricted Import*).

Table 4. Risk estimate matrix

ENTRY × RISK PROBABILITY						
High	Negligible	Very low	Low	Moderate	High	Extreme
Moderate	Negligible	Very low	Low	Moderate	High	Extreme
Small	Negligible	Very low	Low	Moderate	High	Extreme
Low	Negligible	Negligible	Very low	Low	Moderate	High
Very Low	Negligible	Negligible	Negligible	Very low	Low	Moderate
Extremely Low	Negligible	Negligible	Negligible	Negligible	Very low	Low
Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Very low
	Negligible	**Very Low**	**Low**	**Moderate**	**High**	**Extreme**

CONSEQUENCES

2.2 UNCERTAINTIES AND RESEARCH GAPS

2.2.1 Uncertainties

There are a number of elements of uncertainty associated with this assessment. Key sources of uncertainty include:

- Whether SHB is able to consistently reproduce in Canada outside of considerably warmer areas such as the southern tip of ON and southern British Columbia (BC). Evidence from QC, MB and AB suggest the SHB can have difficulty establishing after entry. But there remains little comprehensive research on the life history of the beetle under Canadian conditions outside of simulated laboratory scenarios (Pettis and Shimanuki 2000, de Guzman and Frake 2007, Bernier et al. 2014, Meikle et al. 2015).
- It is unclear how rapidly SHB will spread in ON and how rapidly it may establish in NB, as the province bordering NS. Certainly NB has the largest demands in the region for importing honey bee colonies for pollination, raising its risk of SHB exposure. But ON is looking to restrict the spread of SHB through education, extension and inspection, which may offset this risk.

2.2.2 Research Gaps

Many of these uncertainties could be addressed by:

- Determining the soil temperature (5 cm) in blueberry apiary sites across the bloom period to determine whether there are sufficient cumulative heat units for SHB larval to develop.
- A better understanding of adult SHB flight dispersal under cool conditions (<18ºC).
- The sensitivity of SHB inspection methodologies that fall outside current OIE-approved standards ([OIE] World Organisation for Animal Health 2013), particularly the rapid “top bar” inspection that is being used alongside approved brood nest inspection.
- The efficacy of treatments or traps placed into colonies during transit into NS or sprayed on the soil of apiary sites when they arrive.

2.3 ASSUMPTIONS

A key assumption behind this assessment is that SHB in eastern Canada remains restricted to: 1) the quarantine zone in the southwestern corner of Quebec (QC) and 2) that while SHB in Ontario (ON) now exists outside the 2010 Essex County quarantine zone it is not yet widely distributed among ON beekeeping operations. But since SHB has been found outside the quarantine zone in ON since 2010 and honey bees from ON have travelled to Atlantic Canada there exists a possibility that SHB may have already been introduced into Atlantic Canada and that this introduction has not yet been detected. In this assessment the likelihood of such an introduction is deemed very low given the extensive inspection of colonies in ON (~10% of ON colonies are inspected for SHB with inspections focused on apiaries with higher risk of infestation) and the level of inspection among colonies shipped to NS for pollination since 2012. For this reason there is high certainty that SHB does not presently exist in NS.

Finally, in this assessment OPTION 2 (*Restricted Import)* is assumed to be synonomous with the terms of the 2015 NS Bee Health Importation Protocol.

2.4 SMALL HIVE BEETLE HAZARD ASSESSMENT

2.4.1 Factors Affecting the Small Hive Beetle Entry Assessment

The focus of the entry assessment for small hive beetle (SHB) involves describing the biological path the beetle would take into Nova Scotia (NS).

2.4.1.1 Factors Associated with SHB Entry and OPTION 1 (Border Closure):

Given the history of SHB in Canada the most likely route of entry for SHB under OPTION 1 is either by adult beetles unintentionally shipped with: 1) queens and attendant workers or 2) by adult beetles flying into the province from regions with SHB. The risk of entry from imported queens is **extremely low** as the level of inspection is high (and SHB are easily spotted) and there have been no documented cases of SHB entry into any jurisdiction by queen importation. Flight of SHB poses a **negligible** entry risk to NS as the adult beetles fly relatively short distances (<25 km) and would be unable to fly from areas such as Maine, QC and ON where the SHB is present.

But the entry risk associated with OPTION 1 would rise if SHB were to be found in New Brunswick (NB) since the experience in ON, QC and BC is that SHB is able to readily fly across from adjacent SHB-infested apiaries in the U.S. (Giovenazzo and Boucher 2010, Kozak 2010, Lee 2015). If honey bees from ON are permitted to travel into NB while the NS border is closed to importation, there is an elevated risk that SHB could disperse from colonies in NB across the Isthmus of Chignecto to colonies in NS. But the likelihood of such an introduction will be very low, because: a) although the experience of SHB introduction across the U.S.-Canada border suggests the beetle can also disperse across the Isthmus, research suggests that such long-range dispersal is only likely where beetle densities are high (Spiewok et al. 2008) (e.g., heavily SHB infested honey bees from the southern U.S. are moved to the Canadian border, see discussion of exposure factors in Section 2.5.2.1), b) the climatic conditions in NB are unlikely to generate heavy infestations (see discussion of exposure factors in Section 2.5.2.1) and c) the NS beekeeping industry is centred approximately 100 km south of the Isthmus (although, 50-100 colonies exist in Amherst adjacent to NB on the other side of the Isthmus).

