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Conseil canadien des ministres des forêts

EMERALD ASH BORER PEST RISK ANALYSIS

for Northern Ontario and Manitoba

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Executive Summary

Emerald ash borer (EAB) is a destructive forest invasive alien species of ash trees which was first detected near Detroit, Michigan, and Windsor, Ontario, in 2002. Even before then, however, it was killing trees, and has continued to do so—a number now in the millions of trees. Significant economic and ecological impacts have resulted.

As of December 2013, EAB had been found in 19 American states, 37 Ontario counties and 17 Quebec municipalities; and had been confirmed as far north as Sault Ste. Marie, Ontario, northern Wisconsin and northern Michigan, and as far west as Boulder, Colorado.

Management of EAB is challenging for several reasons. Signs and symptoms of EAB infestation do not appear for three to four years following initial attack, reducing the potential success of eradication and containment efforts. Moreover, human-assisted movement (e.g., anthropogenic) is the main means of spread, by people moving infested material such as firewood and nursery stock. Enforcement of regulations restricting movement of such material is challenging and not proven to be effective.

This pest risk analysis (PRA) pertains to Manitoba and northern Ontario—for the latter, specifically those areas outside the 2014 area regulated by the Canadian Food Inspection Agency and those within the regulated areas of Algoma, Sudbury, Parry Sound, Muskoka, Nipissing (including Algonquin Park) but excluding Sault Ste. Marie, Laird Township and St. Joseph's Island. The PRA was requested by the Canadian Council of Forest Ministers (CCFM) Forest Pest Working Group (FPWG) because of (1) the potential long-distance spread of EAB into the pest risk analysis area by people moving infested materials from infested parts of Ontario, Quebec and the United States, and (2) the potential impacts that EAB could have on the ash population in uninfested areas of Canada.

This PRA, following a framework developed by the Forest Pest Working Group, addresses risk assessment, risk response and risk communication.

The objectives of the PRA were to:

1. Gain a better understanding of the potential timing of EAB arrival in the pest risk analysis area by reviewing the effectiveness of EAB management to date, and the current knowledge and research results pertaining to EAB (risk assessment).
2. Identify an appropriate combination of preventative measures and early management responses and strategies, including appropriate monitoring techniques (risk response).

Based on a review of current regulatory controls, current risk communication, monitoring and treatment efforts, it was found that there are no biological impediments or regulatory controls to prevent the spread of EAB into the pest risk analysis area.

Although it is uncertain when introduction will occur, Winnipeg, Thunder Bay and the communities within the regulated area in Ontario are predicted to be infested within 10 years, and occurrences elsewhere in the analysis area will likely be seen within 1–30 years. Establishment and spread will be impeded by the spatial heterogeneity of host material and colder climate, which could lead to higher EAB mortality rates and a two-year life cycle. The wide range in anticipated establishment dates reflects the high uncertainty associated with a colder climate, anthropogenic spread, effectiveness of provincial or regional outreach programs, and provincial or municipal surveys.

Economic impacts are expected to be significant in all ash forest types: urban forests, woodlots and managed forests, and linear forests and shelterbelts. For example:

- A U.S. study found that the cost of EAB—estimated at US$1.3 billion—is being borne largely by municipal governments and homeowners (Aukema et al. 2011).
- A study in Canada estimated that, over a 30-year time horizon, the potential costs of EAB to Canadian municipalities will be $524 million, and higher—$890 million—when costs associated with backyard trees are included (McKenney et al. 2012).
- Winnipeg is expected to bear some of the heaviest EAB-related losses, an estimated cost of $172 million (McKenney et al. 2012).
- Data from Ontario in 2013 shows that infested municipalities have already spent $71 million to date, and have planned expenditures of $365 million over the next 10 years (T. Scarr, Ontario Ministry of Natural Resources, 2014, unpublished data).

In light of these findings, managing EAB requires taking preparatory steps before the insect arrives, and making plans to slow the spread of EAB when it is discovered. Among the needed activities: regulating the movement of infested material; launching public awareness and education campaigns aimed at delaying EAB introduction; implementing a monitoring program to detect new infestations as soon as possible; developing rapid response plans that use a combination of mitigation tools which can be implemented as soon as infestations are detected, and developing long-term plans (including for species diversification) aimed at minimizing the long-term impacts of EAB in communities.

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Introduction

In 2006, the Canadian Council of Forest Ministers endorsed the vision, principles and approach for a National Forest Pest Strategy (NFPS)—a proactive, integrated response to the threat of forest pests, based on a national risk analysis framework to guide decision-making by the many jurisdictions involved in pest management in Canada.

The risk analysis framework for this work was developed by a Risk Analysis Technical Advisory Group made up of representatives from the Canadian Forest Service of Natural Resources Canada (NRCan-CFS), the Canadian Food Inspection Agency (CFIA), and all provinces and territories except Nunavut.

Risk analysis is an internationally recognized process that employs multidisciplinary evidence and expertise to inform policy decisions in the context of threats to individuals, public and private organizations, society, and the environment, from the local to the global scale.

Risk analysis is broadly defined as including risk assessment, risk response, and risk communication.

- **Risk assessment** uses scientific evidence to estimate the level of risk based on a combination of both the likelihood and consequences of introduction.
- **Risk response** evaluates those risks that warrant control measures, considers options, and determines the appropriate action to manage risk.
- **Risk communication** establishes an interactive dialogue with internal and external stakeholders to provide open and consultative decisions that are effective and clear.

In Canada, the overall relative risk imposed by emerald ash borer (EAB) is high, as determined by two previous risk assessments conducted by CFIA référence (Doebesberger 2002, 2011). Those assessments based risk on a combination of likelihood of introduction (high); establishment (high); spread (medium); and potential economic and environmental impact (high).

Similar conclusions were reached by risk assessments carried out in Oregon (Flowers 2009) and Minnesota (Selness & Venette 2006) and for all of North America (Ciesla 2003).

This document reports on the findings of a pest risk analysis carried out from 2013 to 2014 to study EAB's potential pathways into Manitoba and northern Ontario. The analysis focused on two components: risk assessment (likelihood of introduction, establishment and spread; consequences of introduction) and risk response. The aim was to elucidate the potential timing of introductions into the pest risk analysis area (see "Geographic Scope" below), as well as potential preventative measures that could be implemented to delay the establishment date or decrease the eventual impacts. The specific focus of this pest risk analysis is on the potential pathways into Manitoba and northern Ontario, and potential management responses in urban, linear (shelterbelt) and native forests (woodlots/managed forests).

NATURE OF THE THREAT

Emerald ash borer (EAB) is a destructive forest invasive alien species of ash trees which was first detected near Detroit, Michigan, and Windsor, Ontario, in 2002. However, even before its initial detection, EAB was killing trees and has continued to do so—a number now in the millions of trees. Significant economic and ecological impacts have resulted.

Human-assisted (anthropogenic) movement is the main means of long- and short-distance EAB spread, as people move infested material such as firewood and nursery stock out of infested areas.

Natural spread is minor in comparison. As of December 2013, EAB has been found in 19 states, 37 Ontario counties and 17 municipalities in Quebec; and has been confirmed as far north as Sault Ste. Marie, Ontario, northern Wisconsin and northern Michigan, and as far west as Boulder, Colorado (Figures 1a and 1b).

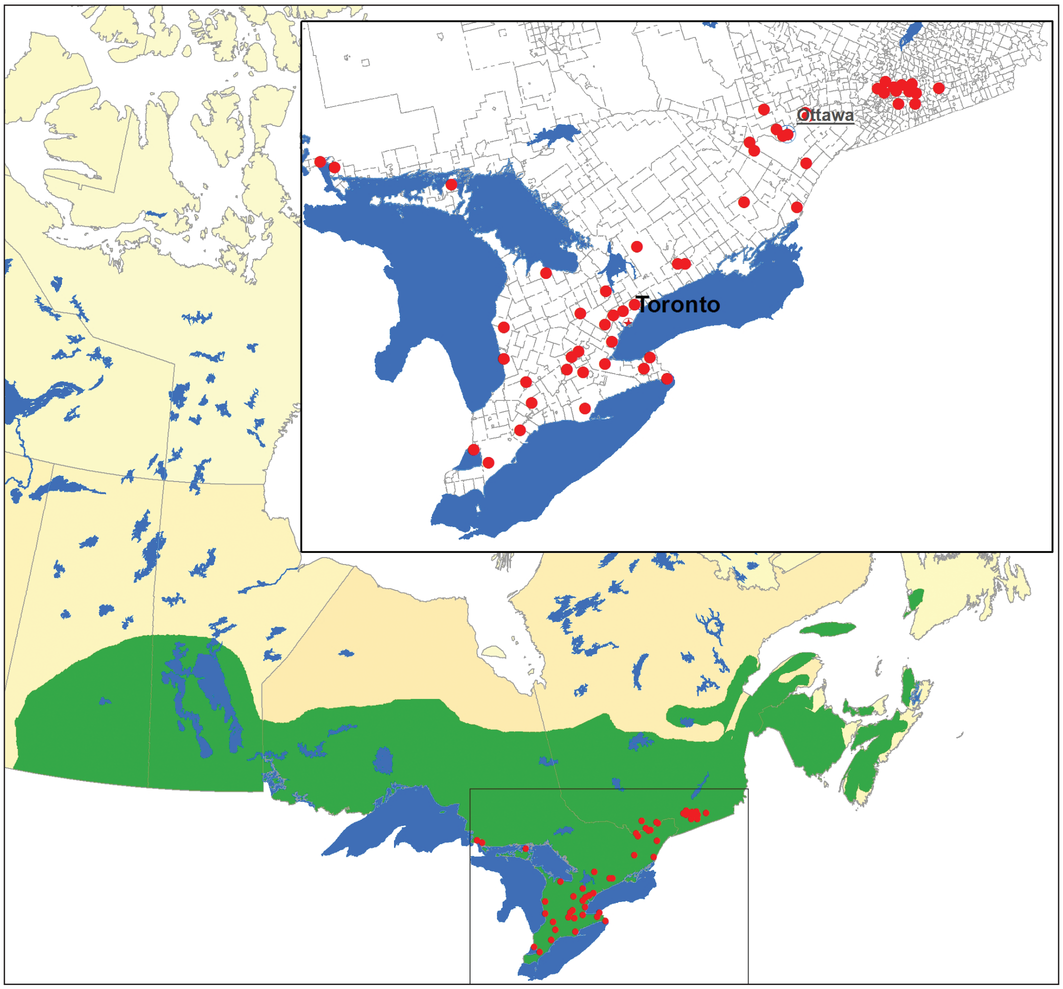

Figure 1a. Distribution of range of native ash species in Canada (Farrar 1995), and infested municipalities and counties as of March 2014. Green areas do not include linear or urban forests.

