Canadian Council of Forest Ministers

Conseil canadien des ministres des forêts

PEST RISK ANALYSIS

Risk Assessment of the Threat of Brown Spruce Longhorn Beetle to Nova Scotia Forests

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Compiled by:

Department of Natural Resources
Forest Protection
Shubenacadie, Nova Scotia

2013

Canadian Council of Forest Ministers
Forest Pest Working Group

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Funding for the workshop and the consultant report was provided by the National Forest Pest Strategy under the Canadian Council of Forest Ministers.

Executive Summary

The brown spruce longhorn beetle (BSLB) (*Tetropium fuscum* (F.)) is an invasive forest insect from Europe that infests spruce trees. BSLB was discovered in Halifax in 1999, but has been established in Nova Scotia since at least 1990. It likely arrived in wood packaging aboard container ships. BSLB is not known to be established anywhere else in North America.

To help slow or prevent the insect's spread, the Canadian Food Inspection Agency (CFIA) issued a Ministerial Order in October 2000 (revised in 2007 and 2013). The order restricts the movement of spruce round logs and firewood of all species out of the containment area in Nova Scotia to prevent the spread of BSLB to non-infested areas.

From 2012 to 2014, the Province of Nova Scotia conducted a pest risk analysis (PRA) in response to new BSLB finds outside the containment area. The PRA used the Risk Analysis Framework developed as part of the National Forest Pest Strategy under the Canadian Council of Forest Ministers. The area of interest for this PRA was restricted to Nova Scotia and the triggers that led to its initiation. The Province recognized the need to re-evaluate BSLB risk management in light of the successes and failures of the existing approach, and to take advantage of new science.

The broad objectives of this PRA were to:

- estimate the rate and direction of BSLB spread and establishment;
- identify the values at risk to BSLB colonization;
- characterize the risk of BSLB;
- develop conclusions and describe factors that could, over the short and long terms, influence the volume of vulnerable host material in Nova Scotia; and

- describe BSLB management options and identify future research needs.

Risk assessment for forest pests considers the likelihood of occurrence, the potential for establishment and spread, and the consequences of introduction.

The overall risk posed by BSLB to Nova Scotia's forests was assessed using available evidence and advice from experts. Risk factors were characterized according to affirmative statements followed by supporting evidence and an explicit identification of any uncertainty or knowledge gaps. Where uncertainty existed, its level was then ranked as either low, moderate or high.

The outcomes of this risk assessment have determined that BSLB poses a low to moderate risk to the forests of Nova Scotia. The possibility of BSLB occurring throughout the province is highly likely, but the magnitude of the consequences—based on those seen to date in terms of economic, social and environmental values—is low. Moderate to high uncertainties and information needs elevated the overall risk assessment of BSLB from low to low–moderate.

Given these findings and their implications for risk response and management of BSLB, it is recommended that:

- Movement of spruce wood products, logs and firewood be controlled to help prevent the artificial spread of BSLB.
- The BSLB population in Nova Scotia be accurately delineated in order to help slow its spread.
- Best management practices, including those for silviculture and harvesting activities, be promoted among private landowners, contractors and others who harvest wood products in order to maintain a healthy forest and so help slow BSLB spread.
- Direct control methods be used to suppress BSLB populations and slow their spread along the leading edge.
- Support for continued research and monitoring be provided.

Information gaps were also identified. Further research is needed to determine the effects of:

- competitive or cooperative interactions between BSLB, native bark beetles and native *Tetropium*;
- native biological control agents on BSLB in Nova Scotia;
- host suitability and/or vulnerability (e.g., hybrid spruce, site conditions);
- climate change on host species and BSLB; and
- BSLB on non-commercial forest values.

Further information is also needed about:

- BSLB ecology and population dynamics; and
- regulation and management policies.

Introduction

The brown spruce longhorn beetle (BSLB) (*Tetropium fuscum* (F.)) is an invasive forest insect that infests spruce trees. It has been established in Nova Scotia since at least 1990, but was not discovered until 1999, when it was positively identified in red spruce (*Picea rubens*) trees in Point Pleasant Park, Halifax. Specimens originally collected in 1990 were misidentified as a similar species, the native eastern larch borer (*T. cinnamopterum* (Kirby)).

The beetle, native to northern and central Europe, is believed to have entered Nova Scotia through solid wood packing material from container ships at the port adjacent to the park. BSLB has been under regulatory control by the Canadian Food Inspection Agency (CFIA) as a pest of plant quarantine significance since 2000. To help slow or prevent the spread of the BSLB, a Ministerial Order was issued in October 2000 (revised in 2007 and 2013). The current (2013) order restricts the movement of spruce round logs and firewood of all species out of the containment area in Nova Scotia, to prevent the spread of BSLB to areas in Canada not infested by the beetle (Figure 1).

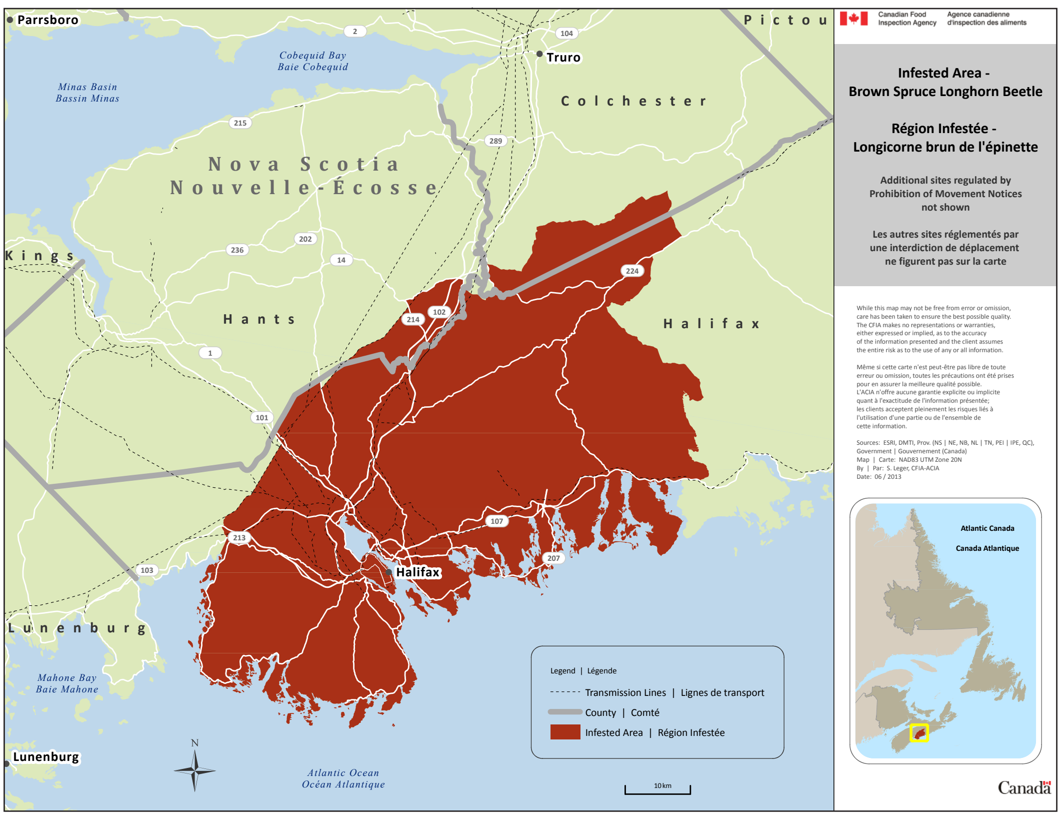

Figure 1. Containment area for the brown spruce longhorn beetle (*Tetropium fuscum* (F.)), current to 2013.

BSLB is not known to be established anywhere else in North America.

- In July 2011, a single adult beetle was captured in a CFIA pheromone-baited survey trap in Kouchibouguac National Park, New Brunswick. In 2012, the CFIA, in cooperation with Parks Canada and Natural Resources Canada–Canadian Forest Service (NRCan–CFS), conducted an extensive trapping survey within the park and no BSLB were detected.

- In Nova Scotia, the 2012 BSLB survey found 28 new positive locations of BSLB outside the containment area (Figure 2). This means that from 2006 to 2012, BSLB were detected in Halifax, Hants, Pictou, Colchester and Richmond counties—or a total of 93 positive sites outside the original containment area (Figure 3).

In 2012, the Province of Nova Scotia agreed to carry out this risk analysis as an implementation case study of the Risk Analysis Framework developed as part of the National Forest Pest Strategy under the Canadian Council of Forest Ministers. This analysis framework enabled the risks associated with BSLB and its spread, as it pertains to the Nova Scotia situation, to be systematically evaluated and described in terms of impact, information needs and uncertainty. Recommended strategies and tactics to mitigate the risk (through research, regulation and control measures) are also included. This risk analysis also promotes collaboration and transparency, two ideals that align directly with the Department's Natural Resources Strategy (Nova Scotia Department of Natural Resources, 2011).

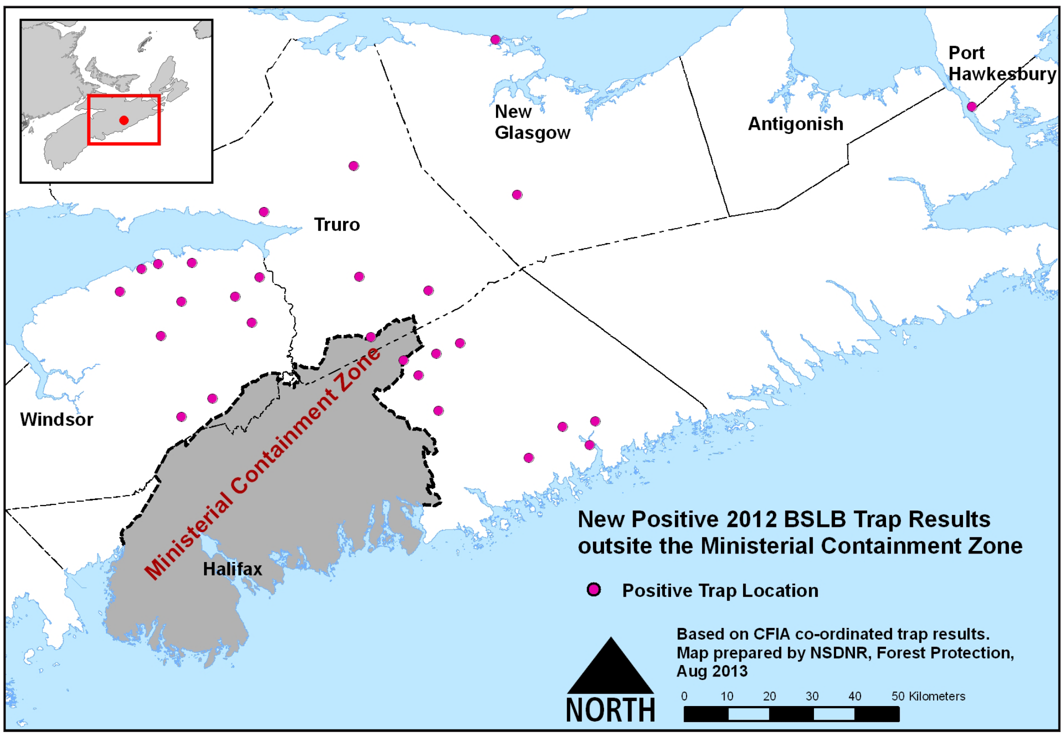

Figure 2. New positive sites of brown spruce longhorn beetle (*Tetropium fuscum* (F.)) found outside the containment area in 2012.

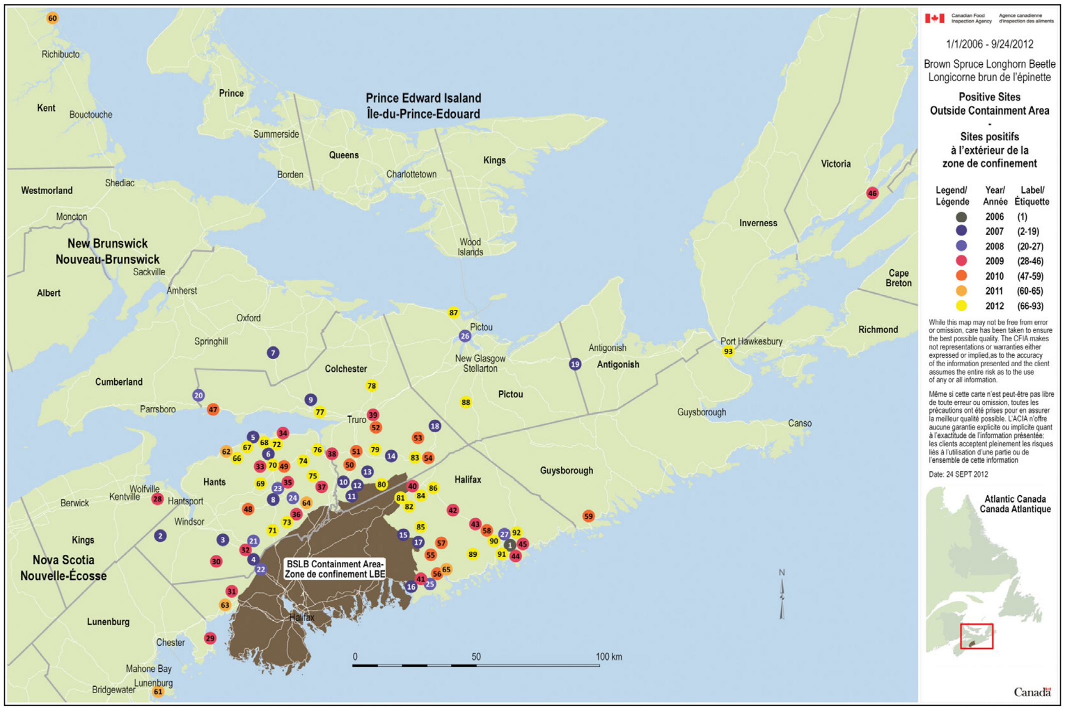

Figure 3. All positive sites of brown spruce longhorn beetle (*Tetropium fuscum* (F.)) found outside the containment area, 2006 to 2012.

RISK ANALYSIS OVERVIEW

A pest risk analysis provides an overall risk rating for a pre-determined geographic area. Pest risk assessments can be qualitative, quantitative or both. For a pest risk analysis, the pest risk is described in a descriptive, or qualitative, way using affirmative statements supported by evidence.

This BSLB risk analysis was restricted in scope to the province of Nova Scotia and followed the framework developed by the Risk Analysis Technical Advisory Group of the National Forest Pest Strategy (NFPS). Although both the NFPS and the CFIA risk models are based on the work of the International Plant Protection Convention, the NFPS Risk Analysis Framework differs in that it includes a risk response and risk communication component in addition to the overall risk assessment (Figure 4).

In the 2008 Plant Health Risk Assessment conducted by the CFIA, the BSLB was given an overall quantitative risk rating of medium since it was determined that the likelihood and consequences of its introduction were both determined to be medium (Canadian Food Inspection Agency 2008).

Risk assessment **–** In risk assessment, risk is defined as the product of the likelihood times the consequences of an occurrence. Consequences are made up of the overall risk of pest establishment and spread, and of the environmental, economic and sociocultural impacts. Risk assessment is science based and uses evidence to characterize risk, acknowledging uncertainties and knowledge gaps. Throughout this assessment, affirmative statements are used to characterize risk factors. These statements are followed by supporting evidence and explicit identification of any uncertainty or knowledge gaps. Uncertainty is inherent to any pest risk assessment, as complete information is seldom available. Identification of these uncertainties contributes to transparency, provides a measure of the analysts' confidence in the evidence, and helps prioritize research needs.

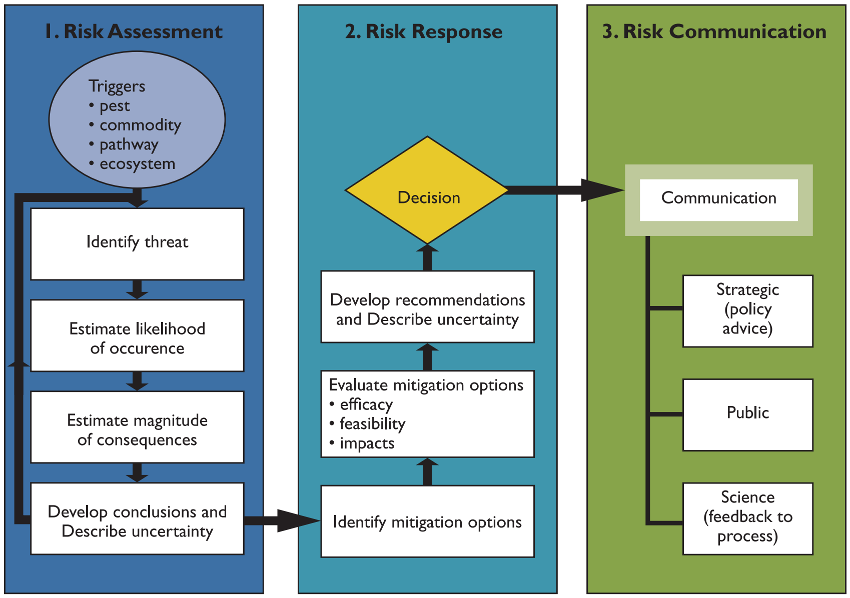

Figure 4. The three elements of the National Forest Pest Strategy Risk Analysis Framework: risk assessment, risk response, and risk communication.

Uncertainty is rated as low, moderate or high (see texbox below).

Risk response – Risk response provides an overview of potential response strategies and tactics to address the overall risk. Conclusions and uncertainties are summarized and recommendations are made.

Risk communication – Risk communication is a continual process and applies to both risk assessment and risk response. Ongoing dialogue and consultation between risk assessors, risk managers, scientific experts and stakeholders help ensure both transparency and accountability. Risk communication includes workshops, conference calls, email correspondence, presentations, and written material. The objective is to increase awareness, assure appropriate involvement, instil trust and confidence, and increase effectiveness and efficiency.

UNCERTAINTY RATINGS

- **Low uncertainty:** Indicates that the supporting survey and scientific data are locally applicable, consistent and comprehensive and that any expected variability will not change the validity or magnitude of the risk statement.
- **Moderate uncertainty:** Indicates that preliminary evidence, if completed, will significantly lower the uncertainty; or inherent variability may significantly change the magnitude of the risk statement but not its truth.
- **High uncertainty:** Indicates that supporting survey and scientific data are missing, are not locally applicable, or an inconsistent and the expected variability can change the validity of the risk statement.

TRIGGERS FOR THIS BSLB RISK ASSESSMENT

This risk analysis was triggered by new BSLB trap findings beyond the containment area, as well as the need for the Department of Natural Resources to re-evaluate its BSLB risk management in light of successes, failures and new science. Also prompting the analysis were suggestions from the CFIA that the agency might reduce its BSLB surveillance and regulatory efforts in the near future.

OBJECTIVES

The broad objectives of this analysis were to:

- estimate the rate and direction of BSLB spread and establishment;
- identify the values at risk as a result of BSLB colonization;
- characterize the risk of BSLB based on evidence, and identify uncertainties and information needs;
- describe factors that could, over the short and long terms, influence the volume of vulnerable host material in Nova Scotia; and
- describe mitigation options and identify future research needs.

RISK COMMUNICATION FOR THE BSLB RISK ANALYSIS

In September 2012, a BSLB knowledge synthesis workshop, organized by the Nova Scotia Department of Natural Resources (NSDNR), was held in Fredericton, NB. Major stakeholders included CFS-NRCan, University of New Brunswick, the CFIA, and the Nova Scotia and New Brunswick Departments of Natural Resources (Appendix A). The purpose of the workshop was to engage these groups in the risk analysis process by identifying and evaluating the current state of knowledge about BSLB.

Discussion concerning risk was focused through the use of affirmative statements designed to elicit debate among BSLB experts. The aim was to reveal the strength of evidence supporting the statement and any knowledge gaps. The affirmative statement was then modified to reflect the consensus of the experts in light of the evidence.

To build awareness that NSDNR was conducting a BSLB risk analysis, an article introducing the initiative was included in the August/September 2012 issue of *The Insectary Notes*, the bimonthly newsletter of the Department of Natural Resources (Appendix B). To reinforce awareness of the BSLB risk assessment and solicit feedback on the process, an overview of the risk analysis framework was provided and a progress update presented during the Atlantic Canada Forest Health Workshop held in January 2013.