2.4.1.2 Factors Associated with SHB Entry and OPTION 2 (Restricted Importation):

The current proposal from ON of lifting: 1) the Essex County quarantine zone and 2) the requirement to quarantine apiaries outside the zone that are positive for SHB, changes the assessment of risk of SHB introduction to NS conducted in 2011 (Kelco Consulting Ltd. 2011). Although ON plans to continue monitoring for SHB and to restrict the movement of highly infested colonies around the province, experience from the U.S. suggests that SHB will spread across ON honey bee stocks (although likely at a slower rate than in the U.S. owing to unfavorable environmental conditions to SHB reproduction (Spiewok et al. 2008)). In turn, this spread will increase the likelihood that colonies inspected for importation into NS will have SHB-infestations. A recent network analysis of the spread of a SHB introduction in southern Italy indicate the importance of colony movement over SHB flight dispersal in spreading infestations ([EFSA] European Food Safety Authority 2015b).

SHB is visible to the eye, but its aversion to light and ability to hide in colony cracks and cervices make low infestations difficult to detect using standard inspection techniques. Although there are a number of different methodologies for inspecting a honey bee colony for SHB, OIE-approved methods are time consuming, either involving: a) frame-by-frame inspection of colonies (e.g., similar to the methods for detecting American Foulbrood, the other pest/disease condition listed in the 2015 NS Import Protocol) or b) the use of monitoring boards that require revisiting the apiary a second time for assessment (Schäfer et al. 2008, [OIE] World Organisation for Animal Health 2013, Neumann et al. 2013). Moreover such methodologies do not detect all the SHB in a colony (Spiewok et al. 2007, Neumann and Hoffmann 2008) and the uneven distribution of beetles within colonies of the same apiary means a relatively high proportion of colonies need to be inspected to conclude the absence of infestation in an apiary (Spiewok et al. 2007). It is important to note that although other methods of colony inspection can detect infestations and may be more efficient (e.g., top bar scan method that is used in conjunction with brood nest assessments in ON) the accuracy of these methods relative to the OIE-approved inspection methods has not been established. But based on the uncertainties associated specifically with a full brood nest inspection, the European Food Safety Authority (2015a) has conservatively estimated that in order to detect a SHB in a population of colonies at a level of 1% would entail sampling 300-1,200 colonies from a population of 20,000 colonies or at a 0.1% level 3,000-11,000 colonies. Based on this assessment, the level of brood nest sampling under the 2015 NS Import Protocol is likely to detect very low incidences of SHB among imported colonies (0.1-1%). Although inspecting additional colonies using the top bar method will invariably improve the level of detection, there is insufficient information to inform the extent of this improvement. Consequently, under the 2015 Import Protocol the risk of SHB entry is considered **moderate to small**.

2.4.1.3 Assessment of the Entry Risk of Nova Scotia honey bees to SHB

<u>Entry Risk Associated with SHB Entry and OPTION 1 (Border Closure):</u> This risk is considered **extremely low** unless SHB is established in NB, in which case the entry risk would be considered **very low**.

<u>Entry Risk Associated with SHB Entry and OPTION 2 (Restricted Importation):</u> Under the 2015 NS Import Protocol this risk is considered **moderate to small**. The risk is deemed less than the CFIA (2014) assessment of SHB importation of packaged bees from the U.S., given 1) the poorer conditions for SHB reproduction in ON compared to the U.S., 2) OMAFRA’s strategy to slow the spread of SHB within ON and 3) the high level of inspection of colonies moving from ON to NS. The risk could be minimized by increasing the level of inspection of colonies travelling into NS, by restricting the importation of honey bee colonies to regions such as to Cumberland County (thereby avoiding 95% of the summer and wintering apiary locations for NS beekeepers), and/or specifying the additional provision on imported colonies: a) to be treated with CheckMite+ (attached to bottom board traps) since even a 5 d treatment can reduce SHB populations by 50% (Neumann and Hoffmann 2008), b) the use of in-hive beetle traps (Bernier et al. 2015) and/or 3) apiary locations be treated with Permanone (a.i., permethrin) immediately after colonies are removed in order to kill any SHB larva that enter the soil to pupate (Levot and Haque 2006). Although none of these measures will eliminate the risk of SHB entry under OPTION 2, in combination they are expected to lower the overall risk.

2.4.2 Factors Affecting Small Hive Beetle Exposure Assessment

The focus of the exposure assessment involves determining the likelihood a SHB could enter and establish itself in a NS-based honey bee colony after entry. Although there is now precedence for SHB establishment in ON, it is important to regard the extent to which the situation shares parallels and contrasts with NS. For example, there is also precedence for SHB being introduced into Canada and not establishing, namely the introductions into Alberta and Manitoba in the early 2000s (Lounsberry et al. 2010) and some, if not all, of the introductions into QC (Giovenazzo and Boucher 2010). Research suggests that exposure risk is associated with two SHB life history factors, namely that its: 1) development is heavily dependent on relatively high soil temperature (Pettis and Shimanuki 2000, de Guzman and Frake 2007, Meikle and Patt 2011, Bernier et al. 2014) and 2) adult dispersal is dependent on whether SHB infestations can reach high levels (both within a colony and across a region) (Spiewok et al. 2007, Spiewok et al. 2008).

Soil Conditions. For SHB to complete their development, late-stage larvae must exit the colony and pupate in the soil (typically within 1 m of the host colony (Pettis and Shimanuki 2000)). This stage of the SHB life cycle constitutes over 75% of its development time, and any factors which disrupt or slow this stage play a key role in whether SHB can establish and spread in a region. Pupation occurs at shallow soil depths (< 20 cm) and both the length of the pupation period and pupal survival is strongly conditioned by environmental factors, particularly soil temperature and moisture (Pettis and Shimanuki 2000, de Guzman and Frake 2007, Meikle and Patt 2011, Bernier et al. 2014), and to a lesser extent, soil type (de Guzman and Frake 2007). Variation across these environmental variables can result in the pupation stage taking anywhere from a week to two months to complete (Cuthbertson et al. 2013).