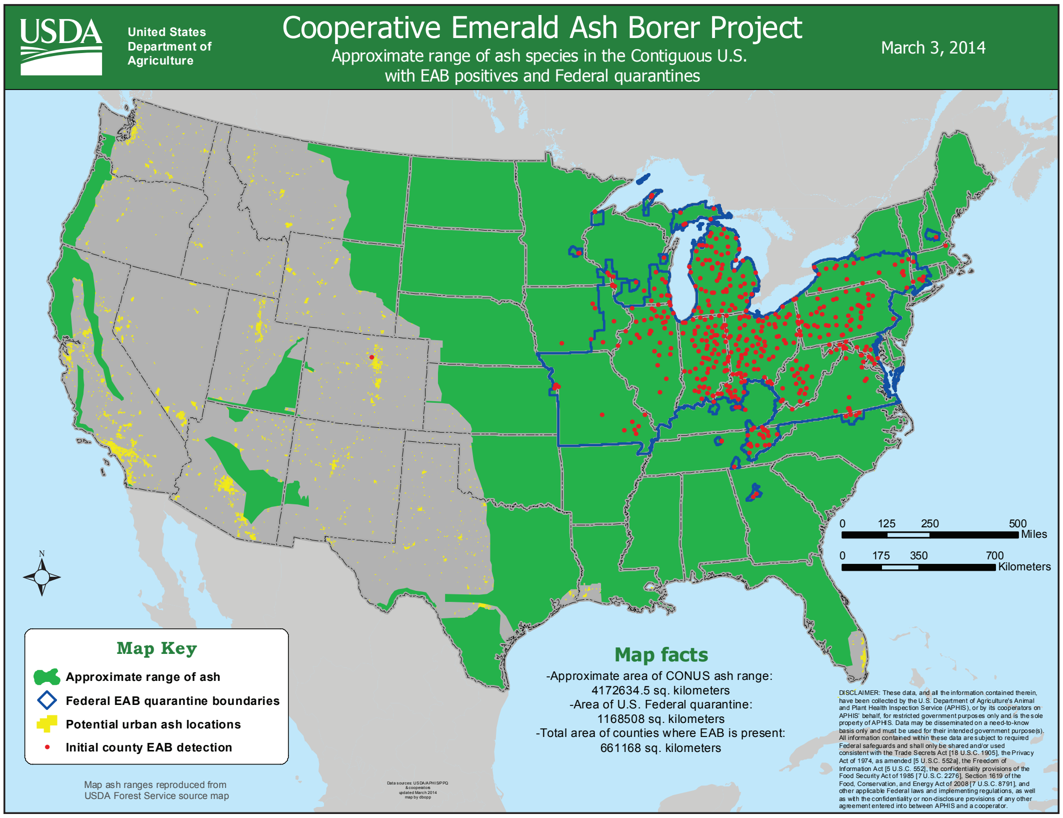

Figure 1b. Distribution of range of native ash species in the United States, and infested municipalities and counties as of March 2014. Green areas do not include linear or urban forests. Yellow areas show potential urban distribution in the U.S.

The natural range of ash species in Canada extends from Saskatchewan to Newfoundland (Figures 1a and 1b).

- Green ash (*Fraxinus pennsylvanica*) is the most widely distributed species. It is found from southern Saskatchewan, east to Manitoba and into the southern part of northwestern Ontario and east to Nova Scotia. It is commonly planted as an ornamental.
- White ash (*F. americana*) is common in the Great Lakes St. Lawrence Forest Region, from Sault Ste. Marie in central Ontario, east to Nova Scotia.
- Black ash (*F. nigra*) has a more northerly distribution, commonly growing in wet areas and riparian zones in southeastern Manitoba, across northern Ontario and east to the Maritimes, with a small range reaching into the western part of Newfoundland.
- Pumpkin ash (*F. profunda*) and blue ash (*F. quadrangulata*) are uncommon species whose ranges are restricted to southwestern Ontario.

Ash species are also commonly planted in urban and rural areas across Canada, including as ornamentals in urban areas in Alberta and British Columbia—far west of the native range for the genus. Because of the connectivity of the range of ash species within currently infested areas, and the potential for people to transport infested material long distances, there is concern that EAB will continue to spread from infested areas across the range of its host tree in Canada. This means there is a high likelihood that EAB will spread into woodlands, linear forests (shelterbelts), and landscape trees (either through U.S. or Canadian pathways).

To date, regulatory measures have failed to contain EAB for three main reasons:

- As the size of regulated areas has grown the potential for long-distance movement of infested material has increased.
- Human-assisted movement of infested material is difficult to control.
- Penalties are difficult to enforce, and therefore the public continues to violate quarantines.

TRIGGER FOR CARRYING OUT THE PEST RISK ANALYSIS

The "trigger" for a PRA means the reason a PRA has been initiated. In this case, the trigger is the potential long-distance spread of EAB into northern Ontario and Manitoba by people moving

IMPORTANT FACTS ABOUT EAB

- EAB is cold-hardy and adapted to the climate where ash species grow in Canada.
- EAB generally has a one-year life cycle. However, a 2-year life cycle is reported for a portion of the population in the northern parts of its native range (China) and in North America (Cappaert et al. 2005; Siegert et al. 2010), including infested parts of Ontario and Quebec (D.B. Lyons, NRCan-CFS, pers. comm., March 2014).
- Females may mate several times throughout their lifetime (McCullough & Katovich 2004).
- To date, 17 known native parasitoids have been identified (Lyons 2014) as using EAB as a host. However, the effect of these parasitoids on EAB populations is currently unknown.
- EAB attacks and kills all (healthy and stressed) ash species (*Fraxinus* spp.) native to Canada, with some resistance evident in blue ash. Healthier (dominant or co-dominant) trees die more slowly and those on mesic sites die more rapidly than those on xeric or hydric sites (Knight et al. 2012).
- European ash (*F. excelsior*) is also attacked and killed by EAB where the tree is planted in infested parts of Moscow, Russia (Baranchikov et al. 2008).
- Ash trees of Asian origin planted in North America are more resistant to attack than North American species (Pureswaran & Poland 2006).
- Tree mortality can take up to six years from initial infestation, with more rapid tree mortality occurring in forests with a lower density of ash trees. However, the eventual outcome remains the same, with >99% mortality of ash trees occurring in individual stands (Knight et al. 2012).
- There is no evidence, based solely on visual assessments of tree health, to suggest that EAB preferentially attacks stressed or declining trees.
- Signs and symptoms of EAB infestation do not appear for about three to four years following initial attack. This reduces the potential success of eradication efforts, given that several generations of EAB will have dispersed and attacked new trees during the incipient, asymptomatic phase of the infestation.
- Anthropogenic movement of infested material—including logs, lumber, firewood, wood pallets, crating and large-caliper nursery stock—all contribute to long-distance spread of insect pests (USDA 2012a).
- Spread rates of EAB are difficult to determine because of the confounding effect of both short- and long-distance anthropogenic movement of infested material.

infested materials from infested parts of Ontario, Quebec and the U.S., and because of the potential impacts that EAB will have on the ash population in uninfested areas of Canada.

GEOGRAPHIC SCOPE

The area of interest for this pest risk analysis was Manitoba and northern Ontario—in the latter, specifically those areas outside the 2014 area regulated by CFIA, and those within the regulated areas of Algoma, Sudbury, Parry Sound, Muskoka and Nipissing (including Algonquin Park) but excluding Sault Ste. Marie, Laird Township and St. Joseph's Island (Figure 2). The risk analysis included all native ash species (*Fraxinus* spp.) that may be growing across this range, as well as those in linear forests (which include shelterbelts, windbreaks and riparian buffers) and in urban and municipal landscape settings within this range.

OBJECTIVES OF THE ANALYSIS

The objectives of this pest risk analysis were:

1. Gain a better understanding of the potential timing of EAB arrival in the pest risk analysis area by reviewing the effectiveness of EAB management to date, and the current knowledge and research results pertaining to EAB (risk assessment).
2. Identify an appropriate combination of preventative measures and early management responses and strategies, including appropriate monitoring techniques (risk response).

The first objective is addressed in the "Risk Assessment" part of this report. The second objective is addressed in the "Risk Response" part.

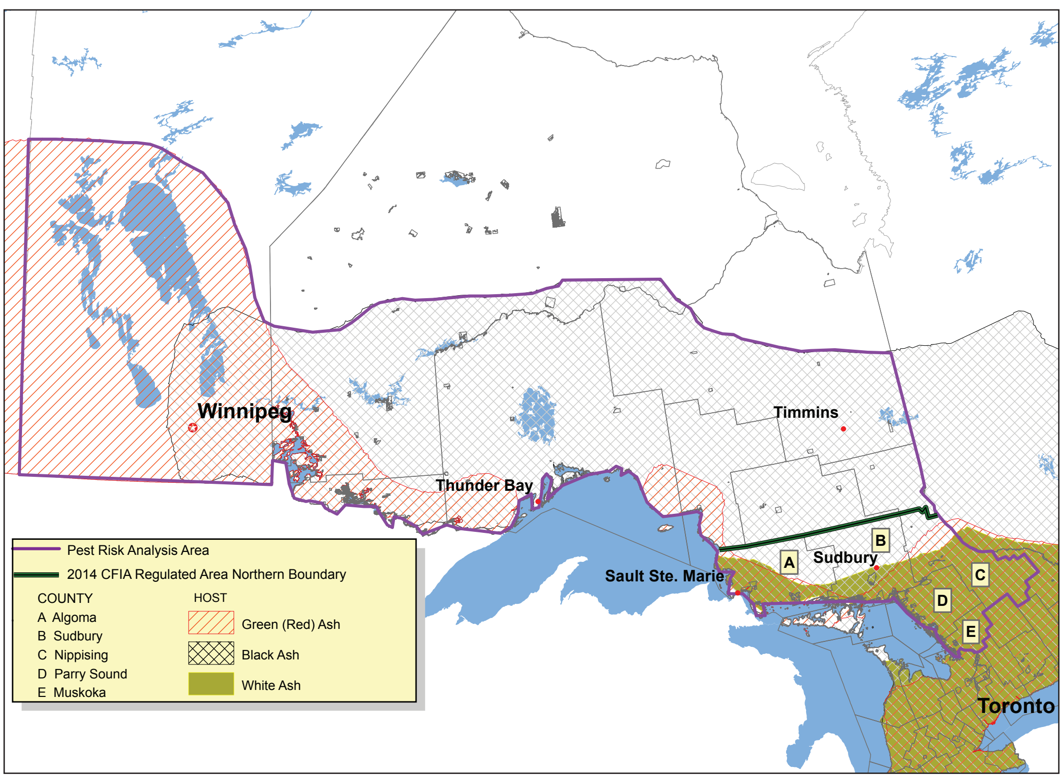

Figure 2. The pest risk analysis area in relation to the northern boundary of the 2014 CFIA-regulated area, and host distribution (Farrar 1995).

Risk Assessment

A pest risk assessment considers the likelihood of introduction, the potential for establishment and spread, and the consequences of introduction. The following section reviews each of these factors and presents affirmative statements (AS) on each topic, supporting evidence, and the level of uncertainty associated with each statement. The level of uncertainty is based on the weight of evidence and on professional or expert opinion from interpretation of the evidence.

LIKELIHOOD OF INTRODUCTION

The likelihood of EAB introduction is based on the potential for the insect to spread into the pest risk analysis area from existing infestations. The most significant pathway by which EAB is likely to be introduced is long-distance transport by people (i.e., anthropogenic movement).

