Species at Risk Act
Management Plan Series

Management Plan for the Blue Ash (*Fraxinus quadrangulata*) in Canada

Blue Ash

2016

Government of Canada / Gouvernement du Canada

Canada

Recommended citation:

Environment Canada. 2016. Management Plan for the Blue Ash (*Fraxinus quadrangulata*) in Canada. *Species at Risk Act* Management Plan Series. Environment Canada, Ottawa. iv + 25 pp.

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Cover illustration: Blue Ash on Pelee Island by John Ambrose. *This photograph may not be reproduced separately from this document without permission of the photographer.*

Également disponible en français sous le titre
« Plan de gestion du frêne bleu (*Fraxinus quadrangulata*) au Canada »

ISBN 978-0-660-04377-7
Catalogue no En3-5/69-2016E-PDF

[1] http://www.registrelep-sararegistry.gc.ca

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed species of special concern and are required to report on progress five years after the publication of the final document on the SAR Public Registry.

The Minister of the Environment and the Minister responsible for the Parks Canada Agency are the competent ministers under SARA for the Blue Ash and have prepared this management plan as per section 65 of SARA. To the extent possible, it has been prepared in cooperation with the Government of Ontario, and any others as per section 66(1) of SARA.

Success in the conservation of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Environment Canada and the Parks Canada Agency, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this plan for the benefit of the Blue Ash and Canadian society as a whole.

Implementation of this management plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

[2] http://registrelep-sararegistry.gc.ca/default.asp?lang=en&n=6B319869-1#2

Acknowledgments

The initial draft of this management plan was prepared for the Canadian Wildlife Service by Judith Jones, Winter Spider Eco-Consulting. The document was facilitated by Bruna Peloso (Consulting Biologist). Madeline Austen, Lesley Dunn, Elizabeth Rezek (Environment Canada, Canadian Wildlife Service - Ontario) reviewed and provided comments and advice during the development of this document. The management plan has also benefited from input, review and suggestions from the following individuals: Manon Dubé (Environment Canada, Canadian Wildlife Service -National Capital), Region), Tammy Dobbie and Gary Allen (Parks Canada Agency), and Ontario Ministry of Natural Resources and Forestry[3] staff.

The following people are gratefully acknowledged for providing information: Mhairi McFarlane, The Nature Conservancy of Canada; Tammy Dobbie, Point Pelee National Park; Muriel Andreae, St. Clair Region Conservation Authority; Carol Quinlan, Upper Thames River Conservation Authority; and Bill Rozel, City of Windsor. John Ambrose is thanked for the use of the photo on the cover.

Acknowledgement and thanks is given to all other parties that provided advice and input used to help inform the development of this management plan including various Aboriginal organizations and individuals, landowners, citizens and stakeholders who provided input and/or participated in consultation meetings.

[3] In July, 2014, the Ontario Ministry of Natural Resources (OMNR) became the Ontario Ministry of Natural Resources and Forestry (MNRF).

Executive Summary

Blue Ash (*Fraxinus quadrangulata* Michx.) is currently listed as special concern on Schedule 1 of the *Species at Risk Act* (SARA) and as special concern under the Ontario *Endangered Species Act 2007* (ESA).

Mature Blue Ash is a medium-sized tree generally less than 21m tall, with opposite, compound leaves. The oval leaflets have short stalks, long-tapering tips, and low teeth on the margins. Although mature trees are somewhat shade tolerant, the seedlings appear to require light for successful establishment. Blue Ash is known to have mast years where there is heavy fruiting and then may have several years in between mast years with little or no fruiting. Blue Ash may easily be confused with other ash species and is probably frequently overlooked or misidentified.

In Canada, Blue Ash is found in Elgin, Essex, Chatham-Kent, Lambton and Middlesex Counties, and on some islands in Lake Erie, especially Pelee Island. Some of the largest populations are in the watersheds of the Thames River, Sydenham River, and Catfish Creek. In 2000, approximately 37 Canadian occurrences of this species were recognized by COSEWIC, with an estimated fewer than 1,000 trees in total in Canada, based on counts at 21 sites. There may be 40 or more occurrences in Canada, however recent population numbers to determine total abundance are not available.