Temperature and moisture influences SHB pupation in the following manner:

- pupation time doubles at 16ºC compared to 20ºC (Meikle and Patt 2011, Bernier et al. 2014), with the most rapid development taking place at 20ºC (de Guzman and Frake 2007, Meikle and Patt 2011)
- a minimum soil temperature of 10.2-13.2ºC is required for SHB development (Bernier et al. 2014)

- survival during pupation rapidly declines in soils cooler than 18ºC, falling to only 20% survival at 16ºC (Bernier et al. 2014).
- SHB develops faster in moist versus dry soil but high soil moisture reduces SHB survival (Bernier et al. 2014)

Because of SHB response to variation in soil conditions, it can, on the one hand, continue pupating in the soil year-round in the humid subtropical climate zone of North America (e.g., Florida), whereas farther north (e.g., South Carolina and Georgia) it can only persist in colonies during the winter months (Pettis and Shimanuki 2000). These environmental factors also explain, in part, why SHB reproductive rates are so considerably higher in areas such as Florida and Australia, compared to more northern U.S. states (Spiewok et al. 2008). By these standards SHB introduced into NS will face a greater challenge completing their reproduction compared to in ON or most northeastern U.S. states.

Consider a best-case scenario for SHB establishment in NS from a colony imported from ON under OPTION 2 (*Restricted Importation*). In this situation the imported colony (missed by the inspection) would already have a heavy load of late-stage larvae and these would migrate into the soil after being situated in NS on ~1 June. The subsequent SHB pupae would encounter average soil temperatures at the lowest range of suitability for beetle pupation (Table 1 – average June soil temperature (5 cm depth) in Kentville ~ 14ºC). Under such conditions beetle development is expected to slow considerably, taking approximately 50 days to emerge as adults (end of July) with high rates of mortality. The surviving beetles would require at least an additional week to locate a new colony and become sexually mature (Meikle and Patt 2011, Bernier et al. 2014). By this time: a) colonies will have been moved from blueberry fields into summer apiary sites, often quite distant from the soil where SHB are emerging (i.e., SHB dispersal distance will increase) and b) SHB that are able to locate and enter a honey bee colony will fail to complete a second generation before winter. Although this first generation could overwinter with the bees and commence reproduction the following spring, the warmest regions in NS (e.g., Pugwash) have 2.5 times fewer degree days > 18ºC as compared to southern ON and will not have soil of suitable temperature for SHB development until July (Table 1). The exposure risk of

OPTION 1 (**Border Closure**) will be even lower than OPTION 2 since introduced adults require at least an additional two weeks to produce the next generation (i.e., the beetle requires time to locate a colony, mature, lay eggs and for her brood to develop) (Meikle et al. 2015).

Table 5. Average monthly soil temperatures (at 5 cm depth) and annual cumulative degree days over 15, 18 or 24ºC for the former small hive beetle quarantine zone in Chatham-Kent County and blueberry growing regions in Nova Scotia (1981-2010 data, Environment Canada)

Climate Station	**June Soil Temperature (5 cm depth)**	**July Soil Temperature (5 cm depth)**	**Degree Days (>15ºC)**	**Degree Days (>18ºC)**	**Degree Days (>24ºC)**
Chatham-Kent County, ON					
Chatham-Kent (Chatham-Kent County, ON)	na	na	794.1	433.5	46.7
Kings County, NS					
Kentville AAFC	14.3	17.6	379.9	149.6	3
Colchester County, NS					
Truro	14.1	na	287.5	96.1	0.9
Upper Stewiacke	na	na	296.8	103.9	0.6
Debert	na	na	307.0	108.6	0.9
Hants County, NS					
Summerville	na	na	325.7	111.7	0.8
Cumberland County, NS					
Parrsboro	na	na	225.3	53.3	0
Nappan AAFC	na	na	297.9	96.6	0.3
Middleboro	na	na	368.3	150.4	4.5
Pugwash	na	na	413.4	171.6	4.7
Annapolis County, NS					
Greenwood (Annapolis County)	na	na	392.7	157.2	4.4
Halifax County					
Middle Musquodoboit (Halifax County)	na	na	309.6	111.5	0.9
Halifax Citadel (Halifax County)	na	na	342.0	115.6	0.8

SHB Dispersal. Although adult SHB occasionally disperse directly from colonies, either at high ambient temperatures (Annand 2011) or when colonies are excessively disturbed, it is far more common for dispersing adults to emerge from the soil. Since the adults are strong fliers they can fly several kilometers to find a new apiary to infest (Neumann and Elzen 2004, Spiewok et al. 2008, Cuthbertson et al. 2013), although there is evidence of considerable movement of adults among colonies within an apiary (Spiewok et al. 2007). Dispersing adults are attracted to odours associated with honey bee colonies, such that they are readily able to orient to any nearby apiary (Neumann and Elzen 2004, Spiewok et al. 2008, Cuthbertson et al. 2013). Clearly, OPTION 2 (*Restricted Importation*) increases the risk that SHB will be able to successfully disperse to NS honey bee colonies over OPTION 1 (*Border Closure*), as it reduces the distance between SHB-infested colonies outside the province and NS colonies.

But a key factor associated with the exposure risk for OPTION 2 is the level of infestation within imported colonies and the total number of infested colonies imported into a region. As Spiewok et al. observed

(2008): a) colonies with low beetle densities (< 10 beetles per colony) are far less likely to infest close-by colonies (~3 km away) as compared to colonies with high beetle infestations (>10 beetles) and b) a high density of infested apiaries in a region greatly increased the likelihood that SHB would spread to an uninfested apiary. For this reason the risk of SHB dispersing to NS colonies is expected to be considerably less than the risk currently experienced in regions such as southern BC, ON and QC, where colonies wintered in southern U.S. states (e.g., Florida, where SHB reproduction continues year-round) are moved to within 1 km of the Canadian border in late summer, resulting in a wave of high SHB dispersal into Canada (Giovenazzo and Boucher 2010). Given the low level of infestation expected from colonies in ON (owing both to high levels of inspection and more challenging environmental conditions for SHB reproduction) the risk of SHB establishing in NS colonies is expected to be **low to small** under OPTION 2.