The potential for EAB to spread via this pathway depends on the effectiveness of management actions to slow or halt the insect's artificial spread into the pest risk analysis area. The main management actions include:

- regulatory controls to restrict movement of infested material;
- communications to educate and inform people of the risk and of the regulatory controls;
- monitoring programs to detect new infestations and inform the delineation of new boundaries for quarantine areas; and
- treatment efforts to reduce or eliminate EAB populations.

CURRENT REGULATORY CONTROLS

Current regulatory controls at a jurisdictional level are outlined below, along with a corresponding affirmative statement about effectiveness and supporting evidence for each jurisdiction. The following affirmative statement represents the overall summary for the effectiveness of current regulatory controls.

AS1: ***Regulatory controls do not contain anthropogenic EAB movement (uncertainty: low), but do slow the spread of EAB (uncertainty: moderate). To what degree the spread is slowed is highly uncertain.***

CANADA

Federal – Within Canada

AS2: ***Current within-Canada regulatory controls do not contain EAB, but may slow the spread but to what degree is unknown. Uncertainty: moderate.***

Since 2002 in Canada, EAB Ministerial Orders (under the federal *Plant Protection Act*) established by the CFIA have restricted the movement of ash wood commodities. These include ash trees or tree parts, nursery stock, logs, lumber, wood packaging materials, wood or bark, wood chips or bark chips, and firewood of all species from regulated areas (Figure 3). In Ontario until recently, the boundary for the regulated area has followed the boundary for infested counties: whenever EAB was found in a new county, CFIA would initially apply a prohibition-of-movement to the infested property, followed about one year later by a Ministerial Order that regulated the entire county. The new areas are subsequently posted on the CFIA website and announced in news releases.

Concern has been raised that a one-year delay in regulating the county after EAB has been found could contribute to spread of EAB.

Regulated areas are therefore updated periodically in response to detection and monitoring results. Historically, these regulated areas have been based on the boundaries of counties known to be infested. However, in April 2014, CFIA discontinued this approach and expanded the regulated area beyond the boundary of counties known to be infested to include a large portion of Ontario north of the area known to be infested. This area-wide regulated zone is made up of counties known to be infested, all the remaining counties in southern Ontario, and several districts or parts of districts.

In southern Ontario, the county forms the judicial unit. In central and northern Ontario, the district forms the judicial unit. Districts are typically quite large, often equal in area to several counties. As a result, the new regulated zone includes large portions of the province in which EAB had not yet been found.

Similarly, CFIA expanded the regulated zone in Quebec to include cities, municipalités régionales de comté (MRC) and municipalities within MRCs not yet known to be infested.

Establishing the regulated boundary beyond known infested counties increases the probability that the area includes the existing range of EAB by including infestations that have yet to be detected by surveys.

However, this approach will result in a regulated area that includes tracts of land that are not actually infested. Because there are no restrictions on movement of infested material within a regulated area, the uninfested lands contained within could become infested earlier than they might have otherwise. This could lead to EAB being spread faster and farther both within, and to the boundary of, the regulated area.

The revised regulated area came into effect on April 1, 2014 (Figure 3). It now includes the natural ranges of white, green, red, pumpkin and blue ash in Ontario east of Lake Superior. The range of black ash extends farther north, as well as west of Lake Superior. Green ash grows west of Lake Superior (and outside the regulated zone) in a narrow band along the Ontario-Minnesota border (Figure 2). The expanded zone now includes the Ontario mills that use ash for wood supply.

The revision creates a geographic expansion of the regulated zone that now includes high-risk corridors. It also represents a shift away from an emergency response-based program (CFIA 2013).

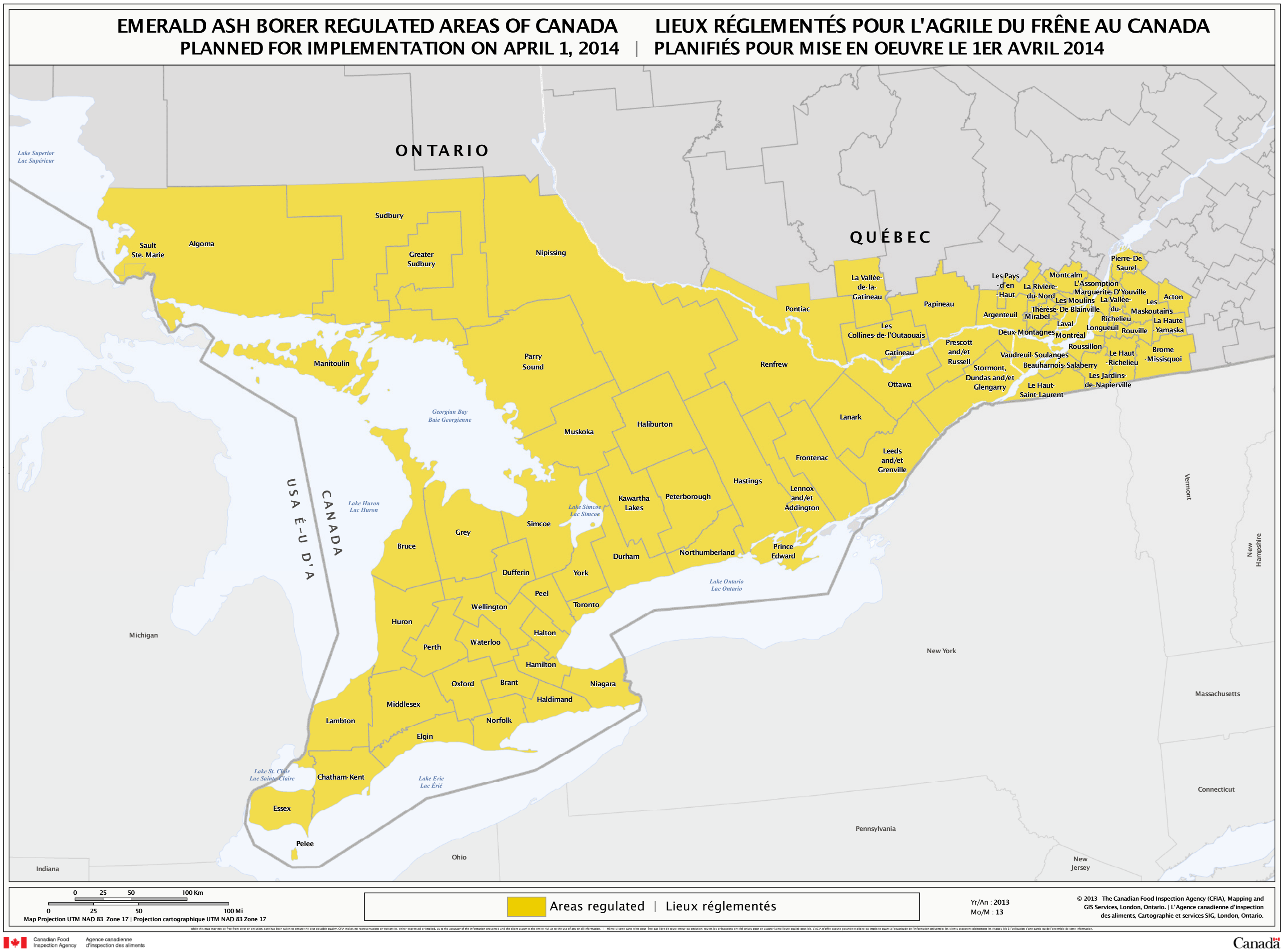

Figure 3. Emerald ash borer regulated area, starting on April 1, 2014 (CFIA 2013).

CFIA no longer conducts detection surveys within this enlarged area. The rationale for these decisions is multi-faceted and includes a realization that previous federal emergency response was ineffective and no longer feasible. During 2013, CFIA had a transition program offering training in survey methods and supplying communications material. In 2014, CFIA continued to conduct detection surveys for EAB at similar levels as during 2013 in Manitoba (40 sites), but at reduced intensity in Ontario (65 sites north of the regulated zone from a planned 400 sites in non-regulated areas in 2013) and Quebec (180 sites from a planned 240 in 2013) (J. Holmes, CFIA, pers. comm., March 21, 2014). Compliance agreements (as described in CFIA policy directive D-03-08[1]) are still required for facilities outside the area to access ash wood from inside the regulated area and move it outside the regulated area during the low-risk period under specific conditions, and for facilities within the regulated area that want to move compliant ash articles outside the regulated area year round. Requirements to be met by facilities under compliance agreement are described in the policy directive.

[1] www.inspection.gc.ca/plants/plant-protection/directives

A penalty schedule has been developed, with maximum penalties for different types of offenses[2] related to the prohibited movement of wood (M. Marcotte, CFIA, pers. comm., March 20, 2014).

Federal – Canada/United States Border

AS3: ***Efficacy of wood disposal bins and vehicle inspections for firewood at border crossings is unknown, but suspected to be low. Uncertainty: moderate.***

It is illegal to import firewood for commercial or personal use from states that are regulated for EAB. However, imports of firewood from non-EAB-regulated states are allowed with an import permit or a certificate of origin. Firewood must be declared when entering Canada, and travellers are subject to inspection. Disposal bins at some U.S. border crossings are managed by Canadian Border Services, but there is no information on the location, type of bins (i.e., closed or not closed), monitoring frequency, and whether or not the disposal protocol (International Waste Directive) is followed. Information provided by Canadian Border Services for the Pigeon River crossing in northwestern Ontario indicates that the bin is open to the air, and is emptied periodically during the year when the material is taken to the Thunder Bay landfill. There is no collection bin or signage about firewood importation at the Sault Ste. Marie border crossing.

Provincial

AS4: ***Effectiveness of provincial regulatory measures in Ontario is unknown, but is suspected to be ineffective as they have not been employed to date. Uncertainty: high.***

AS5: ***Effectiveness of provincial regulatory measures in Manitoba is unknown as there has not been an opportunity to deploy these measures. Uncertainty: none.***

AS6: ***The effectiveness of wood disposal bins managed by the province of Manitoba is unknown as there is no means to measure the number of motorists who did not dispose of their firewood. However, as these bins are properly managed (i.e., closed), monitored frequently and disposed of properly, their efforts probably help to slow to spread. Uncertainty: moderate.***

In Ontario, the *Plant Diseases Act* is administered by the Ministry of Agriculture and Food and Rural Affairs (OMAFRA). This Act covers movement and control of invasive pests. Ontario's *Forestry Act* also grants authority to the Ontario Ministry of Natural Resources and Forestry (OMNRF) to conduct surveys, and to control forest pests on private land at government expense. However, Ontario has taken no action under the *Plant Diseases Act* to restrict the movement of EAB-infested material; and although the ministry has conducted surveys under the *Forestry Act* for EAB, it has not undertaken any control measures.

On February 26, 2014, OMNRF announced a proposed *Invasive Species Act* that would give it powers to regulate invasive species, including EAB. The Act has not been passed by the legislature, and it is not possible to predict whether it would be used to regulate EAB.