Threats to Blue Ash include damage or mortality from the invasive Emerald Ash Borer; loss of habitat from conversion of land to agricultural fields, urban development, aggregate operations, or vineyards; livestock grazing; off-trail recreational activities; damage and nitrification of soils from Double-crested Cormorants (*Phalacrocorax auritus*); and lack of natural disturbance to maintain suitable conditions.

The management objective for Blue Ash is to maintain the current distribution and abundance of the Canadian population of Blue Ash.

A number of conservation measures are suggested which will best be achieved through an integrated approach with recovery initiatives for other species co-occurring in forest habitats occupied by Blue Ash within the Carolinian Zone of Canada.

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1. COSEWIC* Species Assessment Information

Date of Assessment: November, 2000

Common Name (population): Blue Ash

Scientific Name: *Fraxinus quadrangulata*

COSEWIC Status: Special Concern

Reason for Designation: A tree of restricted range within the Carolinian forests of southwestern Ontario where extensive habitat alterations and losses have occurred and populations at risk from habitat disruption.

Canadian Occurrence: Ontario

COSEWIC Status History: Designated Threatened in April 1983. Status re-examined and designated Special Concern in November 2000.

*COSEWIC (Committee on the Status of Endangered Wildlife in Canada). COSEWIC is currently re-assessing the status for Blue Ash in Canada (as of November 2014).

2. Species Status Information

Blue Ash (*Fraxinus quadrangulata* Michx.) is currently listed as special concern[4] on Schedule 1 of the *Species at Risk Act* (SARA) and as special concern[5] under the Ontario *Endangered Species Act 2007* (ESA). Blue Ash has conservation status ranks of secure[6] globally (G5) and vulnerable[7] nationally (N3) and subnationally in Ontario (S3). Table 1 shows the subnational conservation status ranks of Blue Ash in the 19 states were it occurs in the United States of America (NatureServe 2014):

[4] Special Concern (SARA): A wildlife species that may become a threatened or an endangered species, because of a combination of biological characteristics and identified threats.
[5] Special Concern (ESA): A species living in the wild in Ontario, which is not endangered or threatened, but may become threatened or endangered due to a combination of biological characteristics and identified threats .
[6] Secure: At very low risk of extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats (NatureServe 2013).
[7] Vulnerable: At moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors (NatureServe 2013).

Table 1. Subnational conservation ranking of Blue Ash in Canada and the U.S.

Subnational Rank	State
Critically Imperilled (S1)[a]	Iowa, Pennsylvania, West Virginia, Wisconsin and Georgia (S1S2[b])
Imperilled (S2)[c]	Kansas, Mississippi, and Oklahoma (S2S3)
Vulnerable (S3)	Ontario, Virginia
Secure (S5)	Kentucky
Not ranked (SNR)	Alabama, Arkansas, Illinois, Indiana, Michigan, Minnesota, Missouri, Ohio, Tennessee

[a] Critically Imperilled: At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors (NatureServe 2013).

[b] A range rank (such as S1S2) is used when the taxon straddles the criteria for more than one rank (i.e. S1 and S2).

[c] Imperiled: At high risk of extirpation in the jurisdiction due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors (NatureServe 2013).

3. Species Information

3.1. Species Description

When mature, Blue Ash is a medium-sized tree with a straight trunk and a narrow, usually rounded crown of outward-trending branches. The maximum height of mature trees is generally less than 21m (Hosie 1975). The leaves are opposite, compound, and made up of 5 to 11 oval leaflets with short stalks and long-tapering tips, as well as low teeth along the margins. The species' scientific name, *quadrangulata*, refers to the twigs which have a four-sided aspect, formed from four ridges that run the length of the twig. The fruit is a single seed in a 2.5 to 5cm oval wing (a samara). The wing extends to the base of the seed, and the samara is flattened over its whole length and may twist slightly (Hosie 1975; Gleason and Cronquist 1991).

Blue Ash may easily be confused with other ash species and is probably frequently overlooked or misidentified (Mills and Craig 2008). The four-angled or winged twigs may help to distinguish Blue Ash from other ash species (Gleason and Cronquist 1991; Voss 1996; Reznicek et al. 2011), but these twigs may not always be within reach or have very pronounced ridges (Dobbie pers. comm. 2014a). In that case, Blue Ash may also be identified by its leaflets which have both short stalks and are toothed along the margin. By contrast, White Ash (*Fraxinus americana*) has stalked leaflets but smooth margins, while Black Ash (*F. nigra*) and Red Ash (*F. pennsylvanica*, sometimes also called Green Ash) have toothed margins but little or no stalk attached to the leaflets (Hosie 1975; Ambrose and Aboud 1983; Watts 1998).