A conference call with key forest industry representatives was held in October 2012, as a first step to including these stakeholders in the assessment process. Senior executives with the Maritime Lumber Bureau, the Federation of Nova Scotia Woodlot Owners, and the Forest Products Association of Nova Scotia were briefed on the risk assessment process and progress to date, and were asked to contribute their understanding of BSLB risk factors. To address some of the information needs identified during the conference call, Gardner Pinfold Consultants Inc. was hired to assess and report on the impact of the BSLB on the forest industry (including on the forest products market) within Nova Scotia (Appendix D). Impacts on landowners were also assessed.

Findings from the risk analysis will inform discussions by the BSLB Risk Sub-Committee and, in turn, the BSLB Steering Committee.

Risk Assessment

NATURE OF THE THREAT

Spruces (*Picea* spp.) are the only known hosts of BSLB in North America. To date, the beetle has been confirmed in red, Norway, white and black spruce (Smith & Humble 2000; Sweeney et al. 2001). Results of no-choice studies show that BSLB will lay eggs on red, black and white spruce, but when given the choice prefer red spruce (Sweeney & Smith 2002).

In its native range, BSLB attacks Norway spruce (*Picea abies*), preferring trees with a diameter greater than 14 cm (Saalas 1923). In Canada, BSLB shows a preference for trees that are over 10 cm in diameter (Canadian Food Inspection Agency 2008). Larvae of the BSLB feed on the fresh phloem tissue that transports food from the tree's foliage to the roots. Sufficient larval tunnels will girdle the tree, cutting off the flow of nutrients to the roots, weakening the tree. Once a tree is infested, it typically dies in one to five years as the beetles re-infest it year after year (Juutinen 1955; Sweeney et al. 2001).

Spruces are key species in the three largest forest regions of Canada (Figure 5). It is therefore possible that BSLB could spread beyond the borders of Nova Scotia. The predominant spruces in the boreal forest are white and black spruce; the predominant spruce in the Acadian forest is red

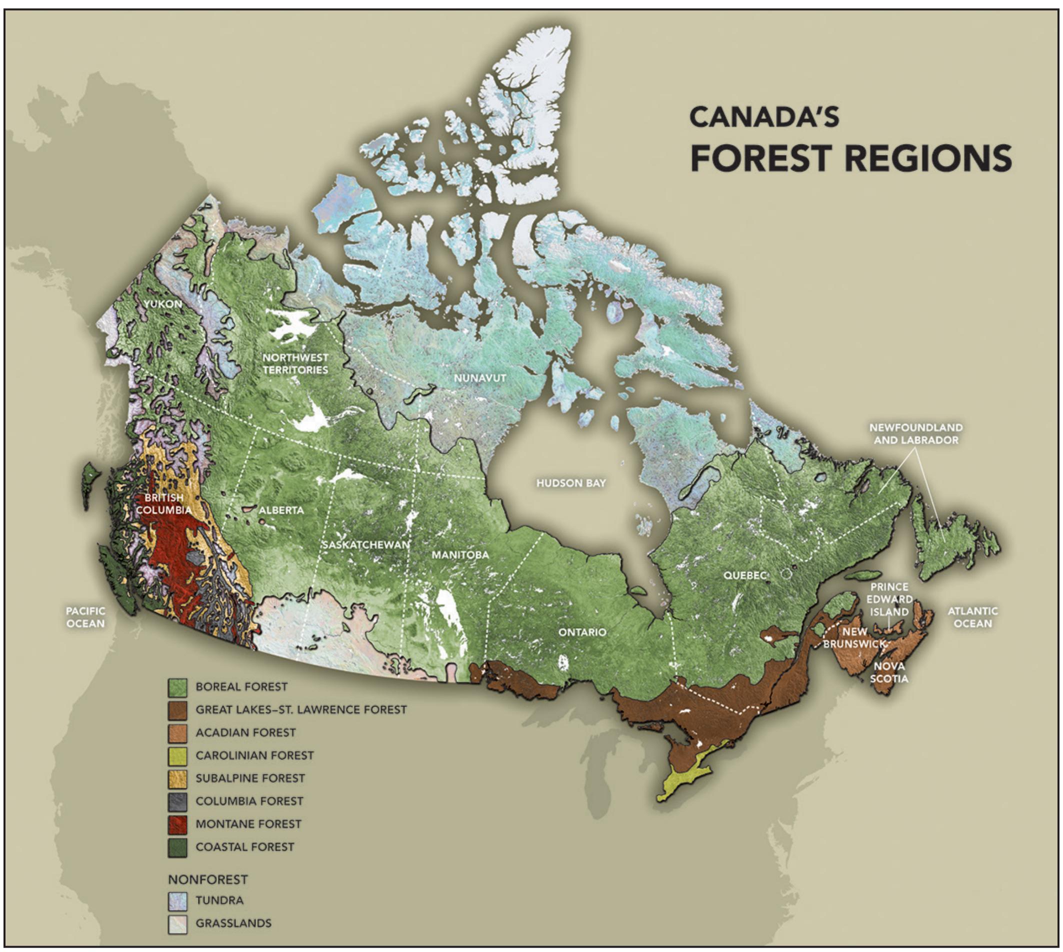

Figure 5. Canada's eight forest regions (Natural Resources Canada, 2013).

spruce. Spruces make up more than one-third (10 billion m^3) of the total wood volume in Canada, covering at least 68 million ha (Power & Gillis 2006). Spruce trees provide paper, lumber, and wildlife food and habitat, and are part of Aboriginal culture. Red spruce is the provincial tree of Nova Scotia and grows widely throughout the province. The estimated road-side value of red spruce in Nova Scotia (for stems greater than 10 cm diameter breast height [DBH]) is over $2 billion (Appendix C).

The scope of this pest risk assessment was restricted to Nova Scotia, because of the limits of provincial jurisdiction and the short window of opportunity provided by NFPS funding. However, BSLB is certainly of concern across Canada, given the national distribution of spruce. Subsequent risk re-assessments by other provincial or federal agencies will benefit from this risk analysis.

BSLB IN CANADIAN FORESTS

In Europe, BSLB is a secondary pest, attacking Norway spruce trees that are weakened or stressed by root rots or other factors (Juutinen 1955). In Nova Scotia, BSLB is more aggressive, attacking apparently healthy spruce as well as dying and recently fallen trees (Smith & Humble 2000; Sweeney et al. 2001). Flaherty et al. (2011, 2013a, 2013b) have shown that healthy red spruce are at low risk of successful colonization, at least at low attack rates. Research to assess the susceptibility of healthy spruce to high attack rates of BSLB is underway.

Once BSLB infests a tree, it will re-infest it year after year until the tree dies, usually in one to five years. Other findings from research by CFS-NRCan into the behaviour of BSLB in Canadian forests:

- Both in its native range and in Nova Scotia, BSLB infestation is most common in older, larger diameter spruce. BSLB has not been found in trees with a DBH less than 9 cm.
- BSLB appears to behave more aggressively than the native *Tetropium cinnamopterum*, which infests weakened or dying spruce trees with sparse crowns.
- BSLB prefers older, mature to over-mature, lower-vigour trees to apparently healthy spruce.
- BSLB colonization of healthy spruce is rare, at average attack rates of 50 eggs per tree (Flaherty et al. 2013).
- BSLB has four life stages:
  - » **Eggs**
    - – In the spring, females lay eggs in the bark of standing or recently felled trees.
    - – Eggs are usually laid singly, but sometimes in clusters of up to 10 eggs.
    - – Egg hatch takes approximately 10–14 days.
  - » **Larvae**
    - – Neonates bore through the bark into the phloem to feed. There they produce a network of irregular tunnels packed with sawdust-like frass.
    - – After about two months of feeding, the larvae are 1.5–2.5 cm long.
    - – Most overwinter as pre-pupal larvae either under the bark or in characteristic L-shaped pupal cells about 2–4 cm deep in the sapwood.
    - – There are six instars (Flaherty et al. 2012b).
    - – It takes approximately 4–6 weeks to go from hatched egg to mature pre-pupal larva. However, duration depends on host condition.
    - – Late–instar larvae diapause as pre-pupae.
  - » **Pupae**
    - – Pupation typically occurs in spring and lasts 10 to 14 days.

- » **Adults**
  - – Adults chew an ovo-speroid exit hole in the bark about 4–6 mm in diameter.
  - – They live about two weeks and can be found at any time from May through to August.
  - – Both males and females are strong flyers. However, as infested spruces remain suitable hosts for up to five years, adults often do not have a great need to disperse too far (Jon Sweeney, NRCan, pers. comm., November 26, 2012).
- Over most of the range of spruce in Canada, BSLB would likely have one generation per year. However, depending on host condition, it can sometimes take up to two years to complete a generation.
- Signs of attacked trees include:
  - » oval to off-round holes in the bark, about 4–6 mm in diameter;
  - » excessive resin production down the length of the stem (sap weeping);
  - » networks of feeding tunnels up to 6 mm across, filled with a sawdust-like material and located just underneath the bark;
  - » L-shaped tunnels in the wood about 4 cm deep and another 4 cm parallel to the grain; and
  - » coarse sawdust in and around the tunnels or plugging the entrance/exit hole.
- The presence of the fungus *Ophiostoma tetropii* is an indication that the infected bole has been colonized by the BSLB (Jacobs et al. 2003).
- Insect identification:
  - » Egg: Is 1 mm long and oblong. It is white with a tinge of green.
  - » Larva: Is yellow-white, about 15–25 mm long and slightly flattened. The head is reddish-brown and is about 3 mm wide.
  - » Pupa: Is white, about 17 mm long and 3.8 mm wide.
  - » Adult: Has a flattened body that varies in length from 8 to 17 mm. Head and neck are dark brown to black. The wing covers are tan, brown or reddish-brown, and have two to three longitudinal stripes. The antennae are red-brown and about half the length of the body.

LIKELIHOOD OF OCCURRENCE

Affirmative Statement 1:

A significant portion of Nova Scotia's forest is susceptible to BSLB colonization.

EVIDENCE

In Nova Scotia, spruces are the primary hosts for BSLB. To date, the insect has been confirmed in red, Norway, white and black spruce (Smith & Humble 2000; Sweeney et al. 2001). However, results of "no-choice" studies show that although BSLB will lay eggs on red, black and white spruce, when given the choice they prefer red spruce (Sweeney & Smith 2002). All stands with red, white, black or Norway spruce over 9 cm DBH are susceptible to BSLB colonization (Sweeney & Smith 2002; Appendix A).

There are no limiting physical or biological barriers to the spread of BSLB within Nova Scotia as the beetle's preferred host species are widespread and functionally contiguous within the province (Figure 6) (Nova Scotia Department of Natural Resources – GIS Division 2012). In Nova Scotia, spruce often occupy areas of nutrient-poor, thin soil where stress due to drought and wind is commonplace (Neily et al. 2011a, 2011b). In these stands, the stressed, slow-growing host material preferred by BSLB will be present (Flaherty et al. 2011, 2013a, 2013b).

Red and white spruce have a significant presence in 53 of 103 ecological vegetation communities recognized in Nova Scotia (Neily et al. 2011b). About 2 million ha of Nova Scotia's forest are composed of a spruce species (Tables 1 and 2). In those composed of greater than 30% spruce, the majority of the stands are between 10 and 70 years old (Figure 7). About 19% of red spruce trees measured in the provincial permanent sample plot program showed a DBH growth rate under 0.6 cm per five-year measurement cycle.[1] This slow growth rate is similar to the growth rate linked to BSLB attack in the red spruce of Point Pleasant Park (O'Leary et al. 2003). Climatic conditions in Nova Scotia are within the range of climatic normals found across the insect's Eurasian distribution (Cherepanov 1990).

UNCERTAINTY

- Low uncertainty about the suitability of native spruces as BSLB hosts. Field observations and laboratory testing have qualified the host preference and reproductive success of BSLB in healthy and stressed native spruces.
- Low uncertainty about the distribution and connectivity of host material. Nova Scotia maintains a detailed and regularly updated forest inventory that is sufficient to locate susceptible spruce stands.
- Low uncertainty about the suitability of the current Nova Scotia climate for BSLB survival.
- Moderate uncertainty about the suitability of hybrid black/red spruce as host species relative to the parent species.
- Moderate uncertainty about the susceptibility of healthy vigorously growing spruce stands.
- Moderate uncertainty about the effects stand structure could have on BSLB risk.
- Moderate uncertainty about the scale of impacts in the forested landscape.

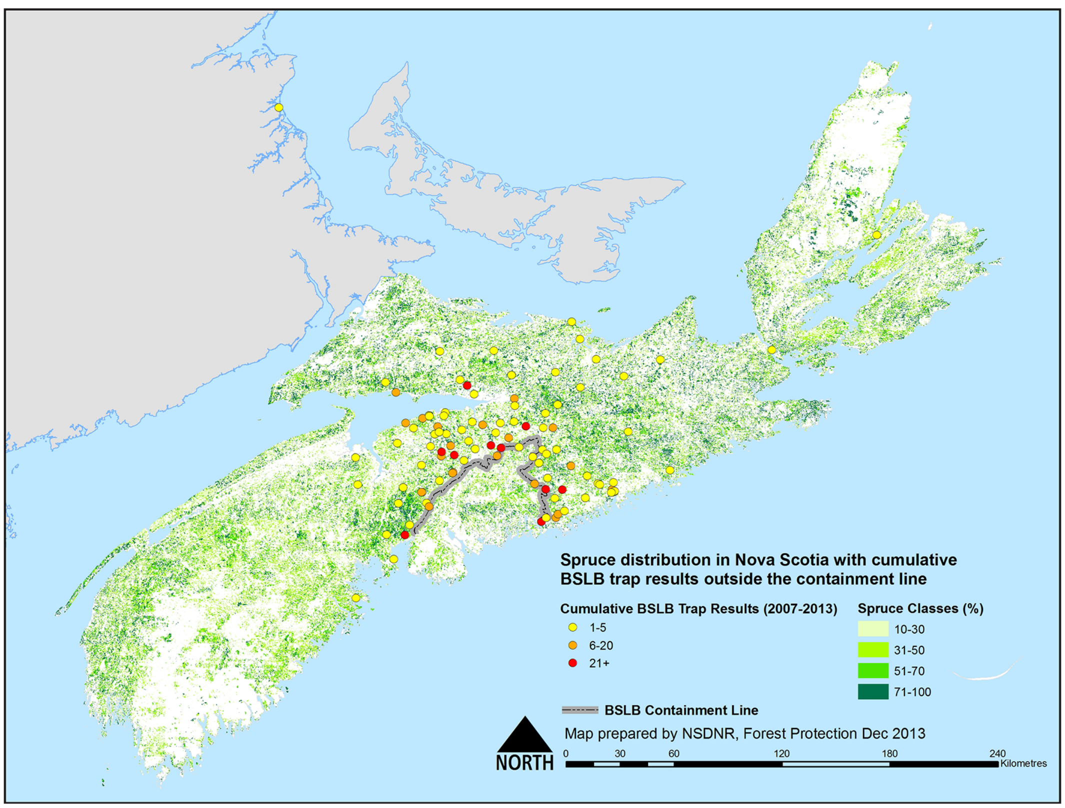

Figure 6. Spruce distribution (2012) in Nova Scotia by percentage class and cumulative BSLB trap results (2007–2013) outside the containment zone.

[1] Nova Scotia Department of Natural Resources. 2012. Forest inventory permanent sample plot. [Unpublished raw data.]

INFORMATION NEEDS

- Suitability of hybrid spruce as BSLB host species.
- Rate of colonization and mortality in the full range of natural spruce stand conditions.

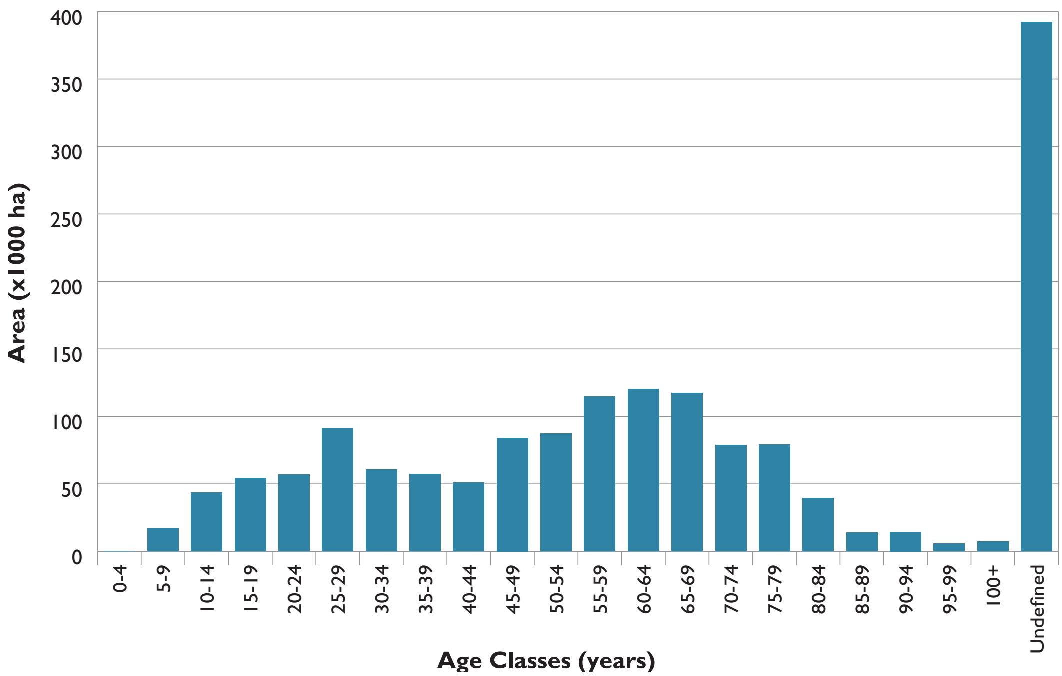

Figure 7. Age distribution, in hectares, for stands with greater or equal to 30% spruce composition.

Table 1. Stands with a spruce component: hectares and provincial percentage.

Spruce component (%)	Spruce (million ha)	Provincial forest land[2] (%)
10–100	2187	51
40–100	1319	31
70–100	419	10

Table 2. Stands with a red spruce component: hectares and provincial percentage.

Red spruce component (%)	Red spruce (million ha)	Provincial forest land (%)
10–100	1736	41
40–100	934	22
70–100	367	9

[2] Percent based on 2006 Nova Scotia Forest Land total of 4 275 000 ha. Provincial spruce component is based on latest photo-interpreted forest inventory, with all available treatment data collected from 1997 to 2011. Forest inventory is based on 1998–2008 interpreted aerial photography, updated with 1998–2006 satellite harvests and 2000–2012 treatment data.

Affirmative Statement 2:

BSLB will slowly expand its current North American range beyond Nova Scotia's borders by natural population growth and dispersal.

EVIDENCE

In Nova Scotia, the preferred host of BSLB is red spruce. However, white, black and Norway spruce are also susceptible to colonization (Sweeney & Smith 2002; Appendix A). Red spruce is widespread and functionally contiguous from the current range affected by BSLB through to the New Brunswick border (Nova Scotia Department of Natural Resources – GIS Division 2012). Nova Scotia's Forest Inventory data was examined to determine the continuity of spruce species between the positive BSLB find in Glenholme, Colchester County, and the New Brunswick border (Figure 6). Consequently, the degree to which the intervening lands would constitute a barrier to the natural spread of BSLB was determined. The examination found no barriers to BSLB dispersal.

In the 22 years since BSLB was first recorded in Halifax's Point Pleasant Park, the insect's dispersal has been slow—a range expansion of approximately 80 km over those two decades. This restricted range may be attributed to limited adult dispersal or to reproductive failures of low-density populations (Rhainds et al. 2011) and not to a lack of host material. Climatic conditions in Eastern Canada do not appear to limit the insect's survival, as demonstrated by its Eurasian distribution (Cherepanov 1990).