In Manitoba, the *Forest Health Protection Act* is administered by the province, with the lead agency being Manitoba Conservation and Water Stewardship (MCWS). This Act provides the legislative

[2] Under the *Plant Protection Act*, those who violate the Act are subject to a penalty of up to $250 000 and/or to imprisonment for a term not exceeding two years. Under the *Agriculture and Agri-Food Administrative Monetary Penalties Act*, those who violate the *Plant Protection Act* are subject to immediate penalties of up to $15 000.

authority to contain and eradicate invasive forest pests, like EAB, on public and private lands. To date, no EAB have been reported in Manitoba, so it is not possible to rate the efficacy of this legislation. However, it has been used successfully for the management of European gypsy moth and Dutch elm disease.

The province of Manitoba also manages four closed wood disposal bins, which are monitored every two weeks—three west of Winnipeg and one east of Winnipeg. To date, less than 5% of firewood in these bins has been ash.

Municipal

AS7: *Municipal regulatory measures are effective only at a municipal level, and hence are minimally effective at slowing the spread beyond municipal boundaries. Uncertainty: moderate.*

Municipalities are generally focused on managing the resources within their own borders, with little concern about the spread of an invasive species beyond those borders. In Manitoba, municipalities work under the *Forest Health and Protection Act* that is administered by Conservation and Water Stewardship. Ontario municipalities can also pass laws enabling them to carry out control programs and to request that homeowners remove infested trees. However, these municipalities do not have powers to regulate the movement of infested material.

UNITED STATES

AS8: *Regulatory measures in the United States will help slow the spread, but are not sufficient to prevent introduction of EAB into Canada via firewood. Uncertainty: moderate.*

The U.S.'s strategies are similar to Canada's in that they focus on survey and regulatory activities to slow EAB spread, and on public awareness campaigns to garner program support and compliance. In 2012, the U.S. Department of Agriculture (USDA) revised its regulatory policy, such that contiguous quarantine areas that cross state borders—and are not associated with protected areas in Illinois and Indiana—are to be treated as a single regulated area (USDA 2012b), thus allowing unrestricted movement of EAB or infested materials across these borders (Figure 4). Movement outside the quarantine zone will require a limited permit or certificate to transport regulated materials to destinations in the protected areas in Illinois and Indiana, to a county not quarantined for EAB or to an EAB quarantine area that is not contiguous.

EAB regulations by the USDA govern interstate movement of hardwood firewood. Movement is limited to firewood that has undergone one of the following treatment options: removal of all bark and a ½ inch of wood, kiln-dried wood not exceeding 3 inches in thickness, fumigated with methyl bromide or heat treated.

Intrastate movement of regulated material varies by infested state. For those states bordering the pest risk analysis area (e.g., Michigan, Minnesota and to a lesser extent Wisconsin), quarantine areas and restrictions of movement of regulated articles exist within these states. In Michigan, two different levels of quarantine exist, with movement of regulated material restrictions specific to each quarantine level (Figure 4). The state of Minnesota has within-state firewood movement regulations which provide for movement of state-approved heat-treated firewood.[3]

[3] For more information, refer to www.mda.state.mn.us/plants/pestmanagement/firewood.aspx.

Despite these regulatory measures, a recent study by Jacobi et al. (2011) indicates that firewood movement occurs throughout the U.S., including outside quarantine zones, suggesting that U.S. regulatory controls pertaining to firewood have low efficacy.

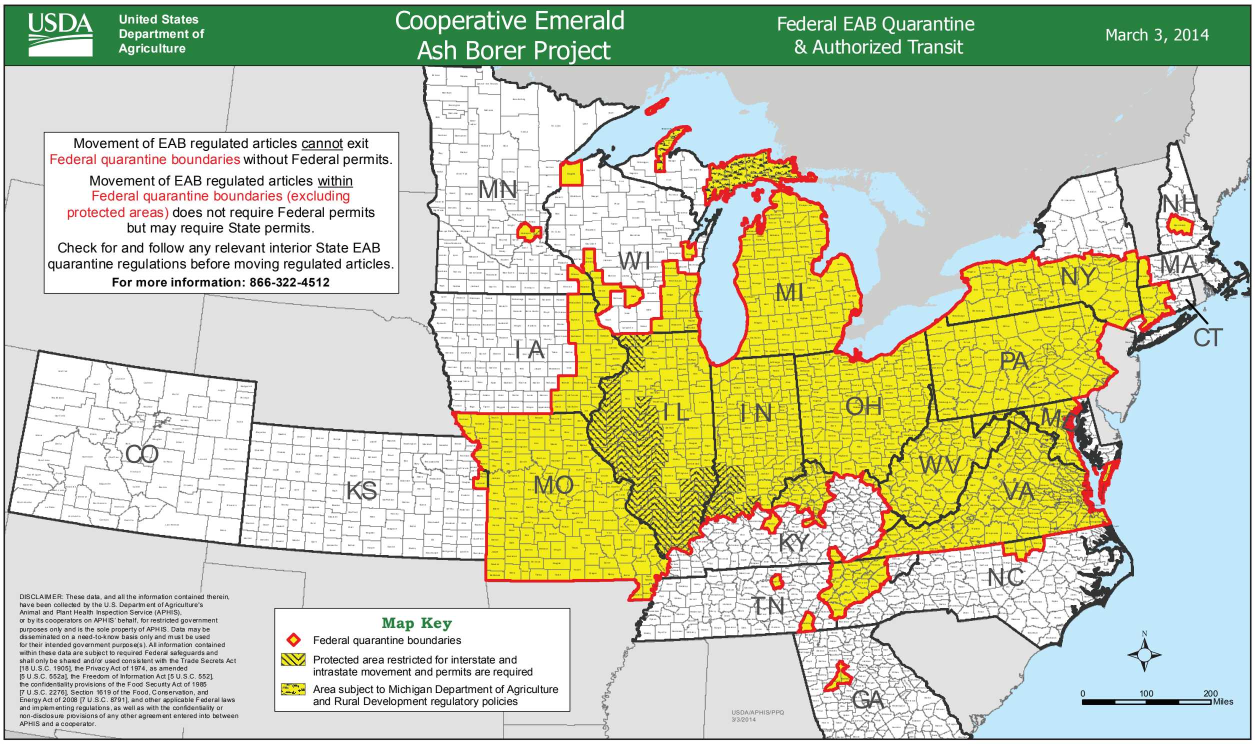

Figure 4. Federal emerald ash borer quarantine and authorized transit zones in the United States, as of March 2014 (www.emeraldashborer.info).

RISK COMMUNICATION

AS9: ***Public education is likely effective at raising awareness, but does not necessarily translate to success in terms of slowing the spread. Uncertainty: high.***

Supporting Evidence

All levels of government, including federal agencies (CFIA, NRCan-CFS), provincial agencies (OMNRF, MCWS, OMAFRA) and municipalities, are engaged in a variety of EAB education and awareness programs that include trade shows, workshops, media days, brochures and flyers, and media interviews. Many non-government organizations (e.g., Ontario Federation of Anglers and Hunters, Invasive Species Centre) also have their own outreach programs.

One of the common messages has been to not move firewood, since this has been seen as the major pathway for long-distance spread of EAB. In 2004, OMNRF initiated a "Don't Move Firewood" campaign with fact sheets, posters and displays at workshops and outdoor shows. Similarly, CFIA launched its campaign in 2008. Since then, CFIA has distributed thousands of brochures, posters and other communications products on its own and through partners. Road signage highlighting the risks of moving firewood has been installed in some locations by CFIA and municipalities, as well as by the province of Manitoba.

EFFECTIVENESS

The success of these efforts is extremely difficult and next to impossible to measure. The people who participate in workshops or attend seminars are often those who are already aware of the issue. For instance, the amount of firewood collected in bins does not indicate how many people actually use the bins.

Several other factors may also decrease the overall effectiveness of the firewood campaigns. "Don't move firewood" road signage can be difficult to interpret when drivers pass at highway speeds. It also refers to firewood in general, with no reference to emerald ash borer or regulated zones. As well, prime signage locations are often difficult to secure. Signs are also costly and have a lengthy approval process. In Manitoba, the province and some municipalities have worked together to erect signs on community boundaries instead of highway—an approach that reduces the approval time and moves the administration from highway departments to municipalities.

The real measure of success for a communication campaign is whether it has successfully changed people's behaviour: have people ceased the risk behaviour, or adopted the preferred behaviour, as a result of the campaign? Few, if any, communications programs build in metrics for assessing the effectiveness of the program campaigns.

To date, CFIA and OMNRF efforts have not been evaluated to determine whether they have been effective.

MONITORING EFFORTS

AS10: ***Current detection and monitoring efforts, combined with early detection challenges, will not be sufficient for the identification of all new infestations. Uncertainty: low.***

Supporting Evidence

A variety of tools and techniques are used to attempt to detect and monitor EAB. Branch sampling, visual assessments and traps are all available.

- Branch sampling is the most effective technique for detecting populations at low densities and before signs or symptoms are visible.
- Visual assessments are the least effective at low population densities, and can also be misleading because other factors can cause similar symptoms in the tree (e.g., drought-causing epicormic shoot growth).
- Trapping is effective at low to moderate population densities, but, overall, traps have a relatively short range for attracting adult beetles. The green leaf volatile lure is not specific to EAB, although it has been shown to increase trap capture in green prism traps. The EAB lactone pheromone also appears to increase capture of male EAB when the pheromone is included with the green leaf volatile in a green prism trap hung in the canopy of an ash tree. As of 2013, that combination represented about 10% of CFIA trapping efforts.

Trapping can be used to complement branch sampling efforts at low population levels. Sampling effectiveness at detecting EAB is directly related to sampling intensity, with sampling regimes generally being determined by resource availability.

Currently, CFIA monitoring efforts outside the quarantine zone are concentrated along main travel corridors and the outer boundary (Figure 5). Monitoring is minimal between Thunder Bay and Manitoba. These efforts are supplemented by surveys conducted by the provinces and some municipalities: MCWS (parks and other high risk areas), OMNRF (provincial parks and general forest health surveillance), the cities of Winnipeg and Thunder Bay, and some municipalities in northern Ontario and Manitoba. Monitoring is coordinated between the provincial government and CFIA to avoid duplication of efforts.

CFIA monitoring efforts for 2014 are described above in the "Current Regulatory Controls" part of this report.

EFFECTIVENESS

Although from a technical standpoint, ongoing research has resulted in improved detection and monitoring tools, early detection remains extremely challenging because of the intensity of sampling required to detect low density populations and the lack of signs or symptoms of infestation by EAB in the first few years following attack. Siegert et al. (2010) estimated that detection could take up to 10 years from EAB site establishment. However, as awareness has increased in recent years, so has the detection of dead trees.

Reductions in government funding and staffing for surveys will likely make the ability to effectively detect and monitor the spread of EAB increasingly challenging. There is also uncertainty as to whether the provinces will increase monitoring efforts as CFIA revises its approach. Although rates of detection could be improved with the formulation of a better lure, research is currently limited in this area.