A final consideration associated with SHB dispersal in NS is its preference for bumble bee colonies over honey bee colonies (Hoffmann et al. 2008). A first generation NS SHB that emerges from the soil very possibly will first encounter a commercial bumble bee colony (*B. impatiens*) that remain in many blueberry fields after the honey bees have left. Unlike honey bee colonies, bumble bee colonies do not overwinter and, subsequently, cannot act as a reservoir for SHB to overwinter ([EFSA] European Food Safety Authority 2015b). As long as these infested colonies are not brought into proximity with honey bee colonies later in the season, they may actual work to prevent broader dispersal of SHB into more distantly located honey bee colonies. Inspection and early-season (July) destruction of the colonies could be an important tool in reducing SHB exposure in NS.

2.4.2.1 Assessment of the Exposure of Nova Scotia honey bees to SHB

<u>Exposure Risk Associated with SHB Exposure and OPTION 1 (Border Closure):</u> This risk is considered **negligible**, even if SHB becomes established in NB.

<u>Exposure Risk Associated with SHB Exposure and OPTION 2 (Restricted Importation):</u> Under the 2015 NS Import Protocol this risk is considered **low to small**. The risk is the same as that attributed by CFIA (2014) in their assessment of SHB exposure risk associated with the importantion of packaged bees from the US. The risk

for OPTION 2 would increase considerably if colonies were permitted to enter NS later in the summer after SHB have sufficient time to reproduce under more favorable conditions in southern ON or following migration from adjacent U.S. colonies in New York State and Michigan.

2.4.3 Factors Affecting the Consequence Assessment

The focus of the consequence assessment for small hive beetle (SHB) involves describing the interaction between a specific risk of exposure and the economic consequences to Nova Scotia (NS). These economic impacts are expected to be felt unequally to different sectors of the NS economy. The key sectors considered in this assessment are the various segments of the NS beekeeping industry (custom pollinators, honey producers, queen and nuc producers) and the wild blueberry sector, which requires large numbers of honey bee colonies moved into fields for the month of June for pollination.

2.4.3.1 Assessment of Consequence to Nova Scotia Honey Bee Colonies

Small hive beetle has been demonstrated to be a significant pest of honey bees, particularly in sub-tropical areas (e.g., Florida, Australia and Hawaii). The beetle can cause severe damage to the colony by feeding on brood, pollen and honey (the primary sources of food for adult SHB females and larva (Neumann and Elzen 2004, Cuthbertson et al. 2013)). At high infestations this feeding causes: a) structural damage to the comb resulting in its collapsing from the frame, b) honey to ferment and c) the formation of a slimy film over the comb (Elzen et al. 1999). These problems are particulary acute if the beekeeper brings comb from infested colonies into their honey house, where SHB can readily spoil all the honey stored in the beekeeper’s hot room (i.e., prior to the honey extraction step). Moreover, SHB larvae infesting comb from honey houses are readily able to find their way to the building’s exterior, where they pupate and act as a reservoir for reinfesting the honey house, as well as nearby apiaries (Spiewok et al. 2007). Although particularly high infestations have been known to kill honey bee colonies with large populations (Elzen et al. 1999), small-sized nucleus colonies (e.g., those used in queen production) are particularly vulnerable to collapse (Mustafa et al. 2014). Moreover, many populous colonies can harbour large numbers of SHB without any negative effects to its productivity (Mustafa et al. 2014), resulting in large honey crops that are subsequently damaged when brought into the honey house. Unfortunately, SHB infestations are particularly difficult to manage, not only because of a lack of effective pest control products (Elzen et al. 1999, Neumann and Hoffmann 2008, Bernier et al. 2015), but perhaps even more, because of the high rate of colony reinfestation from within apiaries and among apiaries (Spiewok et al. 2007, Spiewok et al. 2008).

In spite of the observed high levels of damage in subtropical regions, levels of damage elsewhere appear much reduced. This is, in part, because SHB reproduction is curtailed outside of the subtropics. For example, a comparative study of SHB beetle levels among colonies in Florida versus Maryland indicated that beetle populations in the latter region were up to 40 times lower (Spiewok et al. 2007). The low reproductive capacity of SHB outside of the southern U.S. may explain why beekeepers in the U.S., as a whole, consistently rank damage to SHB far behind other pest and disease problems (vanEngelsdorp et al. 2012, Spleen et al. 2013, Steinhauer et al. 2014). There are no records of SHB increasing the mortality of populous colonies in the U.S. outside of the subtropical region (or among colonies that have not recently migrated from this region) and it does not cause elevated colony winter mortality in northern U.S. states (Schäfer et al. 2010). Given these circumstances there are likely two areas where the consequence of SHB introduction will most impact NS beekeepers:

1. SHB infestations brought into NS beekeeper's honey house can cause considerable damage since a single SHB female can lay up to 1,000 eggs. Honey comb brought into the honey houses that are infested with any of the stages of SHB (eggs, larvae or gravid females) can result in considerable damage. This damage can be offset if beekeepers extract their comb within 48 h of bringing it into their honey house and using immediate sanitation measures if an infestation is detected. Implementation of such SHB honey house best management practices (BMPs), however, will add increased operating costs to the beekeeping operation. Such practices will be of **moderate** consequence to honey producers.