UNCERTAINTY

- Low uncertainty about the suitability of native spruces as BSLB hosts. Field observations and laboratory testing have quantified the host preference and reproductive success of BSLB in healthy and stressed native spruces.
- Low uncertainty about the distribution and connectivity of host material. Nova Scotia maintains a detailed and regularly updated forest inventory sufficient to locate vulnerable spruce stands.
- Moderate uncertainty about the factors required for population build-up. The degree to which the widespread windthrow and wind stress due to Hurricane Juan has contributed to BSLB colonization is still in question.
- Moderate uncertainty about the rate and direction of natural spread. Since the insect was discovered, understanding of landscape-level BSLB colonization has been clouded by changes in sampling effectiveness, effort devoted to sampling, and significant movement of wood products within the affected area. That said, the insect has spread 80 km from the point of entry in 22 years.
- Moderate uncertainty about the effect of stand structure on BSLB risk.

INFORMATION NEEDS

- Better understanding of factors affecting the rate of BSLB dispersal in the landscape.
- Tree health as influenced by growing site.
- Location of BSLB populations outside the containment area.

Affirmative Statement 3:

Artificial (i.e. human assisted) movement has contributed to the spread of the BSLB.

EVIDENCE

BSLB flight behaviour was studied in the lab using flight mills. Most beetles made many short flights or did not fly at all. While some adults flew more than 10 km in 24 hours, the mean lifetime distance flown was only 2–3 km (Sweeney et al. 2009; Jon Sweeney, NRCan, pers. comm., September 5, 2013). In field studies, flights averaged about 25 m.[3] The longest flight recorded was 800 m (Jon Sweeney, NRCan, pers. comm., September 5, 2013).

Given this slow rate of spread, any BSLB detections more than 80 km from Point Pleasant Park (i.e., outliers) are likely the result not of natural flight but of the artificial movement of infested spruce materials. Detections of BSLB in traps near parks and softwood-processing facilities are also likely to the result of the artificial movement of infested material. Woodchips and bark are considered low risk commodities in terms of moving BSLB (Allen et al. 2002; Sweeney et al. 2009), but spruce roundwood moved during the insect's flight season, April 30 to September 15, poses a much higher risk.[4]

UNCERTAINTY

- Low uncertainty about the flying abilities of BSLB and likelihood for BSLB to exhibit rapid dispersal.
- Low uncertainty about BSLB outliers being a result of artificial movement.
- Moderate uncertainty about a natural spread rate of 3–4 km per year, as this estimate is dependant on the detection of BSLB.

INFORMATION NEEDS

- Risk of BSLB being spread by artificial movement of spruce roundwood and firewood.

MAGNITUDE OF OCCURRENCE

Affirmative Statement 4:

BSLB prefers to attack stressed trees, making it predominantly a secondary pest.

EVIDENCE

In its native range, BSLB is considered a secondary pest because it primarily infests windthrow or trees living under stress from other factors such as root rots, drought, or other insects (Schimitschek

[3] BSLB Science Sub-committee. 2010. Summary of discussion of CFIA options and recommendations to slow BSLB spread. Meeting minutes, 23 March 2010. BSLB Science Subcommittee. Conference call.

[4] Sweeney, J. 2008. Relative risk of BSLB in regulated commodites, a document for discussion by the BSLB Science Subcommittee (revised March 7, 2008 after subcommittee discussions). Meeting minutes. BSLB Science Subcommittee conference call.

1929; Juutinen 1955). Although BSLB has attacked both healthy and stressed spruce trees in Nova Scotia, red spruce with reduced growth rates and low vigour or moisture stresses are more susceptible to infestations by BSLB than faster growing more vigorous trees (O'Leary et al. 2003; Flaherty et al. 2013a, 2013b). When trees are stressed, there is a reduction in the production of defensive chemicals used to resist insect infestation (Phillips & Croteau 1999).

In Nova Scotia, BSLB has colonized both apparently healthy trees and stressed and dying trees. However, Flaherty et al. (2011) showed in experiments that tree condition has a direct effect on BSLB success, influencing survival, development time and adult size. About 50% more BSLB larvae developed in stressed trees than in healthy trees. Development also took longer on healthy trees than on cut or girdled (stressed) trees. However, emerged adults were largest on healthy trees. When adult beetles were caged on red spruce trees in the spring, protecting them from natural enemies, survival was highest on girdled trees. In these experiments infested trees were then felled and lab reared. In subsequent experiments where the infested trees remained standing for at least two years, Flaherty et al. (2013a, 2013b) showed that colonization of healthy trees by BSLB was rare. Trees showing obvious signs of BSLB infestation usually die within one to five years (Canadian Food Inspection Agency 2005; Appendix A).

UNCERTAINTY

- Low uncertainty about the preference of BSLB to attack predominantly stressed trees in its native range.
- Low uncertainty about the relative reproductive success of BSLB on red spruce.
- Moderate uncertainty about the health of trees attacked by BSLB in Nova Scotia.
- Moderate uncertainty regarding the preference of BSLB for predominantly stressed trees in Nova Scotia.

INFORMATION NEEDS

- Colonization behaviour of BSLB in representative natural Nova Scotia spruce stands.
- Tree health as influenced by growing site.

Affirmative Statement 5:

Forest pest outbreaks such as spruce budworm make spruce trees more vulnerable to BSLB attack.

EVIDENCE

Forest pest outbreaks that defoliate or otherwise stress spruce trees increase the trees' vulnerability to attack by BSLB. The level of nutrients is often higher or better balanced in stressed trees, making them more suitable for insect development, survival and reproduction (Mattson & Haack 1987). Ostaff and Maclean (1989) studied the effects of an uncontrolled spruce budworm outbreak on Cape Breton Island from 1976 to 1980. During that outbreak, populations were extremely high and killed 27% of the spruce volume. Of the surviving spruce, another 39% of the volume died as a result of native spruce beetle (*Dendroctonus rufipennis*) activity. The outbreak also caused significant exposure-related stress in the affected stands. Four years after the collapse of the outbreak, 4% of the surviving trees had blown down and 60% of all trees had suffered broken tops (Ostaff & MacLean 1989).

Although spruce can generally survive moderate defoliation for a number of seasons (Erdle & MacLean 1999), where BSLB are present, the stress resulting from the defoliation is likely to enable BSLB to colonize the surviving spruce.

UNCERTAINTY

- Low uncertainty about the role of forest stresses on host suitability and the preference of BSLB for stressed or low-vigour spruce trees.
- High uncertainty about the interaction between BSLB and native insects, particularly the native spruce beetle.

INFORMATION NEEDS

- Nature of any competitive or cooperative interaction between native insects and BSLB.

Affirmative Statement 6:

Predators and parasitoids exist in BSLB populations in Nova Scotia.

EVIDENCE

Woodpeckers play a significant role in control of wood-boring pests found in North America (Lindell et al. 2008). This matches study results in Europe, where woodpeckers were found to remove 20% of the BSLB in trees that were inspected and were deemed as a significant factor limiting the propagation of BSLB (Juutinen 1955). In Nova Scotia, there is evidence of woodpecker foraging on BSLB-infested trees (Flaherty et al. 2011), but not known is how much of the BSLB population is removed by predation, or what ability predators such as woodpeckers have to limit the BSLB population. The high number of woodpecker holes observed on bolts during study by Flaherty et al. (2011) suggests that woodpeckers are also an important predator of BSLB in Nova Scotia.

According to Flaherty et al. (2011), two hymenopteran species have also been observed in parasitizing BSLB and the native larch borer: *Rhimphoctona macrocephala* (Prov.) (Hymenoptera: Ichneumonidae) and *Wroughtonia occidentalis* (Cresson) (Hymenoptera: Braconidae). The parasitism on both Tetropium species ranged from 0 to 25% for *R. macrocephala*, and from 5 to 56% for *W. occidentalis* (Sweeney et al. 2005).

UNCERTAINTY

- Low uncertainty about the presence of parasitism of, and predators feeding on, BSLB.
- High uncertainty about the ability of Nova Scotia parasitoids and predators to limit BSLB populations.

INFORMATION NEEDS

- Factors affecting predator and parasitoid foraging and survival.
- Effectiveness of predators and parasitoids in limiting the Nova Scotia BSLB population.

Affirmative Statement 7:

Activities and policies that promote an older stand structure of red spruce will increase the overall susceptibility of Nova Scotia's forest to BSLB colonization.

EVIDENCE

Under typical Nova Scotia site conditions, spruce trees decline in vigour after 80 years (MacPhee & McGrath 2006). Research indicates that BSLB prefers slower growing, less vigorous spruce trees and trees under stress (Flaherty et al. 2013a, 2013b). Parks and protected areas, as well as management based on old-growth objectives and ecological practices that support an older age class structure, will increase the proportion of spruce stands vulnerable to BSLB attack.[5]

In 2013, Nova Scotia had legislation, policy and land use planning guidelines intended to facilitate the preservation and restoration of ecological processes and to preserve or mimic natural forest succession. In June 2007, Nova Scotia made a commitment under the *Environmental Goals and Sustainable Prosperity Act* to protect at least 13% of the province's land by 2015. Through the recently released Old Forest Policy, the Province has committed to concurrently establishing and maintaining 8% of publicly owned forest land as "Old Forest" in each of Nova Scotia's 38 forested ecodistricts (Nova Scotia Department of Natural Resources 2012). With two national parks in the province (Cape Breton Highlands National Park and Kejimkujik National Park, with a combined total area of 135 300 ha), this means that a significant area in Nova Scotia will be left to grow naturally into an older age structure.

Of the common Nova Scotia spruces, red spruce is both susceptible to BSLB and specifically promoted in both the Old Forest Policy and under ecologically based forest management guidelines. Red spruce is a late successional, long-lived, shade-tolerant tree species. In a given stand, the red spruce component will self-perpetuate in the absence of large fires, damaging windstorms, or harvesting. Protected red spruce stands will, over time, normally develop a significant component of mature to over-mature trees. This is especially true for old-growth forests that, under the provincial policy, are set aside for long-term conservation, with the priority being on natural development of old-growth forest conditions (Nova Scotia Department of Natural Resources 2012).

An estimated 83 000 ha of the stands currently with protected status contain enough spruce to be vulnerable to BSLB (Figure 8). This represents an approximate spruce volume of 5940 million m^3, of which 86% is greater than 60 years of age and is at or approaching the stage when tree vigour will begin to decline (Nova Scotia Department of Natural Resources – GIS Division 2012). That 83 000 ha is equivalent to 4.7% of the total area in the province represented by stands with 30% or more spruce in the primary story (excluding black spruce).

Large areas of protected red spruce are found throughout the natural distribution of the species within the province. Given that the host species of BSLB are widespread and functionally contiguous, BSLB can spread without barriers into and out of the protected areas (Nova Scotia Department of Natural Resources – GIS Division 2012). Public opinion and policy restrictions will complicate the removal of BSLB-infested trees or stands from most areas protected under legislation or policy.

[5] For the purposes of this report, a vulnerable stand is considered to contain greater than 30% spruce in the primary story and does not include black spruce.

While BSLB populations may build up in protected areas, it is uncertain what the impact will be on adjacent forested areas. If the adjacent area consists of healthy vigorous spruce, spread will likely be slow and population build up minimal.

Under its current Natural Resource's Strategy, the Province has committed to carrying out ecosystem- based management (Nova Scotia Department of Natural Resources 2011). Forest ecosystem-based management is an approach to managing forest resources with an emphasis on maintaining successional dynamics, species diversity and representation on a landscape level. Since the presence of mature and over-mature trees is a common characteristic of red spruce stands, ecosystem-based management will seek to maintain late successional characteristics in representative proportions.

If widely adopted and consistently practised, ecosystem-based management, as currently conceived, will increase the amount of mature and over-mature red spruce within the province and consequently the amount of suitable host material for the BSLB. Management practices properly applied have been shown to mitigate the impact of BSLB-related damage. Early work in Europe by Schimitschek (1929) found that maintaining or improving biological diversity, planting spruce in appropriate sites, thinning forests and conducting general upkeep can maintain tree health and serve as a cultural control for BSLB.

UNCERTAINTY

- Low uncertainty about whether parks and protected areas contain suitable host material.
- Low uncertainty about whether BSLB can spread into and out of parks and protected areas.

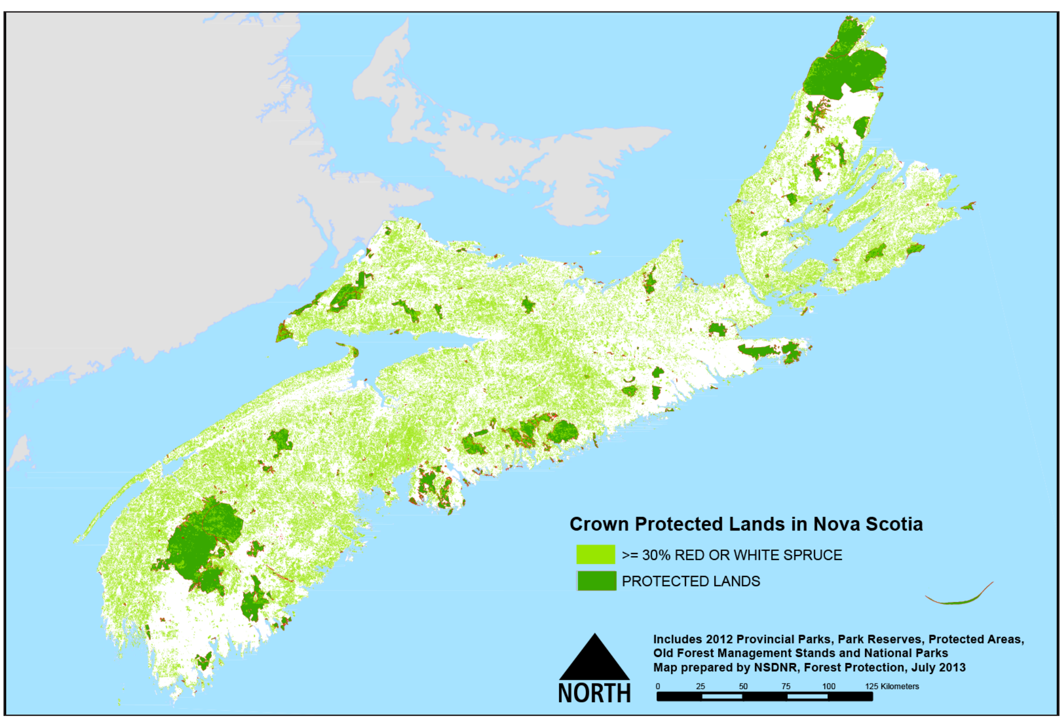

Figure 8. Proposed protected lands in Nova Scotia, current to July 2013.

- Low uncertainty that interventions such as salvage and sanitation harvesting will not occur in parks and protected areas.
- Moderate uncertainty about whether protected areas will act as epicentres from which BSLB will spread into adjacent forests.
- Moderate uncertainty about whether the stand health benefits of ecosystem-based management outweigh stand vulnerability as a result of having a mature and over-mature component.

INFORMATION NEEDS

- Clarification on policies related to sanitation harvesting within provincial and national parks and protected areas.
- Factors affecting the rate of BSLB dispersal in the landscape.
- Rate of colonization and mortality in the full range of natural spruce stand conditions.

Affirmative Statement 8:

Climate change will increase the vulnerability of Nova Scotia forests to forest pests such as the BSLB.

EVIDENCE

Climate change (in terms of drought and/or more severe storms) is expected to increase the vulnerability of Nova Scotia forests by increasing the volume of available stressed or damaged trees. Increases in BSLB host material will likely increase the beetle's population levels and, in turn, increase the probability of BSLB spread and establishment. With an increase in winter temperatures, there is also the possibility that BSLB could complete two generations per year (Hunt et al. 2006).

The fourth assessment of Eastern North America completed in 2007 by the Intergovernmental Panel on Climate Change predicts that warming will be greatest during winter (Randall et al. 2007). There is evidence that severe storm events such as winter and tropical cyclones will increase in intensity in the Atlantic region (Vasseur & Catto 2008). In Europe, BSLB has been found to infest spruce weakened by wind-caused mechanical damage (Natural Resources Canada 2012). Atlantic Canadian forests are vulnerable to large-scale windthrow because of the predominance of shallow-rooting tree species such as the spruces (Peterson 2000; Johnston et al. 2009).

If the increased storm frequency and intensity projected for Atlantic Canada is realized, more wind-stressed forest stands can be expected (Peterson 2000; Vasseur & Catto 2008). The combination of milder winters, drier summers (i.e., drought) and more storms predicted to occur will increase the vulnerability of Nova Scotia's forests to insects (Fleming & Candau 1998). The increase in available stressed trees will likely increase BSLB population levels, which in turn will in turn increase the probability of natural and artificial spread and establishment of BSLB.

Climate is a key factor affecting the frequency, intensity and duration of an insect outbreak, as well as of its geographic distribution (Harrington et al. 2001; Gray 2008). Climate change is expected to increase the risk that exotic insects and diseases will become established in Canadian forests (Williamson et al. 2009). Lemprière et al. (2008) have projected an increase in the severity, frequency and size of biotic disturbances such as insect outbreaks. They predicted the impact of climate change on biotic disturbance to be low for the near term (2011–2040), moderate for the medium term (2041–2070) and unknown for the long term (2071–2100). Insect survival and development are directly related to temperature (Johnston et al. 2009). Insect development is expected to be accelerated by increases in summer temperature, and winter mortality to decrease with warmer winter temperatures (Vasseur & Catto 2008). With an increase in temperature, there is the possibility that BSLB may complete two generations per year. Schimitschek (1929) found that in dry summers, with the average July and August temperatures at or above 20 °C, there may be two generations, with the summer generation developing within a short 122 days, depending on the availability of nutritious host material.

UNCERTAINTY

- Low uncertainty about whether the climate will change over the next half century. The consensus of the scientific community is that the atmospheric carbon levels are positively correlated to higher global temperatures and that current carbon levels will lead to a significant warming of the climate. All of the climate models indicate significant change in the climate regionally under current carbon levels, and global carbon emissions are increasing.
- Moderate uncertainty about the exact effect climate change will have on the composition and distribution of forest communities in the province and on disturbance regimes generally. Bourque et al. (2010) address changes in temperature and moisture pertaining to the requirements of select tree species in the province, but do not address how local site conditions, severe weather, or interspecific competition will influence future species distribution.
- Moderate uncertainty about the effect of climate change on BSLB populations (severity, frequency and size of the area affected by BSLB, as well as effect on the development cycle). Tree-stressing wind events are expected to increase with a warming climate. However, it is unclear how BSLB will respond to significantly warmer winter temperatures, and diapause maybe affected.
- High uncertainty about the exact rate and magnitude of climate change. Significant variation still exists between climate models.

INFORMATION NEEDS

- The potential for BSLB to build with an increase in wind-stressed trees in Nova Scotia.
- Predicted change in distribution for white spruce due to climate change.
- The effect of climate change on the Acadian forest disturbance regimes.
- Changes in BSLB behaviour and distribution due to climate change.
- The likelihood of BSLB completing two generations a year, and diapause requirements for BSLB.

Affirmative Statement 9:

Predicted changes in climate will affect the distribution of susceptible spruce in Nova Scotia.

EVIDENCE

Vegetation modelling under climate change scenarios indicate that red spruce in Nova Scotia will benefit from warmer temperatures in the short term, 2011–2040, but will decline in subsequent decades. The models also indicate that quality of black spruce habitat is currently declining and will continue to decline.

Steenberg (2010) and Bourque et al. (2010) examined the redistribution of tree species due to climate change. Steenberg looked at the distribution of tree species within the Halifax watershed close to established BSLB populations. The results predict a significant change in forest composition, with a sharp decline in the abundance of boreal species (such as balsam fir and black spruce) and an aggressive increase in some temperate and pioneer species (such as red maple and aspens). Bourque et al. (2010) studied two hosts of the BSLB, red and black spruce. That study predicts that red spruce will benefit from warmer temperatures 2011–2040 on existing sites, and then begin declining—on the order of 14–17%—in subsequent decades. Between 2041 and 2070, climatically suitable red spruce habitat is predicted to occupy 47% of Nova Scotia, with a general retreat to Cape Breton Island and the cooler areas of mainland Nova Scotia. After 2070, 20% of Nova Scotia will have climate conditions suitable for red spruce. Currently, vulnerable stands made up of greater than 30% primary story white or red spruce account for 36% of Nova Scotia's forested land base (Nova Scotia Department of Natural Resources – GIS Division 2012).