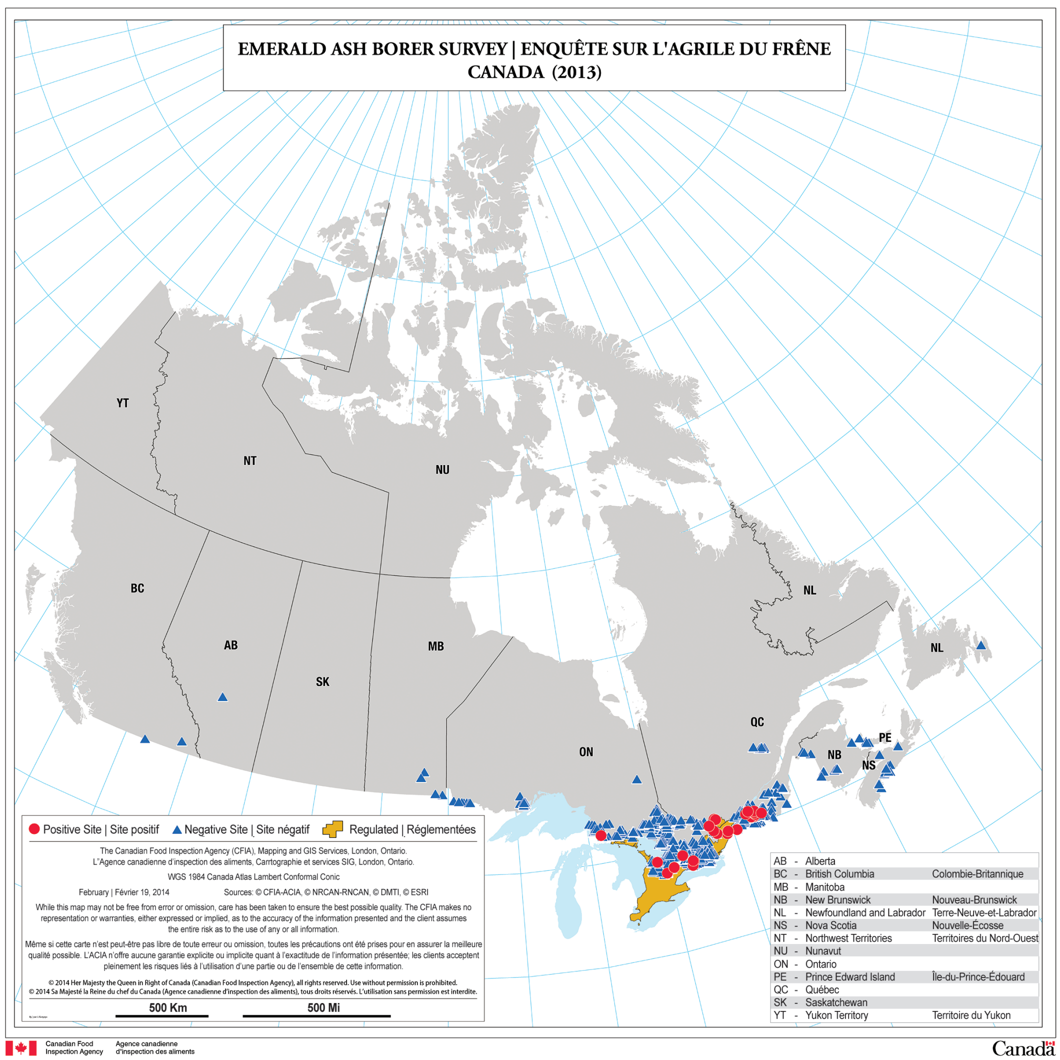

Figure 5. Emerald ash borer CFIA trapping results and distribution of trapping sites across Canada in 2013 (CFIA 2014).

TREATMENT EFFORTS

AS11: ***Eradication of EAB is not feasible or possible given detection and funding limitations. Rather, containment and slowing the spread are more realistic and attainable. Uncertainty: low.***

Supporting Evidence

Effective methods for containing or eradicating new infestations have never been developed, but would likely be based on size and age of the infestation, host availability and connectivity, resource availability, sampling regime and protocol, and EAB life cycle. Despite advances in detection tools, the ability to identify an incipient infestation that is relatively confined remains a challenge because of the intensity of sampling required. This makes the likelihood of eradication low, but increases the likelihood of containing and slowing the spread. A two-year life cycle could be advantageous by providing a lag time and hence greater containment or eradication success rates.

Effectiveness

Containment of EAB is likely to be more effective than eradication, given the challenge of identifying new incipient infestations. Just like eradication, however, containment success will also depend on the ability to detect new infestations and delimit their boundaries.

Early containment efforts were not successful for several reasons: 1) the low likelihood that all infestations would be found, given their small size; 2) the high likelihood that EAB had already spread to surrounding areas; 3) the fact that infested trees could be asymptomatic for a number of years; 4) the inability of the survey method used at the time (visual surveys) to detect newly infested trees, and 5) the lack of a registered insecticide to prophylactically treat adjacent uninfested trees and therapeutically treat asymptomatic trees.

Since then, key research advances have provided some of the tools necessary to eradicate a satellite infestation. Improved detection tools (e.g., branch sampling and prism trapping) do have the ability to find incipient infestations, and several insecticides are now available to treat trees in a buffer around trees known to be infested. Nonetheless, eradication of a satellite infestation using these tools has not been tried in Canada.

CONSEQUENCES OF INTRODUCTION

The consequences of introduction are determined by several factors: establishment and spread potential; and sociocultural, economic and environmental impacts.

ESTABLISHMENT AND SPREAD POTENTIAL

Once EAB has been introduced into a new area, its ability to persist, proliferate and spread depends on host availability, natural and human-assisted movement, dispersal potential, life cycle, and climate suitability. Those factors are reviewed below.

CLIMATE SUITABILITY

AS12: ***Colder climates will influence EAB population dynamics, with the potential for an increase in the proportion of the population with a two-year life cycle, which could negatively affect establishment, rates of population increase, and natural spread rates. The degree to which populations will be affected is highly uncertain; only that they will grow slower than populations with a one-year life cycle. The proportion*** *of the population with a two-year life cycle is expected to be high in Manitoba and northern Ontario, compared to what has occurred to date in Michigan and southern Ontario. Uncertainty: moderate.*

Supporting Evidence

- In the initial phases of population establishment, a two-year life cycle was reported at two locations in Michigan, with larval gallery densities being lower than a one-year life cycle and causing relatively little stress to attacked trees (Siegert et al. 2010). However, the higher incidence of a two-year life cycle in a newly established population may be a result of tree resistance mechanisms (Duan et al. 2010). As populations increase, they overcome the host resistance.
- Cold temperatures in northern locales may impede population growth such that (1) population densities may not be sufficient to cause tree mortality (Venette & Abrahamson 2010; DeSantis et al. 2013); and (2) spread rates will be slower (DeSantis et al. 2013). In EAB populations with a high incidence of two-year life-cycle individuals, many insects would overwinter as feeding stage larvae. However, no one has looked at cold tolerance in feeding stage larvae of EAB—information that would make predictions based on current knowledge less useful (B. Lyons, NRCan-CFS, pers. comm., March 2014).
- A recent model examining the interactions between EAB, cold winter temperatures, snow depth and the influence of tree bark found that temperature thresholds (<-35.3°C supercooling point, as determined by Crosthwaite et al. 2011) are most likely to be reached in Manitoba, and in northwestern Ontario through to the Quebec border in forests not influenced by the Great Lakes (Figure 6) (DeSantis et al. 2013).

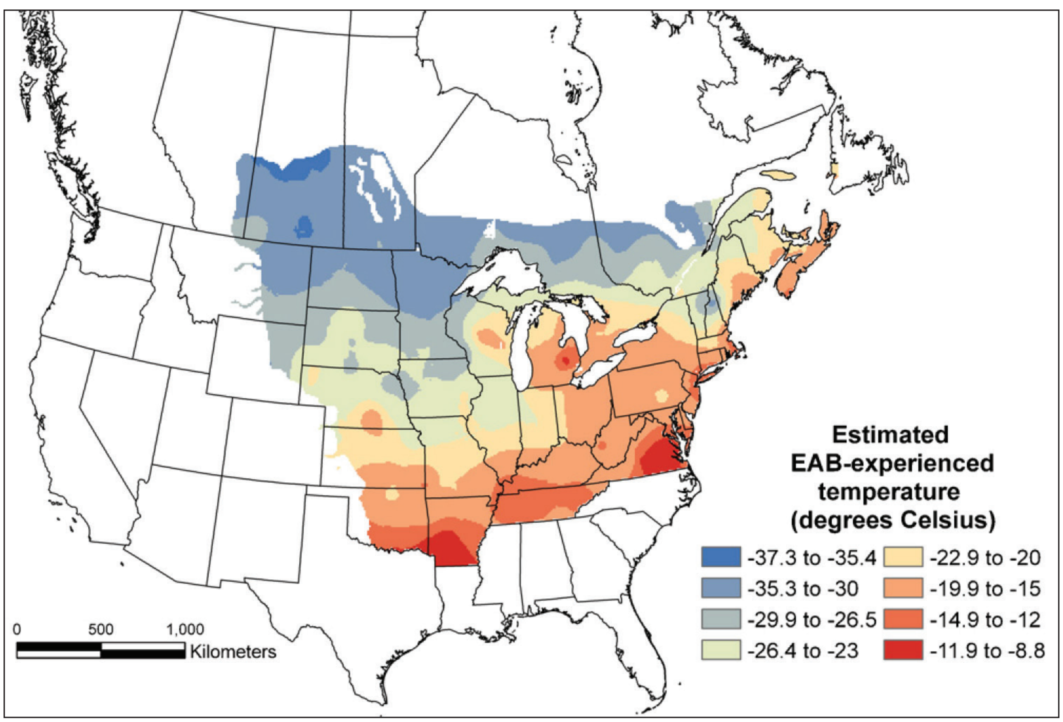

Figure 6. Coldest estimated EAB-experienced temperatures in the United States and Canada (DeSantis et al. 2013).

HOST AVAILABILITY

AS13: ***Green (red) ash in riparian corridors or shelterbelts and ash species in urban settings are more at risk of EAB population establishment and spread than is black ash, given the former's differences in connectivity and spatial heterogeneity. Uncertainty: low.***

Supporting Evidence

- Black ash grows in spatially discrete pockets, occurring north of Sudbury in Ontario and into Manitoba (Figure 2). Green (red) ash occurs along lakeshores and riverbanks in both Ontario and Manitoba, and is frequently planted in shelterbelts in Manitoba. About 217 000 ha of discontinuous green and black ash natural forest occur in Manitoba.
- In urban areas, both Winnipeg and Thunder Bay have completed ash inventories on public lands. Results show that ash account for 34% of city trees in Winnipeg and 25% in Thunder Bay.
- Manitoba conducted an ash inventory to determine the amount of ash present within the province, on public and on private lands. Among the findings was that shelterbelts older than 30 years have a 35% chance of having an ash component, while shelterbelts younger than 30 years have a 98% chance of containing ash.
- Given the limited number of tree species that can tolerate the climate in the prairies, it is estimated that western Canada may have eight times the incidence of ash trees as eastern Canada (McKenney et al. 2012).
- Siegert et al. (2010) found that ash phloem abundance and distance from epicentre—and not wind direction or land use type—influence directional movement of EAB. New attacks were generally found within 200 m of origin provided there was abundant phloem (and regardless of phloem abundance beyond 200 m). Similarly, Mercader et al. (2009) found that larval gallery density on newly attacked trees decreased with distance from adult emergence sites.
- The likelihood of successful EAB establishment can be increased by factors that contribute to maintaining a higher local population density, such as host density and availability of ash foliage for female adult feeding (Mercader et al. 2009).