2. Small nucleus colonies used by the NS queen breeding sector are the most vulnerable to collapse to SHB, since very few SHB can result in colony death (Mustafa et al. 2014). Consequently, there is like a **moderate** consequence to NS queen breeders if SHB become established.

It is important to remark, however, that up 80% of NS honey bee colonies are used for blueberry pollination and that this revenue stream (20,000 colonies × $150 / colony ~ $3 Million) is double that collected from honey sale (~$1.5 Million). Since the introduction of SHB to NS is not expected to impact the capacity of beekeepers to meet pollination contracts, the overall consequence of SHB exposure to the NS beekeeping industry is **low to moderate**.

NS beekeepers could also be directly impacted by border closures and additional inspections. OPTION 1 (Border Closure) will not only restrict the importation of honey bee colonies into NS for pollination (benefiting NS beekeepers in bidding on contracts for NS blueberry pollination), but it will prevent NS beekeepers from moving their colonies into NB and PEI for pollination and back again. Similarly, OPTION 2 will impose new costs of colony inspections for both NS and non-NS colonies entering or re-entering the province (respectively). Consequently, both options appear to neither excessively benefit nor impact NS beekeepers in themselves.

2.4.3.2 Assessment of Consequences to the Blueberry Industry

Approximately 22,000 acres of commercial wild blueberries bloom each year in NS. Honey bee pollination is a key input associated with high blueberry yields particularly at densities of 1.5/colonies per acre (Eaton and Nams 2012). Theoretically, at this stocking rate, NS blueberries require 33,000 honey bee colonies for optimal pollination benefits. Although there has been considerable expansion in the number of honey bee colonies in NS over the past five years through the NS Pollinator Enhancement Program (~50% increase, Figure 1) it has fallen short of the demand for colonies from the blueberry industry (e.g., 20,000 NS colonies were made available for pollination 2015).

Under the conditions of OPTION 2 (*Restricted Importation*) blueberry growers have been able to make up for the shortfalls in honey bee colonies by contracting up to 5,000 honey bee colonies from southern ON and approximately 2,000 commercial bumble bee colonies (*Bombus impatiens*) (Stubbs and Drummond 2001) each year. The potential spread of SHB in ON may reduce the number of available colonies that meet the conditions of the 2015 NS Bee Health Importation Protocol resulting in **low** negative consequences to blueberry producers. OPTION 1 (*Border Closure*) will further restrict the supply of colonies available for blueberry pollination resulting in **moderate** consequences to blueberry producers. Part of these negative impacts could be offset if: 1) the NS beekeeping industry continues to grow at its current trajectory, 2) blueberry growers expand their use of more expensive commercial bumble bees (~70% higher cost compared to honey bees) and 3) blueberry grower are able to better utilize of wild pollinator populations (it is estimated that over 25% of NS blueberry fields are adequately pollinated by wild pollinators alone (Eaton and Nams 2012)). These offsetting factors are helped by the fact that blueberry expansion in NS is proceeding more slowly than in other Atlantic Canada provinces (with approximately 2,000 acres in development) resulting in only minor anticipated increases in future demands on colonies.

2.4.3.3 Risk Assessment for Small Hive Beetle Consequence to Nova Scotia

The consequence of SHB exposure will be of **low to moderate** negative consequence to NS beekeepers.

The two options being assessed, however, will have a differential effect on NS blueberry growers.

Consequence Associated OPTION 1 (*Border Closure*): The consequence of closing the NS border to the NS blueberry industry is expected to be **moderate**.

Consequence Associated OPTION 2 (*Restricted Importation*): Under the 2015 NS Import Protocol the consequence to NS blueberry industry is expected to be **low**.

3 CONCLUSION

The assessment concludes that OPTION 1 (*Border Closure*) reduces both the risk of SHB entry and exposure compared to OPTION 2 (*Restricted Importation*), but the reduced consequence of SHB damage among NS beekeepers from OPTION 1 will have moderate consequences to wild blueberry growers because of increased disruption of honey bee colony supply as compared to the low consequence under OPTION 2 (Table 7).

Table 6. Summary of the risk estimate for SHB associated for two options for moving honey bee colonies into Nova Scotia.

Hazard	Entry Probability	Exposure Probability	Consequence Estimate	Risk Estimate
Option 1: Border Closure	Extremely Low – Very Low	Negligible	Low - Moderate	Negligible
Option 2: Restricted Importation	Small - Moderate	Low to Small	Low - Moderate	Negligible - Low

The risk assessment for SHB associated with OPTION 2 is less than that attributed to the importation of honey bee packages from the U.S. by CFIA (**low-moderate**) (Canadian Food Inspection Agency 2014). This difference can be explained by: 1) the higher entry risk associated with U.S. packages owing to the free movement of colonies from subtropical regions (where SHB thrives) to package producing regions, 2) unlike U.S. packages which would remain in Canada, colonies imported under the 2015 NS Bee Health Importation Protocol would require they depart the province by 1 July, 3) the climatic conditions in NS are less favorable to SHB reproduction than in regions such as southern BC and ON and 4) OMAFRA is requiring ON beekeepers to implement and develop SHB best management practices (BMP) and has committed to continued surveillance of infestations within the province.

It is important to consider that the blueberry industry in NS is roughly ten times the size of the beekeeping industry ($32.5 Million blueberries vs. ~$4.5 Million beekeeping, 2015 figures). Although it is beyond the scope of this assessment to quantify the cost and benefit of OPTION 1 versus 2, the reduced SHB risk associated with OPTION 1 appears to be outweighed by the relative benefits to the NS wild blueberry industry associated with OPTION 2.