Bourque et al. (2010) also predict a decline in black spruce habitat, resulting from a mean temperature increase during all modelled time periods. In the period from 2041 to 2070, black spruce habitat deteriorates on most of the mainland, concentrates on the cooler portions of Cape Breton Island. After 2070, black spruce habitat is projected to occur in pockets along coastal areas (Bourque et al. 2010).

UNCERTAINTY

- Moderate uncertainty about the exact effect climate change will have on the distribution and health of spruce communities in the province and disturbance regimes generally. Confidence in these projections is tied to the questionable accuracy of the climate models. The models do not account for interspecific competition, insects or disease.
- Moderate uncertainty about the direct impacts of climate change on red spruce in both the short and long term.

INFORMATION NEEDS

- Correlation between current changes in climate and migration rates of tree species.
- Effect of climate change on the redistribution of white spruce in Nova Scotia.

CONSEQUENCE OF OCCURRENCE

Affirmative Statement 10:

BSLB wood supply analysis will be done in the future to understand impacts.

In the future, a model will be developed to understand wood supply impacts from BSLB. The model will be based on the current Crown Land Forest Model (CLFM), but use a modified red spruce volume curve with reductions to represent BSLB damage. Because of BSLB preference for red spruce, and the importance of red spruce to the wood supply, only the BSLB–red spruce relationship will be built into the model. To model the effect of BSLB on the wood supply, the following assumptions will be made:

- BSLB damage curves for red spruce accurately depict damage.
- BSLB will spread by zones.
- The time delay set in the model to spread BSLB to zones accurately depicts spread rate.
- Once a zone is eligible for outbreak, all stands meeting the requirements to be infested by BSLB experience reductions in volume.
- Only stands with red spruce content greater than 30% have BSLB damage.
- Only stands older than 75 years have BSLB damage

Model variables were set using field observations of BSLB as well as the spruce beetle relationship observed with white spruce. A sensitivity analysis will be conducted after the base and control model have been run. To do the sensitivity analysis, stand age eligibility, delayed time of spread, decline rate, and red spruce content required for eligibility will be altered individually to understand the impact each has on the model.

The belief is that the optimization of the treatment schedule will mitigate negative impacts on wood supply. The initial test model (without western, central and eastern zones in place) shows that over a 20-period planning horizon (100 years) and relative to the control model: total growing stock is decreased by an average of 2.63% per period; total spruce-fir harvests are decreased by 3.38% per period; and softwood harvests are decreased by 2.17% per period. Early sensitivity analysis shows that the variable with the greatest impact on the model is stand age eligibility.

INFORMATION NEEDS

- Data on age stand susceptibility, volume decline rates after infestation, required spruce content needed for infestation, and spread rates of BSLB.

Affirmative Statement 11:

BSLB has not impacted the volume of softwood exported from Nova Scotia under current domestic and international regulation.

EVIDENCE

Declines in the volume and value of softwood products exported from Nova Scotia since 2002 have been attributed to a combination of weakened export markets, increased costs of trucking and the consequential elimination of both production facilities and supply chain operators from the province's industry. No decline has been attributed to BSLB-related regulation (Appendix D).

The domestic regulations attributable to BSLB control and containment exercises are confined to the CFIA Ministerial Order, which requires movement certificates for the transportation of regulated materials in to and out of a defined containment area (representing the extent of established BSLB populations).

For the past few years, regulated materials included untreated roundwood, bark and chips. Heat treated lumber did not require a movement certificate. Recently, bark and chips were dropped from the Ministerial Order and firewood was added. The BSLB Risk Mitigation Program allowed for the movement of regulated materials from regulated to non-regulated areas in Canada under

CFIA movement certificates. However, moving regulated materials from the infested area in Nova Scotia during the high-risk period (April 30 to September 15) was prohibited, with the exception of bark that had been hogged or mulched.

In 2007, New Brunswick processors implemented a voluntary moratorium on the movement of untreated spruce logs into New Brunswick from Nova Scotia during the BSLB flight period, and expanded the moratorium to bark and chips. The CFIA then made these conditions an informal requirement for issuing movement certificates under the Ministerial Order.

In 2011, the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture issued a Federal Order on all imported firewood from Canada and spruce logs from Nova Scotia. The Federal Order was issued under the *Plant Protection Act* and deemed necessary to prevent the introduction and dissemination of BSLB into the United States. It updated and replaced the Federal Order, DA-2008-69, issued in October 2008, which had a restriction on hardwood firewood. In keeping with that newer order, all commercial and non-commercial shipments of imported firewood from Canada and spruce logs from Nova Scotia must be heat-treated. Specifically, spruce logs and wood with bark from Nova Scotia must be accompanied by a treatment certificate declaring that the logs were heat treated at 56 °C (minimal core temperature) for 30 minutes and an import permit. If the shipment lacks the heat treatment, import permit or copy of a compliance agreement there will be prohibition of entry into the United States. Spruce logs entering the United States from any other Canadian province or territory do not require heat treatment, but must have a certification of origin.

The volume of softwood exported out of the province has decreased because of market forces during the period of BSLB regulation. Very little of what has been considered regulated material (i.e., softwood roundwood and woodchips) has been exported from the province since the downturn of the forest industry after 2007. At peak harvest, around 2006, exports of BSLB-regulated material represented 14% (622 774 m^3) of all softwood harvests. As of 2012, that volume had dropped to 2% (67 190 m^3), with most of the material destined for New Brunswick. In 2011, essentially no regulated material was exported to the United States. All other exports from the province are heat-treated, kiln-dried products not subject to BSLB-related restrictions (Appendix D).

UNCERTAINTY

- Low uncertainty about the restrictions for exporting BSLB-associated spruce materials.
- Low uncertainty about the volume of softwood exported.
- Low uncertainty about the reasons for the decline in softwood exports.

INFORMATION NEEDS

- Response of other provinces and territories, as well as of the United States, to deregulation of BSLB.

Affirmative Statement 12:

The establishment of BSLB in Nova Scotia has not lowered the commodity value of spruce. It has, however, had an impact on existing production practices and additional administrative costs for landowners.

EVIDENCE

Market prices for softwood harvested within BSLB-infested stands have remained consistent with prices for softwood harvested outside the containment area (Nova Scotia Primary Forest Products Marketing Board 2010). No price penalties are levied on regulated lands because of administrative costs, wood quality concerns or otherwise (Appendix D). BSLB was not noted as an issue in the most recent summary report by the Nova Scotia Primary Forest Products Marketing Board (2010). BSLB regulations have resulted in a change to existing production practices.

In 2011, about 576 000 metric tonnes of regulated spruce material was moved from CFIA-regulated areas, made up of roundwood (63%), hogged bark (19%), woodchips (17%) and green lumber (<1%) (Appendix D). Of the roundwood, 67 190 m^3 was exported out of the province, the majority (63 663 m^3) to New Brunswick and a small amount (89 m^3) to the United States. From 2002 to 2012 it is estimated that there was a total volume of about 3294 million m^3 of regulated materials manufactured for an estimated cost of $1 million (low unit cost) to $2 million (high unit cost) to date (Appendix D). In addition, Gebremichael and Jing (2010) estimated a one-time cost of about $231 000 over 2007–2008 for equipment purchase, upgrade and training to meet compliance requirements.

Government and industry efforts to contain the spread of BSLB have necessitated additional requirements for processing, transporting and disposing of firewood, spruce roundwood, woodchips and bark. Restrictions have been set on when and where regulated material can be processed. As spruce roundwood presents the greatest risk, containing live BSLB, it must receive top priority for handling (Jon Sweeney, NRCan, pers. comm., October 18, 2012).[6]

For facilities located outside BSLB-regulated areas, regulated roundwood must, during the high-risk period (April 30 to September 15), be processed in a CFIA-approved manner within 48 hours of receipt at a CFIA-approved facility. All regulated inventory must also be segregated from other inventory: if inventory is co-mingled with regulated wood inventory, it must be processed as a regulated article before April 30. Woodchips with a size exceeding 4 cm in two of three dimensions must be processed in an approved manner within 48 hours of receipt at the CFIA-approved facility. During the low-risk period, September 15 to April 30, bark produced from the processing of regulated wood must be processed to phytosanitary standards or delivered to a CFIA approved bark processing facility by April 30. Non-regulated bark co-mingled with regulated bark is considered subject to regulation; and bark produced from regulated wood during the high-risk period should be segregated from other inventory and immediately removed and transported to a CFIA-approved bark-processing facility. Bark treated by mechanical debarking device can be stored for a period not exceeding five days (120 hours).

[6] Sweeney, J. 2008. Relative risk of BSLB in regulated commodites, a document for discussion by the BSLB Science Subcommittee (revised March 7, 2008 after subcommittee discussions). Meeting minutes. BSLB Science Subcommittee conference call.

UNCERTAINTY

- Low uncertainty about the impact of BSLB on market prices.
- Low uncertainty about the production practices changed as a result of BSLB.
- Low uncertainty about estimating the administrative costs associated with regulation compliance.

INFORMATION NEEDS

- BSLB impacts on property value.
- BSLB impacts on the different categories of wood suppliers.

Affirmative Statement 13:

BSLB will not jeopardize the existence of red spruce in our forests.

Evidence

Given that the rate and pattern of observed BSLB-related red spruce mortality resembles a gap disturbance regime that favours red spruce regeneration, red spruce will still occupy those sites to which it is most suited. BSLB should not interfere with seed production. Red spruce can produce cones at 15 years if exposed to full sunlight. Good seed crops occur every three to eight years, with light crops in intervening years. Germination and establishment proceed best under cover (Blum 1990). Red spruce requires good light for optimum growth, but can remain in dense shade for many years and respond well to the crown openings (Dumais & Prevost 2007).

BSLB is unlikely to create an environment inhospitable to seedling establishment. Red spruce competes and regenerates very successfully after gap disturbance, strip cuts and shelter wood harvests (Nova Scotia Department of Natural Resources 1994; Dumais & Prevost 2007). At a maximum assumed infestation and mortality rate of 30% over five years[7], BSLB should not prevent the successful regeneration of red spruce stands. However, clearcut salvage harvesting of BSLB-affected red spruce is likely to reduce successful regeneration of the species, as red spruce prefers shaded conditions and is sensitive to extreme temperature fluctuations. Remarkably, in the eastern portion of Nova Scotia, red spruce can successfully regenerate in clearcuts, thanks most likely to the common occurrence of fog (Dumais & Prevost 2007).

UNCERTAINTY

- Low uncertainty about knowledge of red spruce regeneration.
- Moderate uncertainty about the mortality rate of BSLB within the range of Nova Scotia red spruce.

INFORMATION NEEDS

- Rate of colonization and mortality in the full range of natural spruce stand conditions.

[7] MacKinnon et al. 2012. Brown spruce longhorn beetle impacts. Unpublished raw data.

Affirmative Statement 14:

BSLB will negatively affect Nova Scotia's old-growth red spruce forest.

EVIDENCE

BSLB has shown a preference for larger-diameter red and white spruce exhibiting low vigour. Red spruce in an old-growth condition normally exhibits low vigour, predisposing the trees to BSLB infestation.

In Nova Scotia, spruce species occupy significant ecological positions in the majority of identified ecological communities (Neily et al. 2011b). Red spruce in particular is a key species in old-growth coniferous forests across the mainland (Neily et al. 2011b). These old-growth forests were once a hallmark of the Acadian forest. However, with several centuries of land use, old growth has become rare.

In 1999, the province implemented an Interim Old Forest Policy to identify and increase the representation and protection of old-growth forests, as well as to restore old-growth forests on Crown land. Under this policy, a minimum of 8% of Crown land in each of the 40 forested ecodistricts (as defined by the Ecological Land Classification for Nova Scotia) will be set aside as old growth and old forest.

An analysis of the selected old forests indicates that Nova Scotia's existing parks and protected areas currently hold approximately 177 000 ha (Stewart & Neily, 2008b). The total area set aside under the Old Forest Policy is 216 711 ha, of which 8026 ha is "old growth" (i.e., greater than 125 years) and 101 667 ha is at the "mature old forest" stage of development (80–125 years) (Stewart & Neily 2008a, 2008b). The most common forest community selected for old-growth management is late seral spruce.

Although BSLB is unlikely to fully eliminate any of the spruces from the forest communities represented in the province, it may alter the competitive balance within the communities, changing the structure of communities—as happened in American beech-dominated forest types after the establishment of beech bark disease (Evans et al. 2005). Although the rate of BSLB colonization is slow, the observed infestation and mortality rate in affected stands, if sustained, may change the role of spruce in some ecosystems.[8]

Recognizing that old-forest habitat plays a critical role in sustaining biodiversity, researchers have predicted that BSLB infesting old-growth forests will impact biodiversity.

UNCERTAINTY

- Low uncertainty, based on Nova Scotia forest inventory and host preference, about a significant portion of Nova Scotia old growth being susceptible to BSLB.
- Low uncertainty about the role of forest stressors on host suitability.
- Low uncertainty about BSLB host preference.
- Low uncertainty about the representation of red and black spruce in current areas selected for old-growth conservation and restoration.

[8] MacKinnon et al. 2013. Brown spruce longhorn beetle impacts. Unpublished raw data.

INFORMATION NEEDS

- Rate of colonization and mortality in the full range of natural spruce stand conditions.

Affirmative Statement 15:

BSLB will change elements of biodiversity in older spruce-dominated forest communities.

EVIDENCE

Mortality caused by BSLB, if sustained, may change the structure of unmanaged red spruce stands.[9] Disturbance may range from stand-initiating events to periodic small gap effects. Via these mechanisms, BSLB has the potential to modify biodiversity in red spruce dominated stands, changing habitat by affecting aspects of stand maturity, succession, horizontal and vertical structure, deadwood, light and moisture. Plant or animal species dependent on older late seral stage conifer stands will respond, in terms of relative abundance, to changes in the quality or quantity of this forest type resulting from BSLB mortality.

BSLB mortality is unlikely to have a major effect on overall biodiversity within white spruce forest communities in Nova Scotia. White spruce often appears early in stand succession, particularly following agricultural abandonment. Widespread stand-initiating mortality due to senescence, forest pests, wind or water action normally occurs in mature stands, when individual trees are most vulnerable to BSLB (Neily et al. 2011b).

Spruces occupy a prominent ecological position in many provincially recognized vegetation communities (Neily et al. 2011b). Red spruce in particular is a key species in old-growth coniferous forests across mainland Nova Scotia, representing approximately 19% of the stands selected for management under the provincial Old Forest Policy (Neily et al. 2011a; Nova Scotia Department of Natural Resources – GIS Division 2012). In even-aged stands, local biodiversity may increase as a result of gap-induced variable structure and the associated increase in the number of niche habitats (Bruce Stewart, NSDNR, pers. comm., May 1, 2013). However, removal of mature spruce from the overstory by BSLB on a habitat-altering scale will impact specific dependent species.

The American pine marten appears to be the vertebrate species most sensitive to potential BSLB-related habitat changes. The marten requires large areas of late seral stage coniferous forests to maintain a viable population (O'Brien et al. 2006). Northern flying squirrels also prefer a similar habitat type, but are not a species of concern in Nova Scotia (Ritchie et al. 2005). Closed canopied mature coniferous stands are used by white-tailed deer for winter thermal and snow refuges (Telfor 1967; Beyer et al. 2010). Moose also use similar stands to reduce daytime heat stresses (Schwab & Pitt 1991).

Two cavity-nesting birds, the Black-backed woodpecker and the American three-toed woodpecker, are dependent on mature to old-growth coniferous forests in Nova Scotia (James 1984). The short-term availability of suitable nesting sites for these species would be expected to rise with BSLB establishment. The availability of suitable nesting sites in stands impacted by BSLB after the initial mortality event would be somewhat dependent on the severity of the disturbance. A few song

[9] MacKinnon et al. 2013. Brown spruce longhorn beetle impacts. Unpublished raw data

birds show a clear preference for mature coniferous habitats: Blackburnian warbler, Blue-headed vireo, Golden-crowned kinglet, Red crossbill, Winter wren, Olive-sided flycatcher, Swainson's thrush, and others (Crawford & Titterington 1979; Benkman 1993; Rosenberg et al. 2003; Sean Basquill, NSDNR, pers. comm., May 6, 2013). From this list, only the Olive-sided flycatcher is considered a species of regional concern (being on the US–Canada Watch List 2012 (Partners in Flight Science Committee 2012).

Dwarf rattlesnake plantain, *Goodyera repens*, is the only yellow-listed species[10] under the General Status Ranks of Wild Species in Nova Scotia, that has an association with BSLB-susceptible spruce stands (Neily et al. 2011b). Forest-dependent fungi and lichens are incompletely documented and understood (D. Boyd, Nova Scotia Agricultural College, pers. comm., May 2, 2013). However, some locally relevant studies have established that late seral stage forests have a greater diversity of calicioid lichens, including species thought to be rare (Selva 2003; Rob Cameron, Nova Scotia Department of Environment, pers. comm., April 30, 2013).

Researchers have speculated that competitive interactions may exist between BSLB and the closely related native larch borer, *Tetropium cinnamopterum*, such that BSLB may eventually replace the native beetle borer through competitive advantages. Field work carried out to explore this possibility has not produced conclusive results (Rhainds et al. 2010, 2011).

UNCERTAINTY

- Low uncertainty about importance of spruce in biotic communities currently representative of Nova Scotia.
- High uncertainty about the influence of unique site conditions on the observed infestation and mortality rates due to BSLB.
- High uncertainty about the scale and progression of impacts in vulnerable ecosystems.

INFORMATION NEEDS

- Rate of colonization and mortality in the full range of natural spruce stand conditions.
- Relationship between the mechanics of habitat change resulting from BSLB and the requirements of potentially vulnerable species.

Affirmative Statement 16:

BSLB-related tree mortality will not significantly change wildfire risk within our forests.

EVIDENCE

In Nova Scotia, red and white spruces are represented in many significant vegetation types. Red spruce is frequently associated with mid- to late successional coniferous forests on moist upland sites, often mixed with eastern white pine, balsam fir, eastern hemlock, yellow birch and sugar maple (Farrar 1999). Red spruce is typically less than 60% of the tree cover in those stands where

[10] Yellow-listed species are known to be, or believed to be, particularly sensitive to human activities or natural events.

it occurs, although nearly pure stands do occur (Neily et al. 2011b). Given the observed rate of stand level mortality typical of BSLB and the proportion of unaffected species remaining in the stand during the infestation, BSLB will not significantly change the fire behaviour of affected red spruce stands (Taylor et al. 1997; Dustin Oikle, NSDNR, pers. comm., June 21, 2013).

Compared with red spruce, white spruce is more frequently dominant in those stands where it occurs (Neily et al., 2011b), but again, given the anticipated rate of mortality and the presence of other tree species, BSLB would not dramatically change fire behaviour (Taylor et al. 1997; Dustin Oikle, NSDNR, pers. comm., June 21, 2013).

The mechanics of how insect mortality changes forest fuel characteristics are well understood. Within the stand, trees that are infested year after year will eventually die and the needles will turn red. At the red stage, trees exhibit reduced foliar moisture content which increases the volatility of ladder fuels and the probability that a fire will torch into the forest crown canopy (Hicke et al. 2012). Once trees lose their needles, the canopy becomes more open and its fuel load decreases, reducing the potential for crown fires. At that point, twigs and needles drop to the ground, adding to the surface load of fine fuels. This, in turn, will increase surface fire intensity for a few years until the needles have decomposed. Years later, the grey standing dead spruce will begin to fall, contributing to a higher surface fuel load and the corresponding surface fire intensities.

Under the most severe BSLB-associated mortality rates observed in Nova Scotia, only 6% of the white or red spruce within a stand will die within a given year.[11] Although this mortality rate will gradually change the fuel type of many spruce-dominated stands, fire hazard is not anticipated to change greatly owing to the presence of non-susceptible species within the majority of affected stands and the ongoing decomposition and regeneration processes (Taylor et al. 1997; Dustin Oikle, NSDNR, pers. comm., June 21, 2013).

It should be noted that even with stand level mortality events such as those caused by the mountain pine beetle, increased fire risk is largely dependent on extreme weather conditions (Bebi et al. 2003). Furthermore, the decomposition and regeneration rates typical of moist climates such as Nova Scotia's will reduce the persistence of surface fuel load from beetle mortality, compared with what would occur in drier climates (Stewart & Quigley 2000; Volney & Hirsch 2005; Lynch 2006).