MODE AND RATE OF SPREAD

AS14: ***Anthropogenic movement of firewood will be the primary means of spread into areas outside the regulated zone of the PRA area, with natural dispersal and anthropogenic movement contributing to spread within the PRA area. Overall, there is likely a low potential for natural spread due to fragmented host distribution and the negative impact of a 2-year life cycle, with the exception of a higher likelihood of natural spread within white ash forests in the regulated zone. Also, there is a low potential for movement via trains, nursery stock, and hitchhiking. Uncertainty: low.***

Supporting Evidence

- Movement of wood products, including logs, nursery stock and firewood, is considered a high-risk pathway for EAB. Current restrictions prohibit the movement of these untreated ash products out of a regulated area, but movement of firewood still occurs because of lack of awareness and non-compliance (Haack et al. 2010; Jacobi et al. 2011). Human-assisted EAB movement in the U.S. has been estimated to be between 25 and 100 km per year, most of which has been associated with movement of firewood (Muirhead et al. 2006).
- Marshall and Buck (2008) identified hitchhiking (e.g., without contact of host material) as a potential means of EAB dispersal, which would require one male and one female, or one gravid female.

- See supporting evidence statements for climate suitability and host availability.

ANTICIPATED TIMELINES FOR ESTABLISHMENT AND POTENTIAL SPREAD PATHWAYS

AS15: *EAB populations from the northern U.S. and infested areas in northern Ontario will continue to move northward and become established in campgrounds along the U.S. border, the nearby cities of Winnipeg and Thunder Bay, and communities within the regulated area in Ontario in less than 10 years. Once established, EAB will move outward and spread to small communities along the Highway 17/Highway 1 corridor and linear forests in Manitoba. Uncertainty: moderate to high.*

AS16: *EAB populations from the northern U.S. and infested portions of Ontario will be introduced into the unregulated portion of northern Ontario in 1–30 years with slow spread rates once established. Spread will be slowed due to the potential for a 2-year EAB life cycle; the relatively low-density road network and human population (compared with those in the Minnesota/Michigan/Wisconsin corridor); and the spatial discontinuity of the major host, black ash (which will reduce the likelihood of infested materials being moved by humans and of natural spread finding a suitable host). Uncertainty: moderate.*

AS17: *Movement northward from Minnesota, western and upper Michigan, and Wisconsin will likely be due to anthropogenic movement (vehicle traffic and firewood movement). There is likely a low potential for natural spread, due to fragmented host distribution and the negative impact of a 2-year life cycle (resulting from colder temperatures) on population growth and spread. As well, there is a low potential for movement via trains or nursery stock. Uncertainty: moderate.*

- Preliminary data from a recent model developed by Yemshanov et al. (2013) examining the risk of firewood movement to provincial, state and federal parks found high-risk areas through the Lake Superior corridor, including Thunder Bay and Quetico Provincial Park, and the City of Winnipeg, Kenora and cities/communities within the regulated zone (Figure 7).
- Well-travelled highway corridors represent the greatest risk for the movement of commercial truck transport of wood products (Yemshanov et al. 2012) (Figure 8). Based on EAB distribution data to February 2011, this model identified the following high-risk cities or sites in the pest risk analysis area:
  - in Manitoba – City of Winnipeg and a border crossing in Manitoba;
  - in Ontario – Dryden, Thunder Bay, White River, Hearst, Timmins, Kirkland Lake, New Liskeard.
- On average, distance between stands of host material may be significantly greater than the average female flight distances. Based on flight mill studies, Taylor et al. (2010) determined that mated females fly farther than unmated females or males, averaging >3 km/day for the majority of the mated females.
- Prasad et al. (2010) found that there is an increased risk of finding EAB within 2 km of roads.
- Probability of infestation is inversely related to distance from EAB epicentres, but positively related to the size of human population centres (Muirhead et al. 2006).
- Most initial finds have been in large urban centres, adjacent to rest stop, or near campgrounds.

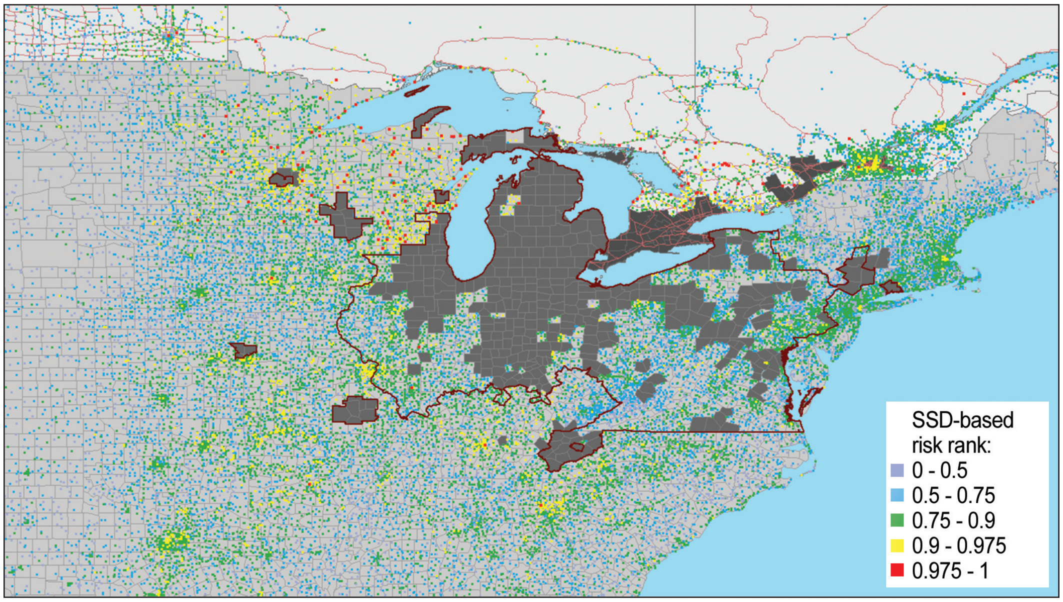

Figure 7. Risk of EAB long-distance spread, via camper travellers in provincial, state and federal parks (grey indicates 2013 regulated areas, SSD=second degree stochastic dominance criteria) (Yemshanov et al. 2013).

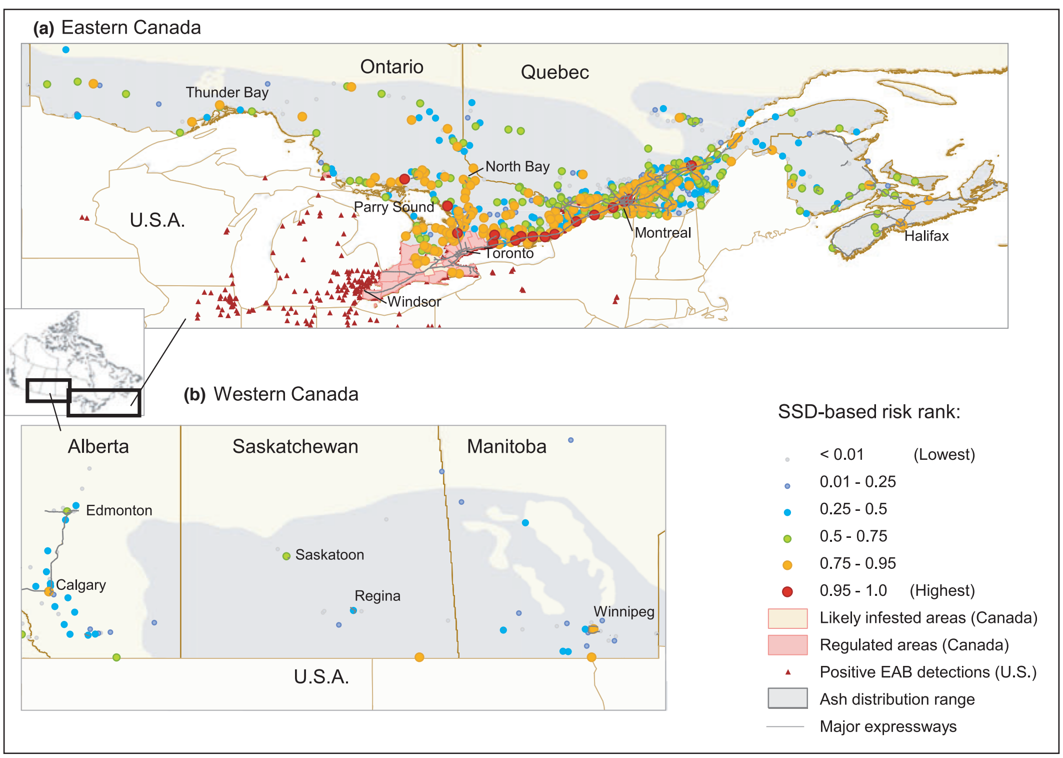

Figure 8. Risk of EAB long-distance spread via commercial freight operation, for major Canadian municipalities (Yemshanov et al. 2012). SSD=second degree stochastic dominance criteria.

SOCIOCULTURAL, ECONOMIC AND ENVIRONMENTAL IMPACTS

This section summarizes the range of key sociocultural, economic and environmental impacts that EAB infestation can have on First Nations, and by forest type e.g. urban, woodlots or managed forests, and linear forests. Economic impacts associated with enforcement are pertinent to all forest types.

IMPACT ON FIRST NATIONS

- Cultural and economic impact: loss of cultural values, and the economic opportunities associated with those values, related to First Nations' use of ash (black ash in particular) in basketry and other traditional crafts.
- Ecological impacts: damage to forest habitats and riparian areas of importance to First Nations.

IMPACTS IN URBAN FORESTS

- Economic impacts: costs associated with –
  - » loss in aesthetic, amenity and property values, and increases in heating and cooling costs
  - » management of EAB, including costs to remove hazard trees (i.e., dead trees), conduct surveys, treat high-value trees with insecticides, and replace trees; and
  - » property damage caused by falling trees (e.g., clean-up costs, costs to repair structural damage).
- Ecological impacts: loss of ecological services provided by trees, including absorption of pollutants and prevention of soil erosion.
- Impacts similar to those noted in woodlots and managed forests in large urban woodland settings with a component of ash (e.g., parks).
- In 15 states in the U.S. between 1990 and 2007, researchers estimated that a loss of trees to the EAB increased human mortality related to cardiovascular and lower-respiratory-tract illness, with higher mortality rates being recorded in counties with above-average median incomes (Donovan et al. 2013).
- Preliminary results from studies in Ontario forests indicate that forest composition and succession are impacted by EAB, with urban landscapes being at high risk to invasion and site dominance by non-native plants (Aubin et al. 2012).
- A recent study estimated that the potential costs of EAB to Canadian municipalities over a 30-year time horizon was $524 million—and about $890 million when costs associated with backyard trees were included (McKenney et al. 2012). These findings were based on a moderate spread rate of 30/km year. When considering a faster spread rate of 50 km/year, the City of Winnipeg was expected to bear some of the heaviest EAB-related losses, at $172 million, just slightly higher than the moderate impacts at $167 million.
- Data from Ontario in 2013 show that affected municipalities have already spent $71 million on EAB management, and expenditures of $365 million are planned over the next 10 years (T. Scarr, Ontario Ministry of Natural Resources, 2014, unpublished data).
- A U.S. study found that the cost of EAB impact (US$1.3 billion) is being largely borne by municipal governments and homeowners (household expenditures and residential property value loss) (Figure 9), and that these costs (for tree removal, replacement and treatment) outweigh the costs of federal government containment programs by at least one order of magnitude (Aukema et al. 2011).