There are a number of factors that could further reduce the risk for SHB under OPTION 2. These include:

- increasing the level of inspection of colonies entering NS for blueberry pollination (to 10% of the broodnests inspected and 50% of the topbars, compared to the current Protocol that specifies 10% of broodnests and 15% of the topbars)
- reducing the timespan between when colonies are inspected and when they arrive in NS (to 30 days from the current 45 days)
- a declaration from the exporter, signed by their Provincial Apiculturalist, declaring their apiary has been free of SHB for the previous 2 years (as is being proposed in QC)
- restricting the movement of honey bee colonies to Cumberland County (thereby avoiding 95% of the summer and wintering apiary locations for NS beekeepers)
- specifying that imported colonies either: a) be treated with CheckMite+ (attached to bottom board traps prior to shipment) b) the use of in-hive beetle traps and/or c) apiary locations be treated with Permanone (a.i., permethrin) immediately after colonies are removed.

4 REFERENCES

[EFSA] European Food Safety Authority. 2015a. Small hive beetle diagnosis and risk management options. EFSA Journal **13**:4048.

[EFSA] European Food Safety Authority. 2015b. Survival, spread and establishment of the small hive beetle (*Aethina tumida*). EFSA Journal **13**.

[OIE] World Organisation for Animal Health. 2011. Guidelines for Assessing the risk of non-native animals becoming invasive. http://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/OIEGuidelines_NonNativeAnimals_2012.pdf.

[OIE] World Organisation for Animal Health. 2013. Chapter 2.2.5 Small hive beetle infestation (*Aethina tumida*). Pages 1-6 Manual of Standards for Diagnostic Test and Vaccines for Terrestrial Animals., Paris, France.

[OMAFRA] Ontario Ministry of Agriculture Food and Rural Affairs. 2015. Small hive beetle confirmed in Niagara region.*in* O. M. o. A. F. a. R. Affairs, editor. Governent of Ontario, Ontario.

Annand, N. 2011. Investigations on Small Hive Beetle Biology to Develop Better Control Options. University of Western Sydney, Sydney, Austalia.

Bernier, M., V. Fournier, L. Eccles, and P. Giovenazzo. 2015. Control of *Aethina tumida* (Coleoptera: Nitidulidae) using in-hive traps. The Canadian Entomologist **147**:97-108.

Bernier, M., V. Fournier, and P. Giovenazzo. 2014. Pupal development of *Aethina tumida* (Coleoptera: Nitidulidae) in thermo-hygrometric soil conditions encountered in temperate climates. Journal of Economic Entomology **107**:531-537.

Canadian Food Inspection Agency. 2014. Risk Assessment on the Importation of Honey Bee (*Apis mellifera*) Packages from the

United States of America. Canadian Food Inspection Agency, Ottawa, ON.

Cuthbertson, A. G., M. E. Wakefield, M. E. Powell, G. Marris, H. Anderson, G. E. Budge, J. J. Mathers, L. F. Blackburn, and M. A. Brown. 2013. The small hive beetle *Aethina tumida:* A review of its biology and control measures.

de Guzman, L. I., and A. M. Frake. 2007. Temperature affects *Aethina tumida* (Coleoptera: Nitidulidae) development. Journal of Apicultural Research **46**:88-93.

Eaton, L. J., and V. O. Nams. 2012. Honey bee stocking numbers and wild blueberry production in Nova Scotia. Canadian Journal of Plant Science **92**:1305-1310.

Elzen, P. J., J. R. Baxter, D. Westervelt, C. Randall, K. S. Delaplane, L. Cutts, and W. T. Wilson. 1999. *Aethina tumida* Murray (Coleoptera, Nitidulidae), attacking European honey bees. Apidologie **30**:361-366.

Giovenazzo, P., and C. Boucher. 2010. Scientific note on the occurrence of the small hive beetle (*Aethina tumida* Murray) in southern Quebec. American Bee Journal.

Hoffmann, D., J. Pettis, and P. Neumann. 2008. Potential host shift of the small hive beetle (*Aethina tumida*) to bumblebee colonies (*Bombus impatiens*). Insectes sociaux **55**:153-162.

Kozak, P. 2010. Small hive beetle found in southern Ontario. Page 30 Hivelights.

Lee, J. 2015. Beetle pest found in B.C. hive. The Vancouver Sun.

Levot, G., and N. Haque. 2006. Insecticides applied to soil for the control of small hive beetle *Aethina tumida* Murray (Coleoptera: Nitidulidae) larvae. General and Applied Entomology **35**:23-28.

Lounsberry, Z., S. Spiewok, S. F. Pernal, T. S. Sonstegard, W. M. Hood, J. Pettis, P. Neumann, and J. D. Evans. 2010. Worldwide diaspora of Aethina tumida (Coleoptera: Nitidulidae), a nest parasite of honey bees. Annals of the Entomological Society of America **103**:671-677.

Meikle, W., and J. Patt. 2011. Temperature, diet and other factors on development, survivorship and oviposition of the Small Hive Beetle, *Aethina tumida* Murray (Col.: Nitidulidae). Journal of Economic Entomology **104**:753-763.

Meikle, W. G., N. Holst, S. C. Cook, and J. M. Patt. 2015. Variability in small hive beetle (Coleoptera: Nitidulidae) reproduction in laboratory and field experiments. Journal of Economic Entomology:tov101.

Mustafa, S. G., S. Spiewok, M. Duncan, R. Spooner-Hart, and P. Rosenkranz. 2014. Susceptibility of small honey bee colonies to invasion by the small hive beetle, Aethina tumida (Coleoptera, Nitidulidae). Journal of Applied Entomology **138**:547-550.

Neumann, P., and J. D. Ellis. 2008. The small hive beetle (Aethina tumida Murray, Coleoptera: Nitidulidae): distribution, biology and control of an invasive species. Journal of Apicultural Research **47**:181-183.