UNCERTAINTY

- Low uncertainty about the mechanics of fire behaviour in response to spruce mortality.
- Moderate uncertainty about the rate of spruce mortality within the range of susceptible spruce stands.
- Moderate uncertainty about changes in forest fuels resulting from BSLB damage.
- Moderate uncertainty about the effect of spruce mortality on the occurrence and severity of wildfires.

INFORMATION NEEDS

- Rate of colonization and mortality in the full range of natural spruce stand conditions.

[11] MacKinnon et al. 2012. Brown spruce longhorn beetle impacts. Unpublished raw data.

Affirmative Statement 17:

BSLB spruce mortality is unlikely to have a significant impact on nature-related activities in Nova Scotia.

EVIDENCE

Because of the anticipated gradual nature of BSLB-related forest changes, BSLB is not likely to impact the non-timber revenue earned from nature-related activities in Nova Scotia. The slow rate of spread and pattern of mortality exhibited by the BSLB infestation minimizes the impact of the insect on the recreation characteristics of affected landscapes. Also, no known nature-related activity in Nova Scotia is dependent on red spruce.

In 1996, nature-related activities in Nova Scotia employed 4850 people and had an estimated value in GDP contribution of $242.3 million out of a total provincial GDP of approximately $19 billion (Environment Canada 2000). The scope of these activities includes outdoor recreation, tourism, hunting and fishing. In 2012, residents of Nova Scotia spent $973 million on nature-related activities and services, accounting for 2% of all such expenditures nationally; and 12% of residents reported that their income relied on a nature-related profession (Federal, Provincial, & Territorial Governments of Canada, 2014).

From April 2001 to March 2006, about 7600 trees showing signs and symptoms of BSLB infestation were removed from the Halifax area. Most of these trees were removed within 5 km of the epicentre, Point Pleasant Park. No socioeconomic assessment has been done concerning the impact of BSLB on public parks in the Halifax Regional Municipality. Therefore, the impact of BSLB on direct-use values such as recreation or indirect-use values such as ecosystem services is unknown. However, despite the period of infestation in Halifax County, no claims related to BSLB impacts were made to the Province.

UNCERTAINTY

- Moderate uncertainty about the impact of BSLB on nature-related activities.
- Moderate uncertainty about the value of nature-related activities. The data is from 1996 and should be updated to represent the current situation.

INFORMATION NEEDS

- Recent data on the value of non-timber economic and social benefits.
- Impact and cost of tree removal from parks and other lands used for recreation.
- Importance of red spruce for nature-related activities and socioeconomic importance.

Affirmative Statement 18:

Tree mortality due to the BSLB will not result in significant water quality or quantity impacts.

EVIDENCE

Recent applicable examples of pest-related water quality effects have focused on hemlock mortality associated with the hemlock woolly adelgid outbreak in the mid-Atlantic States (Yorks et al. 2000; Daley et al. 2007). Other studies have focused on hardwood defoliators (Eshleman et al. 1998) or on western insects impacting watersheds (but with dissimilar hydrological conditions to those of Nova Scotia (Schmid 1991). Studies conducted across North America and within the Maritimes have sought to quantify the impact of harvesting on the quality, quantity and ecology of surface water.

The primary direct consequences of forest harvesting and pest mortality within northeastern North American watersheds are increases in stream temperature, volume and nitrogen concentrations, all of which peak within three years of the disturbance and return to baseline levels within 10 years (Bormann et al. 1974; Hornbeck et al. 1986; Webb et al. 1995; Yorks et al. 2000; Bourque & Pomeroy 2001; Stanley 2003; Scott 2004). With the exception of the effects of access roads and harvester operations, the mechanisms by which harvesting and pest mortality relate to surface water are comparable. Based on the results of these studies, it seems reasonable to assume that anticipated mortality due to BSLB will not be short- or long-term effects on water quality or quantity.

Studies exploring the effects of harvesting on water quality in a New York State watershed experiencing severe atmospheric acidification deposition recorded short-term toxic aluminum concentrations following large-scale clearcutting, but not following selective harvesting (McHale et al. 2008). Thinning 28% of the basal area out of the forested buffer of a New Brunswick watershed did not cause significant change in stream temperature (Bourque & Pomeroy 2001). The same study found that harvesting 16.8–25.7% of the catchment led to a 0.3–0.7 °C increase in mean summer water temperatures and no significant changes in stream chemistry. A related New Brunswick study concluded that harvesting less than 20% of a watershed had no effect on water quality or quantity (Stanley 2003).

Similar results were found in catchments of the Pockwock water supply area within the BSLB quarantine zone (Scott 2004; Chi 2008). Generally, harvesting that removes more than 20–25% of the watershed forest cover or encroaches on riparian habitat can be expected to change water quality measurably for up to a decade depending on revegetation (Bormann et al. 1974; Teti 1998; MacDonald & Stednick 2003). Ongoing monitoring of heavily infested mature red spruce stands within suburban Halifax parks have recorded an average infestation and mortality rate of 30% basal area over five years. [12] Harvest regeneration surveys within Nova Scotia show an average 90% stocking with commercial tree species reaching more than 77 cm in height within five years of harvest (Stewart & Quigley 2000).

All the preceding evidence applies to direct mortality caused by BSLB and not to large-scale salvage of merchantable wood volume.

[12] MacKinnon et al. 2012. Brown spruce longhorn beetle impacts. Unpublished raw data.

UNCERTAINTY

- Low uncertainty about the direct impacts of BSLB-related mortality on water quality and quantity. Although comparatively few studies have looked at pest-related impacts to water quality, many studies have quantified the effect of harvesting on water quality and quantity. With the exception of the effects of access roads and harvester operations, the mechanisms by which harvesting and pest mortality relate to surface water are comparable. Local controlled experiments within the BSLB containment area have not resulted in significant water quality or quantity changes at a local forest disturbance scale more severe than anticipated with BSLB.
- Moderate uncertainty about the rate of BSLB spread and scale of spruce mortality in the forested landscape. Although preliminary BSLB population and impact monitoring indicates that BSLB spread rates and mortality are not sufficient to generate significant watershed impacts, more data is required to establish this conclusion as fact.
- Moderate uncertainty about the salvage harvest response to BSLB mortality. Although the direct impacts of BSLB on surface water are likely to be minor, large-scale salvage harvesting within a short time period would likely have significant impact if total harvest area exceeded 20–25% of individual catchments.

INFORMATION NEEDS

- Rate of colonization and mortality in the full range of natural spruce stand conditions.

Summary and Conclusions

The brown spruce longhorn beetle (BSLB), an invasive pest of spruce, has been established in Nova Scotia since at least 1990, although it was not discovered until 1999.

In Nova Scotia, BSLB attacks and kills red, white and black spruce, but red spruce is its preferred host. Susceptible host material is widespread and functionally contiguous from the current range of the BSLB to the New Brunswick border. There are no evident host-related impediments to the spread of BSLB within the province or further west. However, in the absence of artificial (i.e., human-assisted) movement, the rate of dispersal by BSLB is slow. Evidence from surveys conducted using pheromone- baited traps shows that more than 20 years after its detection, the BSLB's range has increased by only 80 km.

BSLB has attacked both apparently healthy and stressed spruce trees in the province. Manipulative field experiments by Flaherty et al. (2012a) determined that adult beetles landed more frequently, and females laid more eggs, on stressed trees than healthy trees, indicating that healthy spruce are much less likely to be attacked. These experiments also showed that BSLB can colonize healthy trees, but their survival is very low compared with that on stressed trees. Therefore, red spruce trees undergoing periods of stress or with reduced growth rates and low vigour are more susceptible to BSLB infestations than faster-growing, more vigorous trees.

Several factors could, over the short and long term, increase the stress to spruce trees, thereby increasing the volume of vulnerable host material in Nova Scotia:

- **Policies and management** – Parks, protected areas, old-growth objectives and ecologically based management that support an older age class structure will increase the proportion of spruce stands vulnerable to BSLB attack.

- **Forest pest outbreaks –** Stress resulting from insect and disease pressures (e.g., the impending spruce budworm outbreak) is likely to give BSLB an opportunity to colonize the weakened surviving spruce.
- **Climate change –** Climate change scenarios for future environmental conditions and species distribution predict that in the short term, 2011–2040, warming temperatures will benefit red spruce habitat. This, coupled with increased drought and severe storms brought about by climate change, may create a reservoir of stressed host material.

In areas where red spruce is part of the timber supply, the risk posed by this increased volume of host material could be mitigated, if not alleviated, through the continued use of sound silviculture and harvesting activities. Management practices properly applied have been shown to mitigate the impact of BSLB-related damage. Under typical Nova Scotia site conditions, spruce trees decline in vigour after 80 years (MacPhee & McGrath 2006), at which time they should be harvested, removing them from the pool of BSLB host material. Also, red spruce grows best in cool, moist climates and, under current climate conditions, is a dominant tree species on most of mainland Nova Scotia. However, the climate change scenarios proposed by Bourque et al. (2010) suggest that, over the long term (2041–2100), red spruce habitat will begin declining by roughly 14–17%, occupying only 20% of the total land base compared with the current 65%. Over the long term (100+ years), this could considerably reduce the abundance of susceptible BSLB host material.

It is projected that by 2050, the Maritime Provinces will experience a 2–4 °C increase in summer temperatures (Vasseur & Catto 2008). These predicted warming scenarios will likely increase the possibility that BSLB will be able to complete two generations per year (bivoltinism). Bivoltinism, however, will not necessarily lead to larger populations and more severe outbreaks, as success of the second generation produced late in the season may be limited because adults and eggs are not very cold-tolerant (Hunt et al. 2006).

In Nova Scotia, there is evidence of woodpecker foraging on BSLB-infested trees. However, the percentage of the BSLB population removed by predation, as well as the ability for predators such as woodpeckers to limit the BSLB population, is unknown. Two species of hymenoptera have also been observed parasitizing BSLB: *Rhimphoctona macrocephala* (Prov.) and *Wroughtonia occidentalis* (Cresson). There is high uncertainty about the ability of these parasitoids to limit BSLB populations.

The rate and pattern of observed BSLB-related mortality within red spruce stands resembles a gap disturbance regime that favours red spruce regeneration. Therefore, red spruce will still occupy those sites to which it is most suited. BSLB should not interfere with seed production and is unlikely to create an environment inhospitable to seedling establishment. At a maximum assumed infestation and mortality rate of 30% basal area over five years, [13] BSLB should not prevent the successful regeneration of red spruce stands in Nova Scotia. The existence of red spruce in Nova Scotia forests is thus not in jeopardy. BSLB mortality may also affect the structure of red spruce habitats across the landscape, resulting in potential consequences for biodiversity. However, the direct effects of this habitat change on potentially vulnerable species are not fully understood and reflect high levels of uncertainty.

No declines in the volume and value of exported softwood products or in the commodity value of spruce have been attributed to BSLB. There have, however, been increased administration costs for landowners and changes to production practices in order to deal with regulated products

[13] MacKinnon et al. 2012. Brown spruce longhorn beetle impacts. Unpublished raw data.

under the CFIA's BSLB Risk Mitigation Program. BSLB-related tree mortality will not significantly impact nature-related activities, water quality or quantity, nor will it significantly change wildfire risk.

Based on the risk assessment that characterized the risk in affirmative statements supported by evidence, BSLB is determined to pose **a low to moderate risk** to Nova Scotia. The relative possibility of BSLB occurring throughout Nova Scotia is determined to be highly likely, but the relative magnitude of the consequences seen to date for economic, social and environmental values is low. For each affirmative statement, the level of uncertainty and the information needs were identified. Moderate to high uncertainties and information needs increased the risk of BSLB from a strictly low rating to a low to moderate rating.

Important to remember is that a pest risk analysis is a living document. Knowledge about ecological, economic and scientific impacts may be revised as new information is gathered.

Recommendations

Given the outcomes of this risk analysis and their implications for ongoing management of BSLB, the following strategies and tactics are recommended to mitigate the beetle's impacts:

- **Movement of spruce wood products, logs and firewood should continue to be controlled to help prevent the artificial spread of BSLB.**

  BSLB is capable of dispersing both naturally and through the artificial movement of infested spruce wood products. Attempts to eradicate the beetle were discontinued in 2006, although the beetle is still under regulatory control. Regulations combined with non-regulatory control options are essential to the development of a comprehensive management program to reduce the risk of spread.

  Controlling the movement of spruce wood products—logs and firewood—is required to help prevent the artificial spread of BSLB from areas where it is now to currently non-infested areas in Nova Scotia. Such control can be achieved by several measures, such as by: using best management practices; implementing an aggressive "Don't Move Firewood" campaign; educating private woodlot owners and contractors; and encouraging industry to be accountable during the BSLB flight season.

- **The BSLB population in Nova Scotia should be accurately delineated in order to help slow its spread.**

  Accurate delineation of the BSLB population in Nova Scotia is critical to slowing its spread. This can be accomplished through ground surveys using traps baited with pheromone and host volatiles. The more accurately that the leading edge of the infestation can be determined, the more accurately that control measures can be targeted (Sweeney 2008).

- **Direct control methods should be used to suppress BSLB populations and slow their spread along the leading edge.**

  Direct control methods are needed to suppress populations and slow the spread along the leading edge (Sweeney et al. 2011). Currently, various methods are available in the testing and development stages, such as:

» **Mating disruption –** A forest stand is treated with enough sex pheromone to confuse the beetles or desensitize their response to the natural pheromone, resulting in very few males and females finding each other. This results in reduced mating, egg laying and infestation. This work is carried out by aerial application of pheromone-embedded flakes along the infestation's leading edge or in outlying pockets of BSLB infestation (Silk et al. 2008).

» **Mass trapping –** Large numbers of pheromone-baited traps are set out in an attempt to capture sufficient numbers of a species so that the population is suppressed (i.e., "trapped out") in that specific area (Sweeney et al. 2011).

» **Auto-dissemination with pathogenic fungi –** Pathogenic fungi attract BSLB males and females to a trap baited with pheromone and host volatiles. The trap is fitted with a chamber containing spores of a native fungal pathogen, from which contaminated beetles can escape and transmit the pathogen to other BSLB, thereby suppressing the population (Sweeney et al. 2012).

» **Tree stem-injection with TreeAzin®** – Systemic injections of TreeAzin® have been shown to effectively control invasive wood-boring insects such as the emerald ash borer (Mckenzie et al. 2010; BioForest Technologies Inc. 2011; Grimalt et al. 2011). Studies are ongoing to determine if it has similar potential to control the BSLB (Sweeney et al. 2012).

Because these control methods are in research and development stages, no specific recommendations can be made here about their feasibility and use until cost-benefit analyses have been completed. Continued testing and analysis of these direct control measures for BSLB are therefore strongly encouraged.

- **Best management practices, including those for silviculture and harvesting activities, should be promoted among private landowners, contractors and others who harvest wood products in order to maintain a healthy forest and so help slow BSLB spread.**

Maintaining a healthy forest through proper silviculture and harvesting activities is an important step to slowing the spread of BSLB. The Nova Scotia Department of Natural Resources, together with the CFS-NRCan, the CFIA, and the Nova Scotia Association of Woodlot Owners, has developed a "Best Management Practices" pamphlet with the aim of increasing landowner awareness of BSLB and its signs and symptoms. These best management practices include: removing at-risk trees (e.g., blowdown, those with broken tops, weakened/unhealthy trees) from areas where BSLB is known to occur; harvesting infested trees that show signs and symptoms of BSLB; and processing logs during late fall/early winter to help reduce the risk of spread.

Removing at-risk trees should include only spruce species in areas where BSLB is known to occur; and diligence is required to ensure that Wildlife Habitat and Watercourse Protection Regulations regarding "legacy clumps" are being followed (Province of Nova Scotia 2011).

- **Support for continued research and monitoring should be provided.**

Continued research and monitoring should be supported because information gained from these activities is essential to increasing the understanding of BSLB in a novel habitat and to developing effective management strategies. Also, as new scientific information becomes available, it should be used to validate and revise the pest risk analysis, filling knowledge gaps and reducing uncertainty.

Specifically, further research is needed to determine the effects of:

Competitive or cooperative interactions between BSLB, native bark beetles and native *Tetropium*

Research should be conducted to determine the nature and effects of the interactions between BSLB, native bark beetles and native *Tetropium*.

Native biological control agents on *Tetropium fuscum* in Nova Scotia

Research should be conducted to investigate:

- » the factors affecting predator and parasitoid foraging and survival;
- » the ability and effectiveness of native predators and parasitoids in locating and using BSLB as a host; and
- » the effectiveness of native predators and parasitoids in limiting the BSLB population.

Host suitability and/or vulnerability

Research should be conducted to determine:

- » the suitability of hybrid spruce as a host for BSLB;
- » growing site influences on tree health, to assess whether a tree is healthy or stressed; and
- » the rate of BSLB colonization and mortality in the full range of natural spruce stand conditions.

Climate change on host species and BSLB

Research should be conducted to investigate:

- » the correlation between current changes in climate and BSLB host distribution and migration rates;
- » the effects of climate change on BSLB biology and distribution;
- » the effects of climate change on the distribution of spruce species; and
- » the effects of climate change on disturbance regimes of the Acadian forest.

BSLB on non-commercial forest values

Research should be conducted to determine:

- » BSLB impacts on property value;
- » BSLB impacts on the different categories of wood suppliers;
- » the value of non-timber economic and social benefits;
- » the impact and cost of tree removal from parks and other lands used for recreation;
- » the importance of red spruce for nature-related activities and in terms of socioeconomic value; and
- » the mechanics of BSLB-related habitat change and how these changes could impact other potentially vulnerable species.

Further information is also needed on:

BSLB ecology and population dynamics

- » the factors affecting the rate of BSLB dispersal in the landscape;
- » the location of BSLB populations outside the containment area; and

» the risk of BSLB being spread through the movement of spruce roundwood and firewood.

Regulation and management policies

» the response of other provinces and territories, and of the United States, on deregulation of BSLB; and

» clarification on policies related to sanitation harvesting within provincial and national parks and protected areas.

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APPENDIX A. *Knowledge Synthesis Workshop, Fredericton, NB, September 6, 2012*

NFPS RISK ANALYSIS FOR BSLB IN NOVA SCOTIA

PARTICIPANTS

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John Ross – Nova Scotia Department of Natural Resources
Ralph Simpson – Canadian Forest Service, Fredericton
Jon Sweeney – Canadian Forest Service, Fredericton

FACILITATOR

Kevin Porter – Canadian Forest Service, Fredericton

NOTES

Ralph Simpson – Canadian Forest Service, Fredericton

CONTEXT

The purpose of this workshop was to inform the development of a risk analysis for BSLB in Nova Scotia by identifying what science is already known about the BSLB as it relates to the risk analysis objectives. During this workshop, available evidence to support the knowledge, any knowledge gaps, as well as any uncertainties were all identified. A discussion was led by selected statements that examined whether the statement was true, what evidence was available to support or refute the statement and the uncertainty or knowledge gaps associated with the statement. Participants included professionals from the Canadian Forest Service, University of New Brunswick, Canadian Food Inspection Agency, New Brunswick Department of Natural Resources and Nova Scotia Department of Natural Resources.

STATEMENTS AND DISCUSSION

STATEMENT 1:

All stands with red, white and/or black spruce are susceptible to BSLB attack.

Notes

- more or less true with respect to attack and susceptibility
- not true with respect to establishment
- true when defined as laying eggs
- depends on definition of attack
- colonization is defined as egg laying and maturing to adult stage
- young stands are not susceptible (age or size factor)
- are there NS stands that are 100% healthy
- attack versus colonization definition
- once a tree is colonized it will die within 5 years
- exit holes equals tree death (colonization)
- >9 cm DBH, stress leads to susceptibility

Amended Statement

All stands with red, white, black, or Norway spruce over 9 cm DBH are susceptible to BSLB colonization.

Notes

- amended statement is false
  - » susceptibility depends on the level of tree health and vigour (uncertainty low, Flaherty 2012) and BSLB attack density (uncertainty medium, Flaherty et al. unpublished)
- healthy, vigorous spruce stands are not susceptible to BSLB colonization
- growth rate may play a role in attack or colonization
- **uncertainty** of this statement is low
- bS shows less infestation
- bS & rS hybridize to confound the issue
- susceptibility rS > wS & nS > bS
- not sure about susceptibility, it may be influenced by host prevalence
- stress increases susceptibility

Evidence

Flaherty, L., Régnière, J., and Sweeney, J. 2012. Number of instars and sexual dimorphism of *Tetropium fuscum* (Coleoptera: Cerambycidae) larvae determined by maximum-likelihood. The Canadian Entomologist (in press).