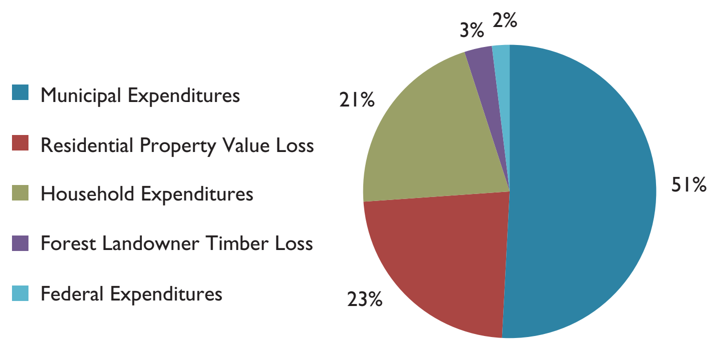

Figure 9. Distribution of costs incurred for emerald ash borer management in the United States, by cost category (Aukema et al. 2011).

IMPACTS IN WOODLOTS AND MANAGED FORESTS

- In 2009, aerial surveys delineated approximately 7300 ha of infested forests (Scarr et al. 2012) in southern Ontario. The area affected has greatly increased since those surveys. By the end of 2012, the area of ash decline and mortality caused by EAB had reached 69 919 ha.
- In a study in Ohio, eradication efforts led to an 18% increase in invasive plants in resultant gaps, compared with the presence of invasive plants in undisturbed or unmanaged areas (Hausman et al. 2009).
- Canopy gaps resulting from ash tree mortality have been shown to provide for establishment of native and non-native invasive species (DeSantis et al. 2012), leading to changes in biotic diversity, including of herbivore species.
- In riparian zones affected by EAB, erosion along stream banks and changes to stream temperatures can harm aquatic ecosystems.
- EAB affects other arthropod species, such that multiple extinctions of those affiliated species could occur (Gandhi & Herms 2009).
- Ecological impacts inlcude loss of shade-tolerant plants, loss of nutrient cycling, loss of aquatic ecosystem sustainability, and changes to stream temperature (Kreutzweiser et al. 2010).
- Trees die more rapidly in stands with lower ash densities. However, the eventual overall stand mortality level remains the same regardless of density: about 99% of ash dies within six years (Knight et al. 2012).
- Healthier trees die more slowly than do stressed trees (Knight et al. 2012).
- EAB regulatory controls could impact wood supply for mills and therefore the local economy, as well as lead to restricted movement of wood by-products (including firewood).

IMPACTS IN LINEAR FORESTS

- Many linear forests have an ash component that provides a variety of services to rural and agricultural areas. Ash mortality can negatively affect any or all of these services, depending on the linear forest application (Agriculture and Agri-Food Canada 2010), as shown below:

Type area	Linear forest service
Farmyards	snow control, reduced energy costs, increased aesthetic value
Field	reduced soil erosion, increased crop productivity
Roadside	trapping of blowing snow, privacy, noise and dust reduction
Livestock	protection, screening, filtering of dust and odours
Wildlife	habitat support, provision of wildlife food and shelter
Riparian	stabilization of soil, improved water quality, enhanced habitat

- Linear forests also assist in drought-proofing of the prairie region by reducing sublimation losses (Kort et al. 2011).
  - Ash mortality and falldown may impede water flow as a result of debris build-up in waterways.

Risk Response

Proactive risk management includes developing and implementing preparatory tactics in advance of EAB establishment (prevention) and suppression tactics in the early stages of an infestation. A recent study in the U.S. found that spending on activities to prevent new satellite EAB populations from establishing, or to slow the expansion of existing populations, can be cost-effective. It also found that continued research on the cost and effectiveness of prevention and control activities is warranted (Kovacs et al. 2011).

The success of risk response hinges on many factors, but effective early detection and monitoring are the most critical. This means that a well-informed and designed detection and monitoring plan should incorporate lessons learned from the current infestation. Among those lessons are the following:

1. Based on historical initial findings, the following sites should be targeted in order of priority:
   i. Urban areas – boulevard trees, major intersections, and areas with a high concentration of ash
   ii. Rest stops
   iii. Long-term campgrounds (private, non-regulated)
   iv. Short-term campgrounds (including parks)
   v. Nurseries
2. A training program is highly recommended because most detections have been made by city arborists, CFIA, OMNRF and other personnel trained to identify EAB or symptoms of EAB infestation.
3. Trapping and branch sampling are more effective than visual sampling.
4. Branch sampling is effective at detecting low population densities. Sampling two branches per tree provides a 74% probability of detection (Figure 10). Sampling procedures are available online at http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/32127.pdf.
5. Trapping has short-range effectiveness and is most effective at moderate population levels. Traps can be reasonably effective at low population densities, and can be used in combination with branch sampling.
6. Visual sampling is not effective at low population densities.

7. Sticky bands are effective and cheaper than traps or branch sampling.
8. Sampling regime and intensity should be based on resource availability.
9. Success of a program will be based on a combination of all the detection tools noted above.

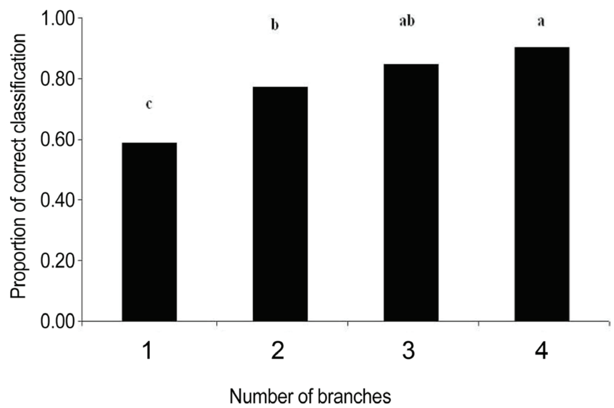

Figure 10. Level of confidence associated with branch sampling for EAB, by number of branches sampled (Ryall et al. 2011).

Several mitigation tactics exist and are described in the preparatory sections below. The use of biological controls is one of them. However, at the time this analysis was done, the efficacy of biological controls to limit the damage caused by EAB had not been demonstrated. In a classical biological control program in the U.S., three species of parasitoids from China have been released in 14 states. One of these species was also released in southern Ontario in 2013 and 2014 as part of a pilot project by NRCan-CFS. All three species of parasitoids have become established and dispersed in the U.S., but control of the associated EAB populations has yet to be proven. Therefore, it is not recommended that land managers focus on classical biological control as a mitigation tactic because it has yet to be proven. The benefits from these releases may also take a long time to be realized. Nonetheless, management actions such as tree injections with insecticides to keep trees alive buys time for this and other research into native parasitoids to mature.

Depending on provincial and municipal mandates, the roles and responsibilities for preventing and managing EAB will vary. Therefore, the following discussion of potential actions for different settings—urban, woodlots and managed forests, and linear forests—does not assign roles or responsibilities to provinces or municipalities (unless it is explicit to one party). Collaborative efforts are highly encouraged wherever possible.

PREPARATORY ACTIONS – PREVENTION

With the variety of stakeholders and jurisdictional boundaries associated with management of EAB, a collaborative approach with clearly defined roles and responsibilities is strongly encouraged. Michigan, for example, has developed a community preparedness plan[4] that provides stakeholders with guidelines and templates on how to prepare for and manage EAB. In another example,

[4] Available at www.michigan.gov/documents/mda/EAB_preparedness_194302_7.pdf.

Minnesota has developed an EAB response plan, a mock response exercise, a readiness plan, science-based recommendations, and strategies for managing introductions.[5]

Institutional arrangements, such as memoranda of understanding between affected jurisdictions, can facilitate discussion for development of such tools.

URBAN FORESTS

1. Familiarization

   Seek advice and guidance from others who have gone through a similar experience, and capitalize on lessons learned. Look for and participate in hands-on learning opportunities, such as workshops. Attendance at these events will also help establish a network of knowledgeable individuals, ranging from urban foresters to research scientists.

2. Communication and Public Education

   Develop a comprehensive communication strategy that focuses on transparency, accountability and science-based evidence. The strategy should include a department communication plan, as well as plans to garner political support and to manage the media, entrepreneurs (selling "remedies") and opposition groups. Consideration could be given to having a non-profit or non-government entity manage public relations.

   There are many successful communication programs to draw from. These include the Canopy Club in the Town of Oakville, the first detectors program in Minnesota, and various citizens' coalitions (such as Trees Winnipeg or Save Your Ash). WaspWatchers, a citizen-scientist program that uses people to help identify and monitor wasp colonies (*Cerceris fumipennis*) that prey on buprestid beetles (including EAB) for their nests, is also a form of biosurveillance successfully used in Ontario and portions of the northeast U.S. (It is unknown, however, if the wasps exist in this pest risk analysis area, but adoption of a WaspWatchers program could assist with delineating their distribution.)

   Effective tools include use of social media, websites, brochures, and give-away items such as cups, key chains, fridge magnets and water-soluble tattoos for kids. Another effective tool is the use of door hangers to inform property owners of any management activities in their neighborhoods. Random firewood checks also raise awareness and should target potential pathways such as those frequented by hunters, anglers or tourists.

3. Planning

   Develop an EAB management plan that includes or addresses the following elements:

   » tree inventory
   » legislation for removal of trees on private land
   » socioeconomic analysis
   » identification of disposal sites and measures and protocols to properly dispose of infested material (see Appendix 1)
   » logistics of wood disposal (e.g., of wood chips), transportation costs and availability of vehicles to transport wood and yard waste

[5] Available at www.mda.state.mn.us/en/plants/pestmanagement/eab/eabplanning.aspx.

» wood utilization strategy for recovering costs from the potentially large volume of wood waste.

– Would include identifying potential markets for affected wood products (e.g., soliciting input or interest in such products as wood chips, mulch and compost). A good resource is a recent USDA publication on use options for urban trees: www.fpl.fs.fed.us/news/newsreleases/releases/20130212.shtml.

4. Mitigation (could be a component of item 3 [Planning] if timing allows).

» Stop planting ash trees now. Diversify urban landscape species portfolios.

» Underplant with a non-host species whenever possible.

» Consider implementing non-regulatory controls, such as providing firewood drop boxes or firewood exchanges, to help prevent the introduction of EAB and to increase public awareness.

» As a preemptive strategy, remove poor quality or hazard trees. Otherwise, removal after EAB establishment can become overwhelming, and land managers may not able to keep up. Removal can occur gradually, on a planned schedule.

– ***NOTE: This option is recommended only for areas with high ash density and where there is high certainty that EAB will establish. Given the high uncertainty around establishment timeframes, it is possible that other management options may become available.***

» Treat trees with insecticide when EAB is detected within 25 km. This prescription assumes that EAB has a high probability of arriving at a site in that season.