Neumann, P., and P. J. Elzen. 2004. The biology of the small hive beetle (Aethina tumida, Coleoptera: Nitidulidae): Gaps in our knowledge of an invasive species. Apidologie **35**:229-248.

Neumann, P., J. D. Evans, J. S. Pettis, C. W. Pirk, M. O. Schäfer, G. Tanner, and J. D. Ellis. 2013. Standard methods for small hive beetle research. Journal of Apicultural Research **52**:1-32.

Neumann, P., and D. Hoffmann. 2008. Small hive beetle diagnosis and control in naturally infested honeybee colonies using bottom board traps and CheckMite+ strips. Journal of pest science **81**:43-48.

Pettis, J., and H. Shimanuki. 2000. Observations on the small hive beetle, *Aethina tumida* Murray, in the United States. American Bee Journal **140**:152-155.

Schäfer, M. O., J. S. Pettis, W. Ritter, and P. Neumann. 2008. A scientific note on quantitative diagnosis of small hive beetles, Aethina tumida, in the field. Apidologie **39**:564-565.

Schäfer, M. O., W. Ritter, J. S. Pettis, and P. Neumann. 2010. Winter losses of honeybee colonies (Hymenoptera: Apidae): The role of infestations with *Aethina tumida* (Coleoptera: Nitidulidae) and *Varroa destructor* (Parasitiformes: Varroidae). Journal of Economic Entomology **103**:10-16.

Spiewok, S., M. Duncan, R. Spooner-Hart, J. S. Pettis, and P. Neumann. 2008. Small hive beetle, *Aethina tumida*, populations II: Dispersal of small hive beetles. Apidologie **39**:683-693.

Spiewok, S., J. S. Pettis, M. Duncan, R. Spooner-Hart, D. Westervelt, and P. Neumann. 2007. Small hive beetle, Aethina tumida, populations I: Infestation levels of honeybee colonies, apiaries and regions. Apidologie **38**:595-605.

Spleen, A. M., E. J. Lengerich, K. Rennich, D. Caron, R. Rose, J. S. Pettis, M. Henson, J. T. Wilkes, M. Wilson, and J. Stitzinger. 2013. A national survey of managed honey bee 2011–12 winter colony losses in the United States: results from the Bee Informed Partnership. Journal of Apicultural Research **52**:44-53.

Steinhauer, N. A., K. Rennich, M. E. Wilson, D. M. Caron, E. J. Lengerich, J. S. Pettis, R. Rose, J. A. Skinner, D. R. Tarpy, and J. T. Wilkes. 2014. A national survey of managed honey bee 2012–2013 annual colony losses in the USA: results from the Bee Informed Partnership. Journal of Apicultural Research **53**:1-18.

Stubbs, C. S., and F. A. Drummond. 2001. *Bombus impatiens* (Hymenoptera: Apidae): an alternative to *Apis mellifera* (Hymenoptera: Apidae) for lowbush blueberry pollination. Journal of Economic Entomology **94**:609-616.

vanEngelsdorp, D., D. Caron, J. Hayes, R. Underwood, M. Henson, K. Rennich, A. Spleen, M. Andree, R. Snyder, and K. Lee. 2012. A national survey of managed honey bee 2010–11 winter colony losses in the USA: results from the Bee Informed Partnership. Journal of Apicultural Research **51**:115-124.

5 APPENDIX

Appendix 1 – 2015 Nova Scotia Bee Health Importation Protocol

2015 Nova Scotia Bee Health Importation Protocol

The Bee Import protocol is established annually under the Bee Industry Act and sets out the conditions in which bees can be imported into Nova Scotia.

Changes to these protocols and associated permit requirements, could be made at any time to accommodate new conditions that could affect the bee industry in NS. Applicants will be given the most up to date protocol upon permit approval or annually.

To obtain an import permit or for more information please contact: **Jason Sproule, Provincial Apiculturalist**
Nova Scotia Department of Agriculture
P.O. Box 890 Harlow Building
Truro, NS, B2N 5G6
jason.sproule@novascotia.ca
(902) 890-1565

Requirements for importing honey bees/ equipment from another province:

- A Certificate of Inspection from the exporting province that meets the inspection requirements for small hive beetle and brood diseases as indicated below, with the inspection having been conducted within 45 days of export.

- A letter confirming tracheal mite treatment (template attached) signed by the exporting beekeeper declaring the colonies to be exported were treated in the spring of each import year or preceding fall (within 300 days prior to export) with a full formic acid treatment as label directed for control of tracheal mites.

Requirements for importing honey bees from outside Canada:

- A copy of the CFIA import document or import number issued is required.

Certificate of Inspection requirements

American Foulbrood (AFB)