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STATEMENT 2:

BSLB always kills trees that it attacks.

Notes

- false
  - we have direct evidence of cases in which BSLB has attacked a spruce, i.e., laid eggs on = attempted to colonize, and has been unsuccessful
  - once it has successfully colonized a tree, the tree is re-infested year after year, and also becomes susceptible to colonization by other insects, weakening and dying in 1–5 years (Juutinen 1955)
  - if attack is defined as egg lay the statement is false
  - if attack is defined as colonizes then the statement is "truer" but a better statement would be: "Trees colonized by BSLB die in 1-5 years"
- attack versus colonization, colonization = egg to adult
- BSLB colonized trees will eventually die within 1–5 years
- other pests and disease could move in
- which trees came first, and how does this affect the BSLB attack
- lethal versus sub-lethal stresses i.e. how much stress does it take to attract BSLB
- other pests and disease come into play somewhere along the line
- **uncertainty** is low to moderate

Evidence

Flaherty, L., J. Régnière, and J. Sweeney. 2012. Number of instars and sexual dimorphism of *Tetropium fuscum* (Coleoptera: Cerambycidae) larvae determined by maximum-likelihood. The Canadian Entomologist (in press).

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STATEMENT 3:

BSLB is spreading toward the NB border and will soon become established in that province.

Notes

- define soon
- soon versus eventually
- it is probably already in NB
  - » it can take many years between the establishment of any insect pest and its actual detection
  - » actual BSLB museum specimens date back to 1990; therefore it was very likely present in Point Pleasant Park even before that, as it is highly improbable the beetle was collected in entomological surveys the exact first year it arrived in Halifax
  - » given the distribution of positives in central Nova Scotia, length of time it has been in Nova Scotia, the limitations with ANY insect detection tools, the impossibilities of limited resources to monitor an almost infinite number of forest stands, BSLB is very likely already established at undetectable trace population levels over much of central Nova Scotia and probably in some parts of New Brunswick
- changes in regulation policy, fibre movement and mill closures will slow spread
- natural spread statement is true but slower than with anthropomorphic spread considered (uncertainty is Low with natural spread)
- we can slow spread but not stop it
- **uncertainty** is low for this statement especially if a regulated zone expansion around the BSLB infested area (Halifax, Hants, Colchester) does not happen
- even though natural spread appears slow, logs infested with BSLB will likely be moved

Amended statement

BSLB is spreading toward NB border and will become established in 30 years.

Notes

- **uncertainty** is moderate

STATEMENT 4:

The degree of connectivity of susceptible spruce stands in Nova Scotia does not appear to be a constraint for BSLB population growth and spread.

Notes

- true, based on the forest inventory for Nova Scotia
- connectivity of infested area versus un-infested area, i.e. the rest of the province
- **uncertainty** is low

Evidence

NS forest inventory - Sweeney unpublished flight data

Sweeney, J, P. Silk, K. Porter, W. MacKay, W. MacKinnon, E. Kettela, J. Wu, J. Price, S. Sopow, and R. Murphy. Risk mitigation, risk analysis, flight behavior, natural control and pheromones of the brown spruce longhorn beetle (Abstract online). pp. 200–203 *in*: Proceedings of the Forest Pest Management Forum, 4–6 December 2007, Ottawa, ON.

STATEMENT 5:

Forest pest outbreaks (e.g., the spruce budworm) and other stressors make spruce trees in NS more susceptible to BSLB attack.

Notes

- true of any wood borer
- true based on Sweeney Flaherty research
- **uncertainty** is low

Amended statement

Any disturbance event that reduces the vigour or radial growth rate of spruce trees, stand or forests (such as a spruce budworm outbreak, root damage from wind storms) will increase susceptibility to BSLB attack, colonization, and premature mortality.

STATEMENT 6:

BSLB causes higher rate of spruce mortality than native wood-boring beetles in NS.

Notes

- false
- this might be true compared to *T. cinnamopterum*

- you get mortality from spruce bark beetle
- question about insect differentiation
  - other than at specific research sites, BSLB mortality is not currently being monitored
- anecdotally there are sites where both BSLB and SBB have been found affecting trees (Bedford, Fall River, St. Margaret's Bay)
  - in areas such as these how much of the morality is BSLB versus SBB
- difficult to compare the two pests: mortality caused by BSLB may be mistakenly attributed to spruce beetle – uncertainty around this
- bark and wood boring beetles
- rS versus wS (bark beetle)
- **uncertainty** is low for BSLB and rS
- **uncertainty** is low for wS and spruce bark beetle
- this is a knowledge gap and analysis is needed
- is BSLB a larger problem than spruce bark beetle in Nova Scotia
- rate of movement, # of trees dying versus # of trees attacked
- duration would have to be considered
- which insect is most detrimental to spruce in Nova Scotia
- this was certainly true for red spruce in Point Pleasant Park, Hemlock Ravine and other areas of older mature red spruce in and around Halifax
  - there was very little evidence of infestation and mortality of red spruce due to either the spruce bark beetle or *T. cinnamopterum* in these areas
  - however, spruce bark beetle was quite common in white spruce on McNabs Island and other areas and spruce beetle definitely infests more white spruce in Nova Scotia than does BSLB
  - however, spruce beetle is also present throughout Nova Scotia whereas BSLB's known distribution is much smaller

STATEMENT 7:

BSLB have a preference for red spruce greater than 10 cm, and therefore parks and protected areas are optimal breeding grounds for the BSLB. *(Limited time –skipped this statement)*

STATEMENT 8:

Climate change will cause increased stress on our forests and in turn increase susceptibility to BSLB attacks.

Notes

- true
- increase stress of spruce will certainly increase susceptibility to BSLB, but there is less certainty on how climate change will cause stress in spruce

- » if climate change results in greater frequency of disturbance events such as windstorms, hurricanes, then yes
- in the long term, rS may be better able to handle extreme weather events
- **uncertainty** is high

STATEMENT 9:

BSLB has shown more potential for damage in Canada than demonstrated in its native habitat where it is a secondary pest. *(Limited time – skipped this statement)*

STATEMENT 10:

BSLB is not having a significant impact on the forest industry in Nova Scotia. *(Limited time – skipped this statement)*

STATEMENT 11:

Regulatory measures have had a non-significant impact on the forest industry in Nova Scotia.

Notes

- Industry thinks there are significant impacts
  - » if you make the containment areas too large, a mill could not handle the amount of trees produced
  - » they only have 48 hours to process the cut logs
- NS produces heat treated lumber
- compliant mills have separate piles for BSLB and other logs
- indications from the industry to the CFIA are that the regulatory measures have had a significant cost impact to the forest industry
- **knowledge gap –** data on fibre flow with or without regulation
- **uncertainty** is medium
- extra effort and perhaps limited wood supply to specific mills
- change in the competitiveness between mills
- the way regulatory measures are currently applied makes the impacts more significant on the forest industry then necessary
  - » a larger regulated area that represented the actual distribution of BSLB would reduce and in many cases eliminate impacts on industry

STATEMENT 12:

The regulatory control measures being undertaken in NS are ineffective in slowing the spread of BSLB.

Notes

- false
- would be more effective if the regulatory area were larger
- assumption – BSLB movement via industrial fibre flow occurs (raw fibre)
- evidence – does not stop spread
- **uncertainty** is moderate

STATEMENT 13:

Movement of firewood outside of a local area increases the likelihood of BSLB spreading into new areas. *(Limited time – skipped this statement.)*

STATEMENT 14:

Firewood is less significant as a spread pathway than spruce roundwood movement.

Notes

- true based on the amount of roundwood
- **uncertainty** is low to medium
- **knowledge gap -** no data on fire wood flow
- data from NSDNR's own report "Registry of Buyers of Primary Forest Products FOR 2011-6" [http://novascotia.ca/natr/forestry/registry/annual/2011/2010AnnualReport.pdf http://novascotia.ca/natr/forestry/registry/annual/2011/2010AnnualReport.pdf]
- contains data on volumes of annual harvest in NS to sawmills versus firewood
  - » these data indicate the annual harvest of softwood that flows to sawmills is >1000 times greater than that sold as firewood
  - » movement of firewood to parks and campgrounds by campers would add to this, but a recent survey by Parks Canada in 2012 suggests the proportion of campers that bring their own firewood is low – only 1% of campers admitted to bringing their own firewood to Kouchibouguac Park in 2012; 99% of those who admitted having firewood readily gave it up in exchange for free firewood provided by the Park

STATEMENT 15:

The loss of red and other spruce trees from BSLB attack has a significant impact on:

Notes

- biodiversity and other ecosystem services in Nova Scotia
  - do not know ,uncertainty is low
- fire risk
  - true – uncertainty is low (magnitude is uncertain)
- other socioeconomic characteristics
  - do not know, gap in knowledge
- urban communities
- **uncertainty** is low

Amended Statement

The loss of red and other spruce trees from BSLB attack can have a significant impact on: …

STATEMENT 16:

In Canada, BSLB is a primary pest and it attacks healthy trees. *(Limited time – skipped statement.)*

STATEMENT 17:

Stand structure has no effect on BSLB risk; spruce trees in different stand types are at risk equally.

Notes

- false
- there is evidence, the tree diameter influences the probability of colonization
- clearcuts are more likely to predispose a stand to BSLB attack (Schimitschek)
- **knowledge gap –** data on tree health as influenced by the growing site
- **uncertainty** is medium
- higher spruce concentration in a stand will affect susceptibility
- factors that increase stress will increase risk

Evidence

Schimitschek, E. 1929. *Tetropium gabrieli* Weise und *Tetropium fuscum* F. Ein Betrag zu ihrer Lebensgeschichte und Lebensgemeinschaft. Zeitschrift für Angewandte Entomologie 15(2):229–334.

STATEMENT 18:

It is feasible to slow the spread of the BSLB.

Notes

- true
- regulatory controls have an impact
- natural spread is very slow
- there is potential for non-regulatory control options
- **uncertainty** is moderate
- **knowledge gap** – where are the BSLB populations on the leading edge
- trap density has a negative effect on insect population

STATEMENT 19:

Certain silvicultural activities (e.g., partial or clearcuts) allow BSLB to establish more quickly.

Notes

- true in the case of selecting for rS
- thinned stands may be more susceptible
- damaged trees are more susceptible, silvicultural activities that increase tree health may have reduced susceptibility (Schimitschek discusses this)
- removing infested trees will decrease susceptibility of remaining host
- **uncertainty** is dependent upon the effect of the silvicultural treatment on the health of the host

Evidence

O'Leary, K., Hurley, J.E., MacKay, A.W., and Sweeney, J. 2003. Radial Growth Rate and Susceptibility of *Picea rubens* Sarg. to *Tetropium* fuscum (Fabr.). Proceedings: ecology, survey and management of forest insects. M. L. McManus A. M. Liebhold Proceedings ecology, survey and management of forest insects 2003. 107–114. U.S. Department of Agriculture, Forest Service Newtown Square

STATEMENT 20:

Nova Scotia currently has an ecological restoration policy that includes planting more red and other spruces. Given the risks associated with BSLB, this is not an effective policy. (Limited time – skipped statement)

STATEMENT 21:

BSLB is largely unaffected by parasites and predators in Nova Scotia.

Notes

- false
- **uncertainty** is low
- parasitoid preference to BSLB
- the significance of this risk factor will likely change as it often does with these biological systems
- **knowledge gap** – is there preference for *T. fuscum* by these 2 parasitoids

Evidence

Flaherty, L., J.D. Sweeney, D. Pureswaran, and D.T. Quiring. 2011. Influence of host tree condition on the performance of *Tetropium fuscum* (Coleoptera: Cerambycidae). Environmental Entomology 40: 1200–1209.

STATEMENT 22:

Can the BSLB be managed in a similar manner as the spruce bark beetles (i.e., treat it in the same way as a native insect?) (Lester Hartling)

Notes

- if the insect is defined as an invasive quarantine pest, then it has to be regulated
- survey and be conservative, remove diseased trees and monitor area
- look at rS distribution in North America and compare it to where the BSLB is currently
  - » it provides great opportunity to study the spread
  - » it is slowly moving and is a good case study because it is slow moving
- the probability of healthy trees being attacked is significantly lower than a stressed tree being attacked
  - » performance is poor in healthy trees that remain healthy
  - » if BSLB does not have a choice, they will lay eggs on healthy trees
  - » if the trees remain healthy, the BSLB does not do as well; but if the trees become stressed, they do better
- healthy trees can be taken out by BSLB, but it is mainly a secondary attacker

APPENDIX B. *August/September 2012 issue of The Insectary Notes*

http://www.novascotia.ca/natr/forestprotection/foresthealth/insect-notes/AugSep2012.pdf

PROVINCIAL FOREST ENTOMOLOGIST'S OVERVIEW ....WHAT'S THE BUZZZ?

Tanya Borgal

Staff from the Department of Natural Resources' (DNR) Forest Protection branch attended a National Forest Pest Strategy (NFPS) technology transfer workshop in the spring. The workshop introduced a risk analysis framework to address forest pest management needs across Canada.

To date, there have been three case studies to help better understand and implement the risk analysis framework: the mountain pine beetle in Alberta; sudden oak death in Ontario; and the spruce budworm in Quebec.

DNR is taking the lead to apply this risk analysis framework to the brown spruce longhorn beetle (BSLB); an invasive insect that was found in Point Pleasant Park in 1999. The analysis, an initiative under the NFPS, is expected to enhance our understanding of the risk associated with BSLB, and will be completed by March 2013. Throughout this process we will identify the critical factors that determine risk related to BSLB, characterize risk utilizing evidence, and address any knowledge gaps and uncertainties there may be. Conducting a risk analysis is very beneficial because it will quantify the risk related to BSLB as well as promote collaboration and transparency which is in alignment with the key values embraced in the Department's Natural Resources Strategy. Keep an eye out for the Insectary Notes in March/April 2013 to see the results of our risk analysis.

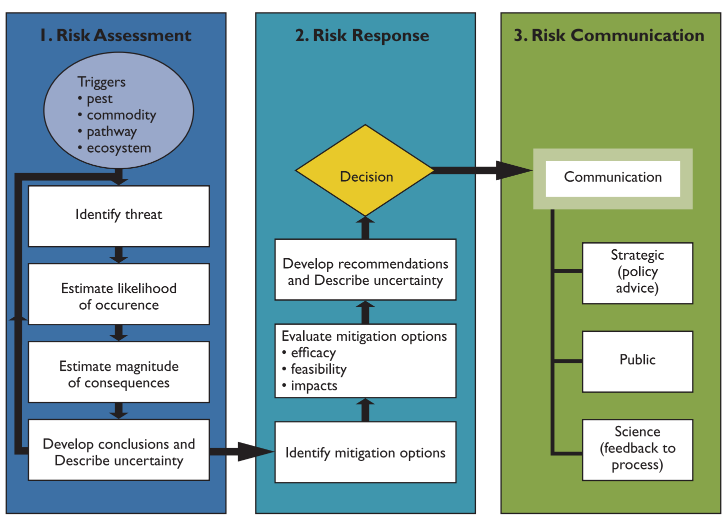

Fig. 1 The National Forest Pest Strategy Risk Analysis Framework showing the 3 pillars to a risk analysis. (Canadian Council of Forest Ministers - Forest Pest Working Group)

APPENDIX C. *Merchantable Volume Assessment of Red Spruce in Nova Scotia*

Table C-1. Estimated area and volume of red spruce in Nova Scotia, by age class.

Stand age classes (yr)	Red spruce (ha)	Merchantable red spruce (m^3)	Working forest red spruce (ha)	Working forest red spruce (%)	Working forest merchantable red spruce (m^3)	Working forest merchantable red spruce (%)	Protected red spruce stands (ha)	Protected red spruce stands (%)	Merchantable protected red spruce (m^3)	Merchantable protected red spruce (%)
0–39	517 000	1 308 000	512 000	99	1 286 000	98	5 000	1	22 000	2
40–59	560 000	16 869 000	531 000	95	16 068 000	95	29 000	5	801 000	5
60–79	509 000	30 839 000	471 000	93	28 590 000	93	38 000	7	2 249 000	7
80+	598 000	27 935 000	562 000	94	25 797 000	92	36 000	6	2 138 000	8
All	2 184 000	76 951 000	2 076 000	95	71 741 000	93	108 000	5	5 210 000	7

Table C-2. Estimated road-side value of red spruce in Nova Scotia, greater than 9 cm diameter at breast height (DBH).

Product in working forest	Total merchantable red spruce (m^3)	Merchantable red spruce minus 8% waste (m^3)	Merchantable red spruce minus 8% waste (t)	Pulp/ lumber prices ($/t)	Revenue ($)
Pulpwood (9–16 cm)	46 039 000	42 356 000	36 299 092	35	1 270 468 220
Stud wood-lumber (17 cm+)	25 435 000	23 400 000	20 053 800	67	1 343 604 600
Currently BSLB vulnerable (10 cm+)	71 464 000	65 747 000	56 345 179		2 614 072 820

Notes

- Regeneration is not species differentiated until 5 m height. At Land Classification 5, unmanaged red spruce is estimated to be 11 years old and 10 cm diameter at 5 m. Therefore, red spruce is largely not captured in regenerating stands.
- Volumes are based on solid cubic metres.
- Pulpwood lumber size breakpoint was derived from the minimum diameter product specification compiled from the major Nova Scotia wood purchases by HC Haynes Inc. for July 2012.

APENDIX D

FINAL REPORT

Impact of the Brown Spruce Longhorn Beetle on the Forest Industry within Nova Scotia

Submitted to:
Department of Natural Resources

Submitted by:
Gardner Pinfold

February 18, 2013

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I Overview

1. Introduction

The Brown Spruce Longhorn Beetle (*Tetropium fuscum, BSLB*) is a pest originating from Europe, most likely introduced into Canada through the importation of infested wood packaging materials. BSLB was first observed attacking spruce trees in Point Pleasant Park, Halifax, Nova Scotia, in 1999, although it is believed that BSLB arrived in about 1990.[1]

It has been determined that the BSLB is responsible for killing apparently healthy spruce trees, and the Nova Scotia Department of Natural Resources (NSDNR) has worked closely with the Canadian Food Inspection Agency (CFIA) since 2000 to implement an eradication and "slow the spread" program in Halifax-Dartmouth comprised of pest detection, surveillance, infested tree removal, enforcement, public awareness and the establishment of a scientific research program. Spruce (*Picea spp*.), in particular red spruce, is the preferred host tree species for BSLB attack. However, BSLB attack can also affect the ecological relationships between its preferred host (spruce) and other tree species, or other organisms that rely on these trees. [2]

The NSDNR is now taking the lead on applying the National Forest Pest Strategy (NFPS) risk analysis framework to BSLB. With this framework, the overall risk of the brown spruce longhorn beetle (BSLB) will be assessed, examining the likelihood of BSLB establishment throughout Nova Scotia as well as the magnitude of consequences of BSLB establishment. From this process, mitigation options will be identified and evaluated.

2. Study Goals and Objectives

The aim of this study is to assess the impact BSLB has had, and will have on the Nova Scotia forest industry if the regulations were to change in the province. Impacts must be determined with respect to the forest industry as well as landowners including: Federal crown, Provincial crown, industrial private, and small private (urban and rural). More specifically, three areas of impact should be examined:

- Additional costs ($) incurred to manage BSLB;
- Fiberflow and ability to move products based on the regulations and restrictions (current regulations, as well as 3 other scenarios: province deregulated, whole province regulated or the central region only regulated); and
- Domestic and international trade implications.

[1] CFIA, 2005. Plant health risk assessment: Brown Spruce Longhorn Beetle Pest Risk Assessment. Science Advice and Intelligence Division Plant Health Risk Assessment Unit, Ottawa, Ontario, p. 2; Smith G, Hurley, JE (2000) First North American record of the Palearctic species Tetropium fuscum (Fabricius) (Coleoptera: Cerambycidae) The Coleopterists Bulletin 54(4):540–540.

[2] Ibid, p.4.

II Context and Approach

1. Context

In order to address the questions posed for this study, it is important to briefly describe the forest industry and the status of BSLB. Both are complex and changing therefore selection of management response options must go beyond assessment at a point in time and consider dynamics over longer periods.