5. Monitoring (could be considered a component of item 3 [Planning] if timing allows)

» Develop a monitoring component to the management plan

– Consider two-stage sampling (detection and delimitation surveys). Stage one should complement trapping efforts of CFIA or the province. Stage two should be initiated once one instance of EAB has been detected within a predefined geographic area, as determined by host availability, connectivity or a tolerance threshold defined by a municipality (e.g., an important green space/park). Stage two sampling efforts would be intensified and possibly expanded and include a mixture of both trapping and branch sampling. The objective of stage two sampling efforts is that of delimitation of infested trees.

WOODLOTS AND MANAGED FORESTS

A landowner's guide prepared by OMNRF outlines approaches to reducing the impacts from EAB in woodlots and linear forests (Streit et al. 2012). The guide recommends applying tree-marking principles to reduce the ash component in woodlots and forested areas. This strategy involves removing ash over time and favouring regeneration by preferred tree species. The objective is to control the timing and size of canopy openings in stands with >30% ash by selectively removing the ash and leaving or underplanting preferred tree species. This approach will not control EAB, but will help direct the future stand composition away from invasive plant species and towards high-value tree species. Williams and Schwan (2012) also provide recommendations for foresters in managing the basal area of stands affected by EAB.

Preventative or anticipatory measures to reduce the impacts of EAB include the following:

1. Management

» Conduct a tree inventory that includes standard mensuration data (e.g., species, age, size).

- » Increase stand diversity (Streit et al. 2012) through:
  - – thinning of stands to reduce the ash component
    - Allows for recovery of economic value, and control of stand openings, but does not slow or reduce tree mortality as EAB invades a stand.
    - A potential consequence of thinning is increased individual tree mortality rates. However, at a stand level the outcome remains similar: the same level of overall mortality occurs over the course of an infestation (Knight et al. 2012).
  - – selection management
    - If a forest is >30% ash, gradually reduce the ash component by removing 25–30% of pre-harvest basal area in each stand entry.
    - If a forest is <30% ash, then remove 33% of the pre-harvest basal area of all species.
    - Favour removal of stressed trees wherever possible.
  - – uniform shelterwood management
    - Target 70% crown closure to encourage growth of non-ash species.
    - Retain non-host species in the understory.
  - – underplanting or promotion of regeneration of non-host species, and retaining of non-ash species as crop trees.
- » Manage openings to reduce invasive or native weed species.

A potential disadvantage of thinning and selection management as a preventative measure is that the timing of operations may not coincide with optimum market conditions (e.g., there could be no demand or a saturated market). In addition, there is a high degree of uncertainty about when EAB will invade a specific woodlot or forest.

2. Education

   Encourage landowners to educate themselves about managing for EAB. For instance, encourage them to obtain a copy of the OMNRF publication, *Preparing for Emerald Ash Borer: A Landowner's Guide to Managing Ash Forest* (Streit et al. 2012), to attend workshops and other EAB information sessions, and to consult reputable online resources.

LINEAR FORESTS

The OMNRF publication (Streit et al. 2012) also discusses preventative measures for reducing impacts of EAB on linear forests: shelterbelts, windbreaks and riparian buffers. Management options include maintaining or underplanting with non-host species to enhance species diversity. As for woodlots and managed forests, landowners of linear forests are encouraged to educate themselves on EAB and its potential impacts, and to keep abreast of the known distribution of EAB in proximity to their area.

Public awareness campaigns about EAB should also include a component that highlights the significance of linear forests.

EARLY STAGES OF ESTABLISHMENT

This phase occurs when EAB has been detected in a given area, with some evidence of infested trees. **All preparatory actions should be in place, and strategies and tactics (e.g., communication and mitigation) should continue to be implemented.**

Monitoring tactics include both detection and delineation. Management tactics include tree removal and insecticide treatments. Communication strategies focus on transparency and accountability of management actions. These are summarized below, by forest type.

URBAN FORESTS

- Delineate the infested area using a combination of trapping (in the summer) and branch sampling (to determine which trees are actually infested). Consideration should be given to an integrated approach, using different methods at different times and locations.
- Remove heavily infested trees and dispose of them properly (see Appendix 1). Replace them with a diversity of non-host species.
- Apply insecticide treatment on lightly infested trees (e.g., where EAB is present with low gallery densities, trees showing no signs or symptoms of infestation, and uninfested high value trees). Consider treating trees with insecticide not just for the prevention, but as a means to reduce the rate at which individual infested trees die. This will allow planted replacement trees to reach effective height, and also staggers mortality so use of resources for tree disposal can be spread over several years rather than all at once.
- As part of the management plan, develop incentives to encourage homeowners to participate in programs aimed at prevention and management, such as cost-sharing and data sharing.
  - » For example, the City of Peterborough offers property owners the chance to win a free tree insecticide treatment if they add their trees to the city inventory. The City of Oakville has an agreement with the company conducting tree injections for the city to offer private landowners the same price.
- Expand the communication strategy to inform the general public of new infestation status, and provide fact sheets or advisory notes to make all actions transparent. Potential communication avenues include social media, websites, tree clubs and community plans.

WOODLOT AND MANAGED FORESTS

- Consider treating ecologically significant (e.g., riparian trees) or high-value trees or patches with insecticide—not just for prevention, but also as a means to reduce the rate at which individual infested trees die. This will allow planted replacement trees to reach effective height, and will also stagger mortality to ensure that tree disposal resources are available over several years rather than all at once.
- Remove heavily infested trees and dispose of them properly (see Appendix 1); and replace them with a diversity of non-host species.
- Manage gaps to discourage growth of invasive species.

LINEAR FORESTS

- Consider treating ecologically significant (e.g., riparian trees) or high-value trees or patches with insecticide – not just for prevention, but also as a means to reduce the rate at which individual infested trees die. This will allow planted replacement trees to reach effective height, and will also stagger mortality to ensure that tree disposal resources are available over several years rather than all at once.
- Remove heavily infested trees and dispose of them properly (see Appendix 1); and replace them with a diversity of non-host species.

Summary

No biological impediments or regulatory controls exist to prevent the spread of EAB into the unregulated portion of northern Ontario and Manitoba. While the new regulatory buffer-like approach to delineating boundaries has a greater likelihood of capturing the majority of satellite infestations, it also provides for long-distance human-assisted movement of infested material within this larger regulated zone—thereby, possibly hastening the incidence along the perimeter.

When introduction will occur is uncertain, but the cities of Winnipeg and Thunder Bay are expected to be infested with EAB within 10 years. Elsewhere in the pest risk analysis area, occurrences are expected within 1–30 years. Populations will likely originate from Minnesota and infested areas in Ontario.

Spread rates will be slower than in southern Ontario and the U.S. because of the colder climates.

The following summarizes the evidence (and associated uncertainties) and the information gaps, presented in the risk assessment section of this report.

EVIDENCE

1. Current regulatory controls, risk communication, and monitoring and treatment efforts will not be sufficient to prevent the introduction of EAB into the pest risk analysis area (low uncertainty).
2. The possibility of a two-year life cycle and spatial heterogeneity of host material will slow the northward progression of EAB, but to what degree is unknown (moderate uncertainty).
3. Host availability and anthropogenic movement of EAB will facilitate movement into northern Ontario and Manitoba, with establishment expected to occur first in cities and campgrounds near the U.S. border and communities within the regulated zone in Ontario, followed by spread to outlying communities or forests along major highway corridors (moderate uncertainty).
4. Impacts will be significant for all forest types and all stakeholders (low uncertainty).

INFORMATION GAPS

- the frequency of a two-year life cycle in the pest risk analysis area and its effect on population dynamics (e.g., higher mortality of larvae by predators and parasitoids might occur because of the longer time spent under the bark)
- the influence of regional climate on EAB larval mortality, tree mortality and rates of decline
- the distribution of black ash in northern Ontario (current inventories frequently lump ash with other hardwood species)
- the survival rates of two-year life cycle EAB in firewood
- the frequency of anthropogenic movement
- the probability and rates of establishments in new introductions
- the influence of landscape structure on the distance dispersed by mated females
- the influence of ash species and forest habitat on reproductive rates
- the effect of regulatory controls (movement bans, containment efforts, communication strategies) on mitigating spread
- the fate of local EAB populations once host has been removed
- improved lure for detection purposes

To manage EAB requires taking preparatory steps before the insect arrives, and making plans to slow its spread when it is discovered. These activities should include: regulation of the movement of infested material; public awareness and education campaigns to delay introductions; implementation of a monitoring program to detect new infestations sooner; development of rapid response plans with a combination of mitigation tools that can be implemented as soon as infestations are detected; and long-term planning (including for species diversification) to minimize the long-term impacts of EAB in communities.

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Appendix 1

CFIA DIRECTIVE D-03-08, APPENDIX 5 AND 6

APPENDIX 5: CFIA-APPROVED DISPOSAL METHODS FOR NON-COMPLIANT REGULATED ARTICLES

The following methods are approved by the CFIA for disposing of non-compliant regulated articles:

- Incineration that complies with municipal by-laws and environmental laws.
- Deep burial with a minimum soil overburden of 2 m, with immediate soil coverage. Provincial or municipal regulations may apply for the disposal of organic matter. Contact the local municipality and/or your provincial department of environment for further information.

Other methods must be approved by the CFIA. Contact the local CFIA office for further details.

APPENDIX 6: CFIA-APPROVED TREATMENT METHODS

The following methods are approved by CFIA for treating regulated articles to generate compliant articles:

- Processing to create bark-free wood and removal of underlying sapwood to a depth of at least 2.5 cm.
- Grinding or chipping to create chips to a size of less than 2.5 cm in any two dimensions.
- Article exclusion of ash for firewood and wood chips under a compliance program.
- Heat treatment for regulated articles, where specific treatment schedules have been recognized by CFIA.
- Secondary processing to produce wood by-products such as paper, fibre board, or oriented strand board to render the articles free from EAB. The processing facility has to be approved by CFIA.

Other treatment methods, as approved by CFIA. Contact the local CFIA office for further details.

Appendix 2

RISK ANALYSIS WORKSHOPS AND PARTICIPANTS

Workshop 1. Sault Ste. Marie Emerald Ash Borer Knowledge Synthesis – November 2012

Participants:

Canadian Forest Service	• Kevin Porter • Barry Lyons • Chris MacQuarrie • Dan McKenney • Denys Yemshanov • David Kreutzweiser • Krista Ryall
Canadian Food Inspection Agency	• Mireille Marcotte • Martin Damus • Erin Bullas-Appleton
Manitoba Conservation and Water Stewardship	• Fiona Ross • Irene Pines • Jon Leferink
Ontario Ministry of Natural Resources	• Taylor Scarr
City of Montreal	• Antony Daniel

Workshop 2. Sault Ste. Marie Emerald Ash Borer Knowledge Synthesis – March 2013

Participants:

Canadian Forest Service	• Kevin Porter • Krysta Ryall • Barry Lyons
Manitoba Conservation and Water Stewardship	• Fiona Ross
Ontario Ministry of Natural Resources	• Taylor Scarr
National Forest Pest Strategy	• Janice Hodge