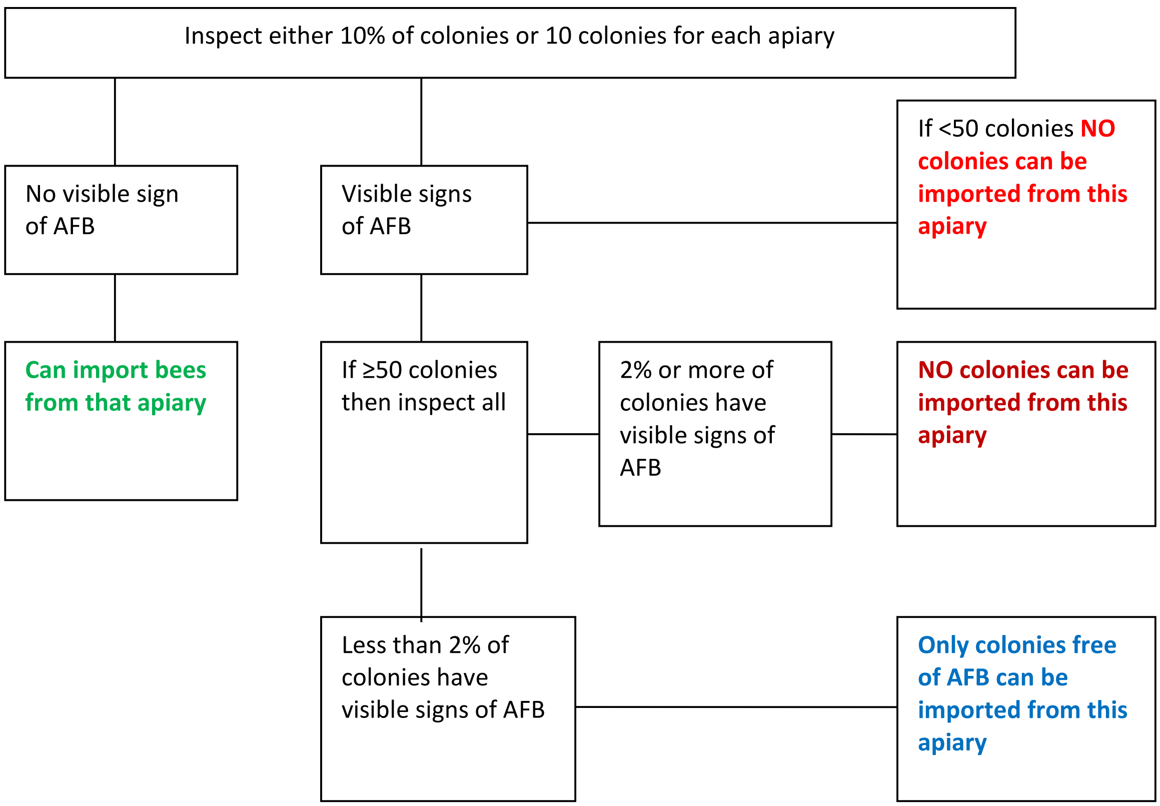
- Colonies are not allowed to enter Nova Scotia from an apiary where antibiotic-resistant American foulbrood (rAFB) has been diagnosed within the previous two years of the importation date.

- For each apiary, at least ten percent of colonies or ten colonies, whichever is greater, must be inspected for visible signs of AFB. If no visible sign of AFB is found, all colonies from that apiary can be imported.

- An inspection for AFB consists of a visual examination of a minimum of 3 brood frames with at approximately 75% or greater brood coverage.

- If any colonies inspected show visible signs of AFB, then every colony in that apiary must be inspected for AFB. Only colonies free of AFB will be permitted to enter NS.

- If an apiary was found to have two (2) percent or more of colonies with visible signs of AFB from any inspection made up to six months before the importation date, its colonies will not be permitted to enter NS.



Small Hive Beetle (SHB)

- No colonies from a SHB quarantined apiary site or designated Zone may be imported into Nova Scotia. Colonies from apiaries in zone 1-ON (Essex County, Ontario) or from any quarantine zone that is in effect from April 1, 2015 are not permitted to enter NS. Colonies which have traveled through any Canadian zones declared quarantine as of April 1, 2015, or which will have to travel through any such zones to get to NS, will not be permitted to enter NS in 2015. This includes zones 1-ON in Ontario.

- For colonies to be imported, for each apiary, at least 10 (ten) percent of colonies or ten colonies, whichever is greater, must be inspected for presence of SHB. This inspection must be a full brood nest inspection with a minimum of three frames removed and inspected and include inspection of the bottom board where feasible. If any SHB (adult, eggs, or larvae) are found, then no colonies from that apiary will be allowed to enter NS. For any colonies to be exported from a province with established SHB an additional minimum inspection of 15 % of the colonies or a minimum of 15 colonies per apiary whichever is greater must be carried out through the top bar inspection technique.

- For any colonies to be exported from a province where SHB has been detected in previous years, but is not to be considered to have established SHB, an individual review will be conducted and conditions established based on risk assessment.
- For queens imported from outside Canada from a country where SHB has been detected an inspection of queen cages must be carried out before the release of queens to the importer.
- For colonies imported from a province with established Small Hive Beetle the NS beekeeper requesting a permit should make the supplier aware that the NS Department of Agriculture may conduct monitoring for SHB while colonies are in Nova Scotia.
- If SHB is detected in any imported colony, the supplier must be notified immediately, and all hives in the imported lot with SHB must be shipped back to the province of origin within 72 hours of detection, in fine mesh netting for the entire journey.

Tracheal Mites

- All colonies imported must have been treated in the spring of each year or preceding fall with a full formic acid treatment as label directed for control of tracheal mites. The letter template must be completed and signed by the exporting beekeeper and sent to the Jason Sproule.
- All queens imported from Canadian provinces or California must have the attendants destroyed before queens are introduced to a colony.

Requirements after permit is granted

Transportation requirements for colonies

After inspection, shipments are to be transported directly to NS and not be modified en route.
The importer is responsible for ensuring the truck drivers of each imported shipment will have a copy of the NS permit and applicable inspection reports. The importer is responsible for obtaining transportation permission from the provinces through which the imported colonies must travel to arrive in NS.

Netting or an enclosed vehicle must be used when transporting all imported colonies:
- from point of departure in the exporting province;
- through all provinces travelled; and
- within Nova Scotia for relocation and return to exporter.

Colonies imported for pollination:
Before colonies are moved into, within and out of NS, the importer must provide

a minimum of three days' notice to Jason Sproule (Provincial Apiculturalist) as to where the colonies will be placed. All imported colonies must leave Nova Scotia by July 1st.

Approved By:_______________________________ **Approved Date:**_____________________________