Forest industry

Forested lands represent about 77% of the primary land base in Nova Scotia, and about 66% of this land base is available for harvesting. The area of available lands are divided according to land tenure: small private 51%, provincial crown 28%, (almost 35% now with recent industrial land purchases) large industrial 18% (now 10–12%), and federal crown 3%. The forest resource is about 50% softwood, 25% mixed-wood, 10% hardwood, and 15% recently cut and now regenerating. The Province estimates the total standing volume of merchantable timber at just over 400 million m^3. In recent years the large industrial portion has reduced as the provincial crown portion increased. This is due to land-purchasing associated with mill closures as the Province moves toward it's goal of protecting 12% of lands in the province.

Woodland owners The starting point for understanding potential impacts is the small private woodland owners, which tend to be the most resistant to downward pressure on product prices (BSLB induced or otherwise). Industry representatives have indicated in the past that most woodlot owners in Nova Scotia do not rely on their woodlots as a primary source of income. They sell when they need money for some specific need, or if approached with an attractive offer by a buyer or contractor. For this reason, if prices fall below a certain level, owners are simply not interested in selling and will wait until prices rise. This tends to place a floor on the stumpage rate since for management or cost reasons, mills may be unable or unwilling to obtain what they need from Crown land and their own lands. The Crown must set stumpage rates according to prices on private lands, in order to avoid countervails on exports to the U.S.

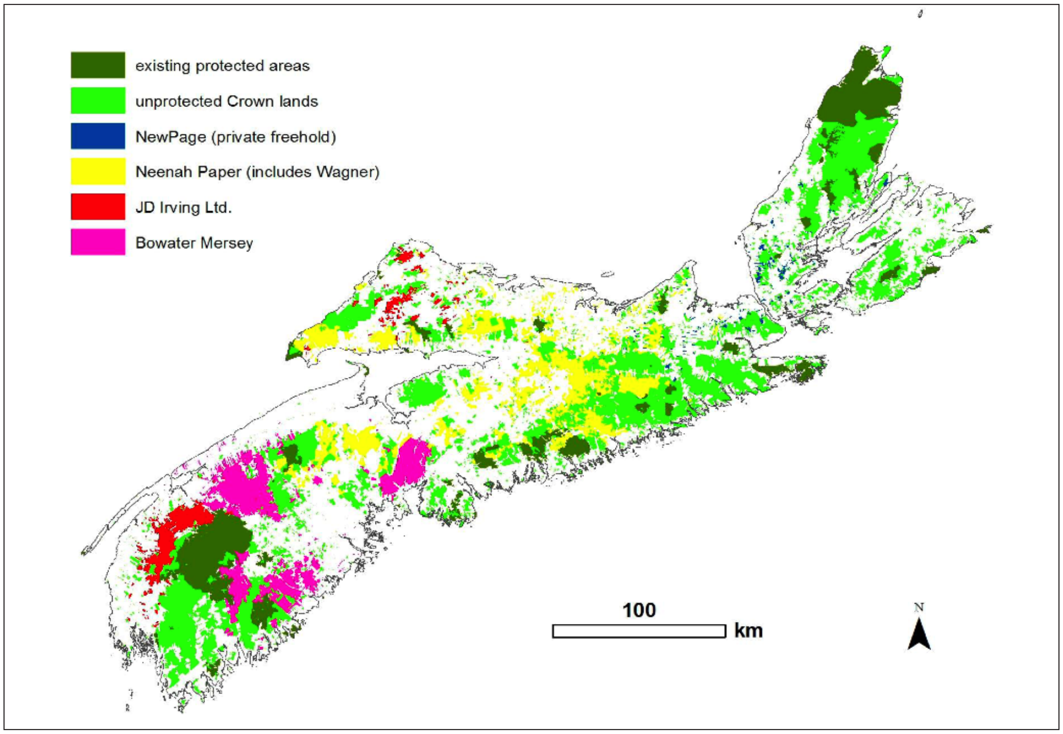

Figure 1. Map of forest land ownership in Nova Scotia (as of 2009).
(Source: Colin Stewart Forum)
Note: A significant portion of J.D. Irving and Bowater land shown on this map has been recently purchased by the province.

Harvesting in the 1950s and 60s remained in the 2–3 million cubic metre per year range then climbed to a peak of 6.9 million m^3 in 2004. The harvest has dropped since then due to poor lumber and paper markets in the U.S., and the harvest is now in the 4–5 million m^3 range. Softwood accounts for 85–90% of the harvest. Over 95% of the harvest is destined for sawmills and pulpmills that frequently exchange wood to meet one another's needs. Private lands typically account for 50–60% of the harvest, with industrial lands in the 30–35% range and Crown lands in the 10–15% range. The Central Region of Nova Scotia accounts for 50–60% of supply, the Western Region 25–30%, and the Eastern Region 15–20%.

The **sawmill industry** has been highly concentrated with the top 7 firms representing over 80% of production. A strong U.S. market with favourable conditions for Maritime mills contributed to an almost four-fold increase in output between 1992 and 1999. Then the combination of declining markets and a strong Canadian dollar put pressures on margins throughout the industry after 2004, forcing one of the province's largest mills into bankruptcy late in 2007. Softwood lumber shipments from Nova Scotia plummeted from 160,000 m^3 in 2005 to under 40,000 m^3 in early 2009, their lowest level in about 20 years. The industry is dependent on the U.S. market for 98–99% of its export earnings.

The **pulp & paper** industry in Nova Scotia was composed of three mills, (Bowater Mill recently closed) one located in each of the province's forest regions. The mills had a combined production capacity in the one million tonne range and, when operating at full capacity, required about 2.5–3.0 million tonnes of raw material (in the form of wood chips). The pulp & paper industry in

North America has faced several years of challenges in the form of strong competition from low cost producers, declining demand for newsprint and other paper products and rising production costs. Canadian mills have faced the added burden of a strengthening dollar that has resulted in price cuts and heavy losses. With recent changes to pulp and paper production in the province, it is important to determine the new arrangements that are emerging for wood harvesting and exchanges with sawmills and others.

The **export sector** accounts for about 10% of the total harvest (500–600,000 m^3), comprised mainly of hardwood that is either chipped for pulp mills or pelletized for fuel. Again, the sawmill industry is crucial to the success of the export industry. As lumber demand and the softwood harvest have declined, the chip and pellet producers have operated below capacity because they are unable to secure sufficient raw material at acceptable prices. However, the demand for their products remains strong as renewable energy development continues in destination countries.

The **contractors** for harvest and transportation are also affected by the overall economic circumstances of the forest industry, and they are specifically affected by the BSLB regulatory measures if they service regulated areas. Any requirements for movement certificates also draw upon their administrative and financial resources to complete transactions and move material accordingly.

BSLB status

The Canadian Food Inspection Agency confirms BSLB presence based on a detection network of traps positioned in Canada and specifically in Nova Scotia and the rest of Atlantic Canada for the purpose of tracking pest movement. The map below shows the confirmed BSLB sites as of October, 2012 including one location in New Brunswick within Kouchibouguac National Park. The color of sites marked on the map also indicates the year BSLB presence was first confirmed (lighter colour is more recent), and this is an indication of the spread rate and direction.

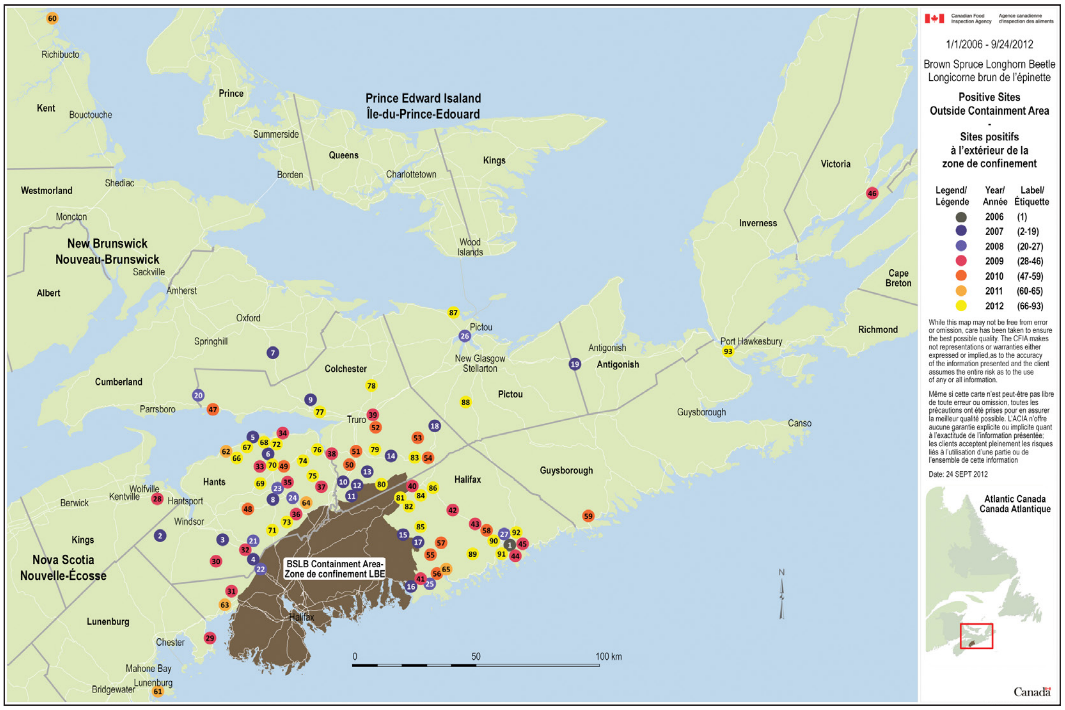

Figure 2. Map of BSLB confirmed presence by year as of October 1, 2012.
(Source: CFIA, 2012)

BSLB is believed to have arrived in Point Pleasant Park, Halifax circa 1990 so the map depicts just over thirty years of BSLB dispersal. Much of the BSLB distribution is within the Central Region of Nova Scotia although some more distant points, particularly in Cape Breton and New Brunswick, are somewhat anomalous. These likely represent cases of artificial movement associated with firewood, rather than new introductions into Canada or artificial movement associated with forest industry products. Rates of natural dispersal in the range of 2–6 km per year have been supported by scientific research. However forecasting of future distribution has not been undertaken yet. At least two key factors make it difficult to simply apply these natural dispersal rates to future projections: 1) hurricane Juan is believed to have helped the spread so future spread may be slower, while 2) greater establishment from this point forward may also increase the rate of natural dispersal. Many other factors must also be considered, but these have been highlighted by key informants.

2. Approach

With a short time-frame for this analysis, Gardner Pinfold immediately contacted representatives of key stakeholder groups to set up interviews. The following outlines the target stakeholders and the specific individuals that were finalized with input from NSDNR as needed using Registry of Buyers information and other sources.

- **Landowners** – 1 Provincial crown, 3 Industrial private, 2 Small private (Associations)
- **Processors** – 2 Sawmills, 1 Pulpmill, 1 Biomass energy, 2 Associations
- **Government** – 2 Scientific, 2 Regulatory

A number of questions are asked of stakeholders to help understand and assess the potential outcomes with each response. As the regulated area expands to the Central region or the whole province will this impose costs on landowners and forestry operators for compliance? Will they change their arrangements for wood exchange in the province? Will operators change their processing capacities to comply with requirements, and what effects will this have? Having said this, Gardner Pinfold did not rely entirely on the views expressed, but formally assessed these management options as outlined below.

Gardner Pinfold contacted DNR staff, Canadian Forest Service, and CFIA representatives to collect and analyze available data resources. Wood flows for Nova Scotia provide an indication of wood buyer and seller challenges associated with each response option. First, CFIA movement certificates indicate the flow of BSLB risk materials from the current regulated areas. Then Nova Scotia Registry of Wood Buyers provides information on flows of roundwood and chips from points within the province.

3. Response Option Analysis

BSLB risk management

It is important to be clear on assumptions and objectives so that assessment of options is carried out accordingly. Underlying the assessment of the four BSLB management response options is an assumption that BSLB will continue to spread by natural means. The selected option is therefore primarily focused on preventing spread by artificial means associated with personal movement of wood (firewood) and industry movement of primary and secondary forest products. This must be balanced in the context of all risk management objectives as follows:

1. Contain and reduce BSLB spread
2. Minimize disruption of markets
3. Protect international trade

Response options

Our understanding of the current movement under existing regulations is the starting point for analysis. The regulations that exist for the current containment zone will likely be altered going forward since the relative risk of BSLB with different forms of wood is being reassessed. In particular, the de-regulation of all products except firewood and roundwood during the "fly season" is being considered for all response options. Monitoring, surveillance, and enforcement may change as well.

The four regulatory response options are as follows, recognizing that the geographic boundaries for option B is approximate and may be larger to encompass some additional locations with existing BSLB finds:

- A: Current regulated area;
- B: Central region regulated;
- C: Whole province regulated; and
- D: Whole province deregulated.

III Nature of the Threat

1. Affected forest landowners have access to markets

Evidence

When the containment zone did not include a processing facility and regulations had not been fully formed to support movement of wood outside the zone, landowners within the zone had few outlets for their harvests or salvaged wood (e.g. hurricane Juan). The access to markets was improved when the zone expanded to include sawmills. Since then small private woodlot owners, industrial land-owners, municipal, provincial crown, and federal crown land managers have all been able to sell their wood from within the zone. The combination of mills within the zone and availability of movement certificates to sell wood outside the containment zone has maintained access to markets. This is based on input from representatives of provincial crown, large industrial, and particularly the Federation of Nova Scotia Woodlot Owners (FNSWO) and the Forest Products Association of Nova Scotia (both having small private landowners among their membership). The Nova Scotia Registry of Wood Buyers also indicates the flows of softwood from the containment area are now similar to historic norms after accounting for other market changes.

Uncertainty

Uncertainty is low given the consistency of information provided from all sources. It is recognized that there is increased complexity with the containment zone in place, but access to markets has not ultimately been restricted.

Information Needs

There have been some unconfirmed reports of Nova Scotia and New Brunswick mills not accepting product from regulated properties and the containment zone. It is unlikely that this materially limits market access for sellers of wood, but the nature of any restrictions could be investigated to substantiate the claims and better understand the underlying rationale.

2. Affected forest landowners have access to fair prices

Evidence

There were issues when the containment zone did not include mills, and especially when there were difficulties processing wood after the hurricane. The Province disbursed about $700,000 in recognition of increased costs and lost value of wood from salvage operations. Despite this some landowners may have still suffered losses in the value of their wood, but this is not formally documented. Since then all forest landowner types have enjoyed fair pricing of their wood. Evidence of fairness is found in consistent pricing for wood regardless of the land status with respect to BSLB. No price penalties are levied on regulated lands due to administrative complexities, perception of wood quality with BSLB, or otherwise. This is based on input from representatives of all land ownership classes, and particularly the FNSWO and FPANS. The most recent reported pricing analysis for wood products in Nova Scotia (Primary Forest Products Marketing Board) did not indicate any concerns or effects associated with BSLB regulation.

Uncertainty

Uncertainty is low given the consistency of information provided from all sources.

Information needs

This could be further substantiated by a survey of wood buyers and sellers, or questions regarding BSLB or insect damage price adjustments could be investigated in the next market analysis conducted by the Nova Scotia Primary Forest Products Marketing Board.

3. Affected forest landowners are not managing specifically for BSLB

Evidence

Forest landowners in regulated areas are not performing silviculture or harvest operations any differently than they did before, or any differently than their counterparts on non-regulated lands. BSLB and it's effects on trees are not specifically identifiable to landowners and have not caused landowners to shift their forest management approach. Evidence is confirmed with managers of crown lands, industrial lands, small private woodlots (FNSWO and FPANS) within industrial and crown land management plans, and in the HRM urban forest management plan.

It should be recognized that this is distinct from landowners that may manage their forests differently due to (anticipated) regulatory restrictions on their property. There are some alleged cases of landowners outside the containment zone harvesting their woodlot earlier than they would otherwise, because they were concerned that future regulation on their property would put them at a disadvantage.

Uncertainty

Uncertainty is low given the consistency of responses and lack of BSLB specific measures in forestland management planning documents.

Information needs

None.

4. Wood buyers contend with some administrative challenges when sourcing wood

Evidence

The CFIA cost-benefit analysis in 2010 acknowledged efforts required by wood buyers associated with CFIA compliance. This has been re-affirmed by representatives of forest industry including operators and associations (MLB and FPANS). The logistical challenges are primarily administrative in nature and tend to be a lesser burden on larger operators and greater burden on smaller operators, with some notable exceptions. The administrative burdens include; regulatory compliance required for CFIA certification to handle regulated wood products (e.g. equipment maintenance, documentation, auditing), and operational requirements related to movement certificates (communications, documentation, logistics and timing, and controls). Larger companies with harvest management software and technical expertise can more easily track land status, wood movement, and documentation needed for compliance. The overall administrative costs have not manifested in price penalties for BSLB regulated lands (as indicated above) or BSLB-related suspension or termination of operations therefore administrative costs appear reasonable.

Notable exceptions are operators (of any size) outside the containment zone that require a disproportionate amount of relatively higher risk BSLB wood (e.g. bark), don't have equipment to handle this material on their own (e.g. certified hogger), and have greater difficulties managing wood supply from regulated areas because they must consume the material within a 48 hour time period. For this situation the current arrangement is manageable, but any increase in the containment zone that does not include their facility will make it difficult if not impossible to operate. Their only recourse would be an equipment purchase that could jeopardize their financial viability.

Uncertainty

Uncertainty is medium given the diverse experience of wood buyers depending on their circumstances. Reports of mills not accepting wood from regulated lands should be investigated further to ascertain the rationale for those choices, some of which may relate to administrative and logistical burdens.

Information Needs

Although the information to date is representative and indicative of industry circumstances, only a broad survey of wood buyers by type (e.g. small. large, by primary wood product type) would yield a complete picture.

5. Wood buyers incur costs related to regulatory compliance

Evidence

The CFIA cost-benefit analysis in 2010 documented costs incurred by wood buyers for CFIA compliance. This has been re-affirmed by representatives of forest industry including operators and associations (MLB and FPANS). Sawmills, pulp mills, wood exporters, and biomass energy facilities are required to train staff, maintain equipment up to CFIA standards for processing BSLB wood, and administer wood movements meeting CFIA requirements. These activities entail costs, some of which are one-time (e.g. equipment purchase and training), and others that are on-going (e.g. maintenance, administration, logistics). The CFIA conducted a survey of wood buyers to ascertain these costs, and although the survey was limited, the low and high cost estimates are useful goal posts for assessing impacts. The detailed analysis is contained in the Appendix with past, present and future consideration of the four response options.

Applying the low and high unit cost values to past regulated wood movements suggests a cost estimate range from $1.0 million to $2.0 million to date. CFIA (2010) estimated one-time costs of about $231,000 (CFIA, 2010) over 2007 and 2008 for equipment purchase, upgrade, and training to meet CFIA compliance requirements. Adding this yields a combined cost of $1.2 to $2.2 million to date.

Projecting forward from 2013 to 2043, the net present value of costs with a 5% discount rate decline from Option A through Option D (low estimates in $millions: A $3.0, B $1.5, C $0.5, D $0, and high estimates in $millions: A $11.9, B $5.9, C $2.3, D $0). The costs with option B are about half of option A, and option C costs are only about a sixth of option A.

The cost burden may be relatively higher for small operators than for large ones, and depends on the type of facility considering it's location relative to where it sources wood (inside or outside regulated areas). The costs are not spread evenly across the industry; some facilities are moderately affected while there may be little to no effect on others.

If there is a decision to de-regulate all but the unprocessed roundwood during the "fly season", costs will be much lower. Unprocessed roundwood represents about two–thirds (62%) of regulated materials, and movements during the "fly season" might be about one-third (4 of 12 months) relative to the full year total. Applying these factors suggests that costs could be only 20% (62% times 33%) of the above estimates. Considering the possibility of scheduling harvests in regulated areas during the "no-fly season" with a blanket movement certificate (issued for entire non-flight season) the costs could be even further reduced.

Uncertainty

Uncertainty is discussed in the Appendix according to the key assumptions including: the future level of forest harvest activity, the amount of wood movement out of regulated areas, and the unit cost estimates.

Information needs

A more thorough survey of wood buyer costs could yield more accurate estimates and a better sense of the distributional issues (who is affected most), but this is not expected to change the overall assessment.