The flowers of Blue Ash appear in April just before the leaves unfold, and unlike other North American ash species, flowers of Blue Ash are perfect[8] (Hosie 1975; Fernald 1970) and wind-pollinated (Wallander 2008). Most wind-pollinated species have adaptations to prevent or limit self-fertilization and to favour out-crossing, such as dioecy (separate male and female plants) or male flowers that mature earlier than

[8] Containing both female and male parts.

female flowers in a given tree (Raven and Johnson 1986). No such adaptations or structures are reported for Blue Ash, and it is unknown whether Blue Ash flowers are self-fertile.

Fruits of Blue Ash mature in the fall and, in Canada, mature fruits have been observed in the first two weeks of October (Ambrose and Aboud 1983). Blue Ash is reported to have mast years with heavy fruiting, and then may have several years in between mast years with little or no fruiting (for more details, see section 3.4 Limiting Factors).

The inner bark contains a sticky substance that turns blue when exposed to air (Peattie 1950), and a blue dye was reportedly obtained from boiling the bark (Cramer 1968). This may be the source of the species' common name. In addition, the wood was noted as hard, heavy and brittle, and historically used by First Nations and European settlers for construction work, flooring, agricultural implements especially tool handles, and wagons (Peattie 1950; Ontario Ministry of Natural Resources and Forestry 2014).

3.2. Population and Distribution

Species Range

In Canada, Blue Ash is restricted to southwestern Ontario (Figure 1). It is found in Elgin, Essex, Chatham-Kent, Lambton and Middlesex counties, as well as on a few islands in Lake Erie, including Pelee Island and Middle Island. Some of the largest populations[9] of Blue Ash are found in the watersheds of major river systems, such as within the floodplains of the Thames River, Sydenham River, and Catfish Creek (White and Oldham 2000). Globally, Blue Ash occurs in central North America from southwestern Ontario west to southern Wisconsin, and south to West Virginia, Georgia, Alabama, and west to Kansas and Oklahoma (Gleason and Cronquist 1991).

Populations

White and Oldham (2000) evaluated all existing records of Blue Ash and determined there were 37 occurrences[10] in Canada. Since their review, additional field work has been undertaken and many new stands of Blue Ash have been reported (Kirk 2013), including 21 natural and 6 planted stands of Blue Ash on St. Clair Region Conservation Authority lands in 2006 (Mills and Craig 2008). Additional records of the species have been found at Point Pelee National Park since the White and Oldham (2000) review. However, it has not been determined how many of the new records/observations constitute newly discovered occurrences, and how many would be considered additional observations within already-known occurrences. Staff at the Nature Heritage

[9] This document refers to several authors that have used the term "population" in different ways. Due to the lack of consistency among authors, the term "population" in this document is applied loosely, and may refer to population in general, local population, sub-population, etc. To ensure consistency, the Management Plan adopts occurrences (or elements of occurrence), defined by the NHIC, as the operational unit for species' distribution.

[10] Patches of plants within 1 km of each other are considered one occurrence (or element of occurrence), therefore occurrences do not correspond to number of observational records. Patches that are more than 1 km from each other are considered separate occurrences (NatureServe 2014).

Information Center (NHIC), Ontario Ministry of Natural Resources and Forestry, are responsible for evaluating new observations and designating species' occurrences.