6. Trade concerns are associated with changing response options from the status-quo

Evidence

No inter-provincial or international forest products trade concerns have been raised regarding response A (status quo). However, different concerns have been expressed regarding each of the other three response options as follows.

Forest industry representatives including sawmills, pulp mills, FPANS, and the Maritime Lumber Bureau (MLB) have raised concerns associated with response option B (Central region). The concern is that a greater volume of wood in Nova Scotia will be perceived as "BSLB affected", thereby curtailing inter-provincial export volumes and/or lowering prices offered to Nova Scotian wood suppliers. Although the concern is primarily raised by processors, it would also affect crown and small private woodland owners as depressed prices affect the entire market. Trade to the U.S. would not be affected.

Forest industry representatives have raised two concerns associated with response option C (regulation of the whole province). First, the export volume and price concern expressed for response option B is magnified by the expansion to the whole province. Additionally, there is a concern this will become a discussion point in the 2015 renewal process for the U.S. Softwood Lumber Agreement. In particular, the requirement of a Maritime free-market "wood basket' is important to the Maritime exemption from duties applied to softwood products elsewhere in Canada. A regulatory restriction on Nova Scotia may be perceived as a disruption in the free-market status by forming a partition in the market. Although the U.S. already regulates Nova Scotia as if it were a province-wide containment zone (see explanation with response option D below), this does not address inter-provincial trade the way CFIA regulation would for the province in option C. The Maritime exemption has avoided just over $1.1 billion in duties since 1996, or about $70 million on average each year. The amount has been lower in recent years with declining interprovincial trade (e.g. $29 million in 2011/12).

CFIA staff have raised trade concerns associated with response option D (de-regulation). The May 24, 2011 Notice to Industry from CFIA concerning new U.S. import requirements for all firewood and spruce logs from Canada states that these must be heat treated and accompanied by an import certificate when they come from Nova Scotia. For the rest of Canada these products must simply have a certificate of origin.

CFIA representatives have confirmed with U.S. regulators that the requirements currently only applied to Nova Scotia could be expanded to the rest of Canada if BSLB is de-regulated. These restrictions on Nova Scotia are manageable since there is little trade with the U.S. in these products, however this represents a much greater concern for other provinces.

As BSLB spreads to New Brunswick and further in the distant future, indeed the U.S. can be expected to take the same approach with each province and gradually apply these requirements, however it is critical to avoid them as long as possible.

De-regulation is a desirable option for industry and landowners to avoid the burdens of regulation, but this will hinge on agreement from domestic and international interests regarding the status of the BSLB as either a quarantine pest or a secondary pest more akin to native equivalents.

Uncertainty

Uncertainty is high since this account mainly reflects concerns expressed, most of which rest on potential future actions by trade partners in Canada and abroad that are not fully predictable. The possible trade impacts for some response options ranges from none to extremely serious.

Information needs

These are difficult subjects to investigate further due to the complexity and sensitivity of information involved, however enquiries to key informants in other provinces and the U.S. might yield some insights.

IV Response

1. Response Options

The following outlines the four response options with some basic description of their intent and implications for BSLB risk. The geographic boundaries for option B is approximate and may be larger to encompass some additional locations with existing BSLB finds. The analysis section that follows will delve into the implications for landowners and wood buyers. The de-regulation of all products except firewood and roundwood during the "fly season" is also being considered for all response options.

A. Maintain existing containment zone and regulation of properties with new BSLB finds outside the zone

This option represents no change from the current regime, although this approach allows flexibility for regulations to expand according to the geographic spread of BSLB. As BSLB spreads, this option relies on monitoring programs to detect BSLB presence in order to introduce regulation on new properties.

B. Expand the containment zone to the Central Region of Nova Scotia and regulation of properties with new BSLB finds outside the zone

This option expands the containment zone to include most of the existing BSLB confirmed locations outside the current containment zone, and continues to maintain flexibility for regulation of further new finds outside the zone. This option eliminates the reliance on monitoring to trigger regulatory measures on lands in the Central region, but does eliminate this need for lands elsewhere in the province. Compared to option A, this option would reduce the risk of BSLB artificial movement outside of the Central Region, but may increase risk of BSLB artificial movement within the Central Region. Since the Central Region also contains the route for road export of wood products from the province, this may also reduce the risk of BSLB wood products leaving the province if wood travelling from Eastern and Western Regions (not in containment zone) will also be regulated due to passage through the Central Region.

C. Expand the containment zone to the entire province of Nova Scotia

This option eliminates all reliance on monitoring for introduction of regulatory measures since all lands within the province would be in the containment zone. Compared to options A and B, this option would further reduce the risk of BSLB artificial movement outside of the province, but may increase the risk of BSLB artificial movement within the province since there would be no regulatory measures within the province-wide zone.

D. Remove the containment zone and regulation of properties with new BSLB finds outside the zone

This option removes all regulatory measures in the province and allows free flow of wood and unrestricted wood processing operations. This option is just like C except the provincial border controls are dropped. Compared to options A and B this increases the risks of BSLB spread both within and outside the province.

2. Analysis

Risk assessment

The four options must be treated as legitimate, each with their own merits. Views supporting and countering all options have been expressed by representatives of landowners and forest industry operations, therefore it is not possible to simply eliminate any option out of hand. Risk is a combination of the likelihood of an impact occurring and the magnitude of the impact. For there to be "high" risk this requires both high likelihood and high magnitude of impacts. Low risk can result if either the likelihood or the impact is very small.

- **NS BSLB risks** –Although not the primary focus of our industry analysis, this is clearly a key goal of BSLB regulation and establishing containment zones. This is the only goal not focused just on Nova Scotia, but with a view to reducing risks to other jurisdictions. This implies Nova Scotia will continue to recognize it's role in helping to protect others and, in fact, the risk assessment is more focused on this objective. The risk of spread within the province is secondary since Nova Scotia landowner and wood processing concerns regarding BSLB impacts have been muted so far. Although BSLB does kill trees, it represents a very slow spread and damage rate, leaving many mitigation measures open including timely harvest and thinning as needed. The regulatory zone will not influence future natural spread, other control measures if available will be required for this. A very small amount of BSLB risk material leaves NS, most is KD-HT so differences between response options reflect the degree of regulatory coverage (geography and movement of wood products). Over time, as natural spread of BSLB brings it closer to the border, the importance of regulatory measures increases for control of firewood movement across the border.
- **NS market risks** – (See appendix A for details) This considers a combination of logistical challenges and costs across landowner types and those involved in the supply and demand of forest products. As the zone increases, landowners have increasing flexibility to access market buyers, especially in the case of full-province regulation, but also true for the Central region if care is taken to delineate the zone in a way that causes minimal disruption.
- **NS trade risks** – Concerns have been expressed with respect to response options B, C, and D. Response option B entails mainly a price concern if inter-provincial exports are curtailed based on a perception that a larger portion of Nova Scotia wood is "affected" by BSLB. Response option C has the same concern only greater, as well as a concern that the Maritime exemption could be questioned if there is a "partition" in the free-market Maritime wood basket. Response option C raises a concern that U.S. restrictions on Nova Scotia BSLB risk wood exports will apply to other parts of Canada if Nova Scotia becomes de-regulated.

V References

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Appendix A – NS roundwood and chip markets

Wood flows for Nova Scotia provide an indication of wood buyer and seller challenges associated with each response option. First, CFIA movement certificates indicate the flow of BSLB risk materials from the current regulated areas (Table A-1). Then Nova Scotia Registry of Buyers of Primary Forest Products (NSRB) provides information on flows of roundwood and chips from points within the province (Tables A-2 to A-4).

Table A-1. Product breakdown for the BSLB risk material approved by CFIA for movement out of regulated areas (576,000 mt in 2011, 440,000 in 2012).

Product	%
Logs	62.7%
Hogged bark	19.3%
Chips	17.1%
Green lumber	0.2%

Source: CFIA movement certificates.

The total amount is only approximate since movement certificate information does not exactly reflect the amount of wood that was actually moved. Using conversion factors from the Nova Scotia Registry of Wood Buyers 2011 Annual report, this represents approximately 1.2 million m3. This will be set in context of wood movement information presented below. It should also be recognized that the logs and chips portion in Table A-1 is approximately 975,000 m^3 since only these product forms are represented below.

The Nova Scotia Registry of Buyers of Primary Forest Products (NSRB) reports volumes of softwood in chip and roundwood forms moving out of Halifax County, Central Region, and the Province to various destinations. Sometimes wood brought into these three locations from elsewhere in the province is included in the reported movement data. Wood buyers acquiring under 1000 m^3 are not required to report where wood is sent. The data does not show the movement within each of the three areas, only what moves out. Data were requested for 2006 and 2011 to show the differences between high harvest years and low harvest years. The total provincial softwood harvest in 2006 was 4,566,816 m3, and this has slid to 3,428,590 in 2011. The Central Region amounts were approximately 2.5 million in 2006 and 1.5 million in 2011.

Table A-2. Softwood roundwood movements from points in NS (m^3).

	2006 Sources			2011 Sources		
Destination	Halifax County	Central Region	Nova Scotia	Halifax County	Central Region	Nova Scotia
Western Region	66,692	132,763		25,545	80,152	
Central Region	153,934			313,975		
Eastern Region	10,901	38,204		9,230	48,784	
New Brunswick	1,460*	316,461	359,524	-	53,155	63,663
Other provinces	18,331	46,779	79,589	-	-	3,438
United States	-	3,325	20,719	-	89	89
Other Countries	-	-	-	-	-	-
Total	251,318	537,532	459,832	348,750	182,180	67,190

*This amount may have gone in part to Quebec or Maine. (Source: NSRB)

Table A-3. Softwood chips movements from points in NS (m^3).

	2006 Sources			2011 Sources		
Destination	**Halifax County**	**Central Region**	**Nova Scotia**	**Halifax County**	**Central Region**	**Nova Scotia**
Western Region	30,968	47,790		23,740	26,054	
Central Region	463,839			92,700		
Eastern Region	-	32,070		462	67,339	
New Brunswick	44,112*	76,553*	162,942*			
Other provinces						
United States						
Other Countries						
Total	538,919	156,413	162,942	116,902	93,393	-

* These are approximate and may not all stay in New Brunswick; reporting product form of exports is not required of operators. (Source: NSRB)

Table A-4. Softwood roundwood and chips movements from points in NS (m^3).

	2006 Sources			2011 Sources		
Destination	**Halifax County**	**Central Region**	**Nova Scotia**	**Halifax County**	**Central Region**	**Nova Scotia**
Western Region	97,660	180,553		49,285	106,206	
Central Region	617,773			406,675		
Eastern Region	10,901	70,274		9,692	116,123	
New Brunswick	45,572	393,014	522,466	-	53,155	63,663
Other provinces	18,331	46,779	79,589	-	-	3,438
United States	-	3,325	20,719	-	89	89
Other Countries	-	-	-	-	-	-
Total	790,237	693,945	622,774	465,652	275,573	67,190

(Source: NSRB)

Several key points are clear from the data, namely:

- **Product type consistency** – The percentage of 2011 movement certificate volumes that is roundwood (63%) is very similar to the roundwood component of the 2011 softwood movements from Halifax (75%) and Central Region (66%).
- **Majority of 2011 regulated movements come from Halifax County** – If the 975,000 m^3 worth of movement certificate volumes is somewhat comparable to the NSRB information, this suggests the majority (790,237m^3 from Halifax County is 81%) of regulated movements come from the containment zone. The balance, some 185,000 m^3 are associated with the "new" BSLB find locations.
- **Movement out of Central Region has changed since 2006** – at high harvest levels in 2006 it was about double the Halifax County amount, but today's Central Region movements to other destinations are only just over half the Halifax County rate. This is the result of a combined increase in shipments out of Halifax County and a reduction in shipments out of the Central

Region. Extensive harvesting in Central Region culminated with Hurricane Juan salvage operations and harvests have dropped off significantly since then.

- **Movement out of the province has changed since 2006** – Shipments out of the province in 2011 were just over 10% of what they were in 2006. The combination of weakened export markets, increased costs of trucking, and collapsing forest industry operators are the main factors that help to explain this decline. Some have suggested New Brunswick buyers have avoided wood from Nova Scotia because of BSLB, but although this may be true in a few cases, the Mirimachi, NB mill was once a large buyer and accounts for a large drop in the demand.
- **Trade risks are negligible** – At peak harvest around 2006 exports of BSLB risk material (622,774m^3 in Table A-4) represented 14% of all softwood harvests, but now represent only 2%. Most of this is destined for NB, less than 0.5% went to the U.S. in 2006 and in 2011 it was essentially none. All other exports from the province are heat-treated kiln-dried (HT-KD) products that would not be subject to any BSLB-related restrictions.

Appendix B – NS Landowner & Wood Buyer BSLB-Related Costs

The analysis of Nova Scotia forestry sector costs associated with BSLB utilizes the most recent unit cost estimates ($ per cubic metre of wood) available from the CFIA 2010 cost-benefit analysis of regulatory options for controlling Brown Spruce Longhorn Beetle (BSLB) in Nova Scotia. However, these unit costs are applied to more recent wood movement data obtained from the Nova Scotia Registry of Buyers of Primary Forest Products (NSRB), and movement certificate data from the CFIA. The analysis provides a retrospective assessment of costs, as well as projections with the four response options assessed in this report.

The cost analysis here does not reflect potential inter-provincial or international trade implications discussed separately in this report (e.g. concerns about reduced prices or export volumes with certain response options).

Before proceeding, it should be recognized that costs discussed here are predominantly borne by wood buyers, and are not passed on to the wood sellers (regulated BSLB landowners). Wood buyers absorb these costs into their general operations, and furthermore they unable to pass the costs on to consumers since they are currently "price takers" in the sluggish domestic and U.S. forest products markets.

Unit costs

Simply the CFIA low and high ongoing unit cost estimates ($0.30 and $0.62 per cubic metre) are used here. These unit costs are associated with the movement of BSLB material that is currently regulated. If all but roundwood during the "fly season" is de-regulated, it is assumed that the unit costs will still remain the same, they will just be applied to a smaller volume of wood moving. It is also assumed that these costs have remained unchanged since the time of the survey (2010). One-time costs for equipment and staff training will be added to the analysis.

Past costs

The movement of BSLB regulated material is tracked by the CFIA according to movement certificates. Wood buyers must obtain a movement certificate before harvesting and moving wood therefore the recorded volumes do not necessarily match the actual volume moved. It is assumed that on average a greater volume is permitted on the movement certificate to ensure all harvested material can move. Information is not available on the potential discrepancy so the analysis may overstate (possibly by 20% based on comparison with NSRB data).

Table B-1. Product breakdown for the BSLB risk material approved by CFIA for movement out of regulated areas (576,000 mt in 2011, 440,000 in 2012).

Product	%
Logs	62.7%
Hogged bark	19.3%
Chips	17.1%
Green lumber	0.2%

Source: CFIA movement certificates.

CFIA confirmed that 2,171,000 tons (2,605,000 cubic metres) was approved from 2002 to 2010. Using conversion factors from the Nova Scotia Registry of Wood Buyers 2011 Annual report, and adding all tonnages from 2002 through 2012 yields a total volume of about 3,294,000 cubic metres. Applying the low and high unit cost values to these estimates would suggest a cost estimate range from $1.0 million to $2.0 million to date. CFIA (2010) estimated one-time costs of about $231,000 (CFIA, 2010) over 2007 and 2008 for equipment purchase, upgrade, and training to meet CFIA compliance requirements. Adding this to the total yield a combined cost of $1.2 to $2.2 million to date.

Projected costs for response options

Assessing future costs begins with the anticipated wood volume movements. Projections depend on three key factors that will change from the analysis base year of 2011 (year of latest available data from NSRB). The three key factors affecting future movement, and corresponding assumptions are as follows:

- **BSLB spread** will cause more properties to become regulated outside the containment area for response options A and B, and it is assumed that the amount of regulated wood movement will then increase gradually by another 30% over the next 3 decades.
- **Harvest activity** will gradually improve as a result of strengthening markets and development of biomass energy projects. It will remain at current levels for a few years then gradually increase 40% over the remainder of the next three decades. This will bring provincial total harvesting to about 5.5 million (85% of peak harvest year to date).
- **Exports of BSLB** risk material over the next three decades will gradually return to about 50% of the peak levels in 2006. Only 67,000 cubic metres of such material was exported in 2011 compared to 623,000 in 2006.

Recognizing the difficulties with long-term projections for the sector, these assumptions are sufficient for the purpose of the analysis. This depicts a relatively healthy forest industry over the long term. The next component involves the anticipated wood movement volumes that will be regulated according to each response option:

- **Option A (HRM+):** Long-term BSLB spread and harvest assumptions (above) will apply, gradually increasing the volume of affected movements from 2011 to 2030, after which the volume will decline very slightly. The decline may seem counter-intuitive with spread, but as BSLB covers the entire province there will eventually be a decline to zero regulated movements since wood buyers and sellers will all be on BSLB lands.
- **Option B (Central+):** Long-term BSLB spread and harvest assumptions (above) will apply to this option. The maximum affected volume in 2011 would be the amount of softwood reported to have left Central region (NSRB), as well as from regulated properties outside the zone and additional amounts of hogged bark not reported by NSRB. This is considered a maximum because the delineation of the zone may be larger than Central region in order to facilitate operations for some facilities, and this will reduce the volumes leaving the zone.
- **Option C (Province):** Only the long-term export assumptions apply for this option. Harvest activity and BSLB spread within the province do not affect costs of industry operations within the province if there is only regulation at the border. Inter-provincial and international trade concerns are discussed separately in the report.
- **Option D (No regulation):** None, only inter-provincial and international trade concerns discussed in the report.

Although the analysis is done based on regulated wood movement projections for every year, the following table excerpts the base year values then every decade starting in 2013.

Table B-2. Projected volumes of regulated wood by response option (2013–2043).

Volumes	Option A	Option B	Option C	Option D
2011 (base)	689,388	345,197	67,000	-
2013	627,343	314,129	69,617	-
2023	953,148	477,269	158,748	-
2033	1,185,998	593,864	255,458	-
2043	1,241,760	621,785	368,500	-

Table B-3. Projected regulated wood movement costs (low and high estimates: 2013–2043).

Low cost	Option A	Option B	Option C	Option D
2011 (base)	$206,816	$103,559	$20,100	$-
2013	$188,203	$94,239	$20,885	$-
2023	$285,944	$143,181	$47,624	$-
2033	$355,799	$178,159	$76,638	$-
2043	$372,528	$186,536	$110,550	$-
High cost	**Option A**	**Option B**	**Option C**	**Option D**
2011 (base)	$423,974	$212,296	$41,205	$-
2013	$385,816	$193,189	$42,815	$-
2023	$586,186	$293,520	$97,630	$-
2033	$729,389	$365,226	$157,107	$-
2043	$763,682	$382,398	$226,628	$-

Table B4. Net present values using 3%, 5%, and 8% discount rates for projected regulated wood movement costs in $millions (low and high estimates: 2013–2043).

Low cost	Option A	Option B	Option C	Option D
3%	$5.78	$2.89	$1.11	$0.00
5%	$4.34	$2.17	$0.79	$0.00
8%	$3.00	$1.50	$0.52	$0.00
High cost	**Option A**	**Option B**	**Option C**	**Option D**
3%	$11.85	$5.93	$2.27	$0.00
5%	$8.89	$4.45	$1.63	$0.00
8%	$6.14	$3.08	$1.06	$0.00

The costs range from the low cost 8% discount values (A $3.0m, B $1.5m, C $0.5m, D $0m) to the high cost 3% discount rate (A $11.9m, B $5.9m, C $ 2.3m, D $0m). The costs with option B are about half of option A, and option C costs are only about a sixth of option A. There would be some additional one-time costs for facilities that have yet to purchase or upgrade equipment and train staff for CFIA compliance amounting to another $250,000.

A decision to de-regulate all but the unprocessed roundwood during the "fly season" will reduce costs substantially. Roundwood represents about two–thirds (62%) of regulated materials, and movements during the "fly season" might be about one-third (4 of 12 months) the full year total. Applying these factors suggests that costs could decrease to 20% of the above estimates. Considering the possibility of scheduling harvests in regulated areas during the "no-fly season" with a blanket movement certificate (issued for entire non-flight season) the costs could be further reduced.