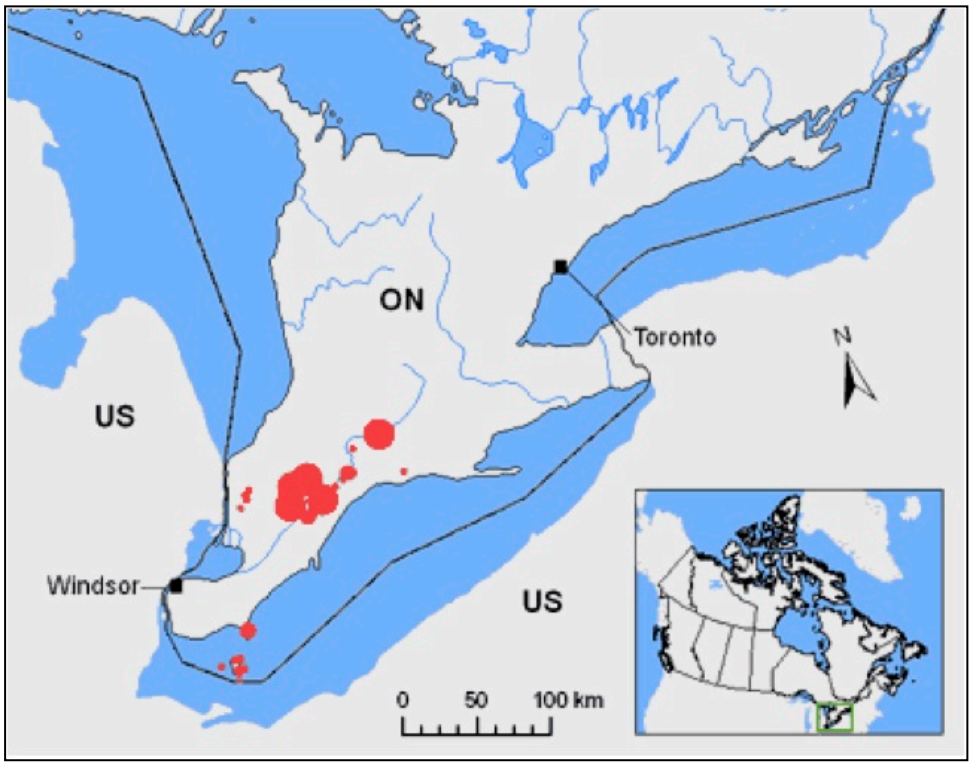

Figure 1. Range of Blue Ash (red dots) in Canada.

Abundance

White and Oldham estimated that the Canadian range of Blue Ash contained fewer than 1,000 mature trees (COSEWIC, 2000). Saplings and seedlings were not tallied. The total abundance of Blue Ash in Canada has not been tallied recently. A rough estimate derived from recent information indicates that the number of mature trees in Canada is not likely to exceed 2,500 trees. For example, an inventory of Blue Ash on St. Clair Region Conservation Authority lands (Mills and Craig 2008) found 39,091 individuals, of which only 391 had diameter at breast height (DBH) greater than 10 cm indicating mature individuals (capable of bearing seeds). A 2005-2006 survey conducted on Point Pelee National Park, found around 130 mature trees[11] (Otis et al., 2006) on the mainland; on Middle Island, a survey conducted in 2012 found 126 mature trees[12] (Parks Canada Agency, 2012). Also, Kirk (2013) conducted field work during 2012 and 2013 in 26 known Blue Ash sites and found a total of 708 mature trees.

[11] Otis et. al (2006) consider mature trees as those that have diameter at breast height (DBH) of 4.5cm or higher, because the minimum size Blue Ash tree recorded flowering was 4.5 cm DBH. They have found 77 trees with DBH equal or greater than 10cm.
[12] Trees were considered mature when DBH was equal or greater than 10cm.

There is little information on population trends for Blue Ash in Canada. At some sites, recent counts appear to have fewer stems than in previous years, but it is impossible to know if individuals within the same area and boundaries were counted each time. Ambrose and Aboud (1983) found no evidence that the species was more abundant or widespread historically (i.e. searching records as early as 1882).

Blue Ash also occurs as plantings in many places, including the City of Windsor, St. Clair Region Conservation Authority properties, and the University of Guelph Arboretum. Blue Ash trees planted in the University of Guelph Arboretum were grown from seed from documented wild sources (University of Guelph 2014).

3.3. Needs of the Blue Ash

Based on habitats in Canada where Blue Ash has been observed (see Habitat, below), Blue Ash, once established, is able to tolerate a broad range of moisture, soil, slope, exposure, and light conditions and is found adjacent to many types of vegetation communities. The species is reported to be moderately shade tolerant (Barnes and Wagner 2004), yet in some life stages Blue Ash is in fact sensitive to the amount of available light (Mills and Craig 2008). Ambrose and Aboud (1983) reported that seedlings were not seen in forests with complete canopy closure. Mills and Craig (2008) observed that saplings often died when shade levels increased, that growth rates of larger saplings improved after forest thinning operations, and that Blue Ash responded favourably to increased light after a lumber harvest in 2004, with heavy seedling emergence. Seedlings also appear to require light for successful establishment (Payne pers. comm. 2014).

Habitat

Throughout its global range, Blue Ash is mainly found in moist soil in deciduous forest, especially along floodplains but also occasionally on uplands (Gleason and Cronquist 1991; Reznicek et al. 2011; NatureServe 2014). Within its Canadian range, Blue Ash is present in three distinct kinds of habitats (Ambrose and Aboud 1983; White and Oldham 2000; Nature Conservancy Canada 2013). These include:

1) Floodplain Habitat;
2) Sand-based or Dune Habitat; and
3) Alvars and Bedrock-associated Habitats.

Floodplain Habitat

Suitable floodplain forest occurs along rivers and creeks in the watersheds of the Thames, Sydenham, North Sydenham, and St. Clair rivers as well as along Catfish Creek (Ambrose and Aboud 1983; White and Oldham 2000; Kirk 2013). In the Thames and Sydenham watersheds, Blue Ash is present on rolling uplands, floodplains, slopes, gully slopes, floodplain ridges, and in parks (Mills and Craig 2008). The species is present in rich deciduous floodplain forests, with deep alluvial soils that range from silt loam to clay loam, and occasionally to clay (Ambrose and Aboud 1983). Drainage ranges from poor to good (Mills and Craig 2008).

Species frequently associated with Blue Ash include Black Maple (*Acer saccharum* ssp. *nigrum*), Common Hackberry (*Celtis occidentalis*), White Ash, and Chinquapin Oak (*Quercus muehlenbergii*) (Ambrose and Aboud 1983). In the St. Clair River watershed, forest composition where Blue Ash occurs varies greatly and may be dominated by Black Maple, White or Red Ash, Black Walnut (*Juglans nigra*), White or Red Oak (*Quercus alba* or *Q. rubra*), White Elm (*Ulmus americana*), Shagbark or Bitternut Hickory (*Carya ovata* or *C. cordiformis*), with large components of Basswood (*Tilia americana*), Hawthorns (*Crataegus* spp.), and other species (Mills and Craig 2008).

Sand-based or Dune Habitat

At Point Pelee National Park, Blue Ash occurs in well-drained calcareous sand (pH 7.3 - 8.2) and has been documented in a broad range of vegetation types[13] (Dougan and Associates 2007) including:

A) Lake Erie Shoreline Spit Savanna (LESSS) types:

SHOM1-2 Sea Rocket Sand Open Shoreline
SBOD1-1 Little Bluestem-Switchgrass-Beachgrass Open Graminoid Sand Dune
SBSD1-2 Hop-tree Shrub Sand Dune
SBTD1-3 Red Cedar Treed Sand Dune

B) woodland and forest types:

WODM4-x Dry-Fresh Hackberry Deciduous Woodland
FODM4-3 Dry-Fresh Hackberry Deciduous Forest

Ground flora in these vegetation types (Dougan and Associates 2007) varies greatly and ranges from a sparse cover of low annuals or a continuous grass cover of Little Bluestem (*Schizachyrium scoparium*) and Beach Grass (*Ammophila breviligulata*), or it may have shrub cover of Common Juniper (*Juniperus communis*), Poison Ivy (*Rhus rydbergii*), and Fragrant Sumac (*Rhus aromatica*). In woodlands and forests (with a discernable litter layer and shallow soil), ground flora may include aggressive invasive species (English Ivy (*Hedera helix*), Periwinkle (*Vinca minor*), and Winter-creeper (*Euonymus fortunei*)) or Carolinian forest species such as Dutchman's Breeches (*Dicentra cucullaria*), Smooth Sweet-cicely (*Osmorhiza longistylis*), Lopseed (*Phryma leptostachya*) and Wild Blue Phlox (*Phlox divaricata*), as well as Garlic Mustard (*Alliaria petiolata*). Blue Ash is also in some roadside verges, utility corridors and landscaped areas.

Significant numbers of Blue Ash seedlings have been observed in areas restored as part of Lake Erie Sand Spit Savannah restoration initiatives at Point Pelee National Park (Dobbie and Allen pers. comm. 2014).

Alvars and Bedrock-Associated Habitats

Blue Ash occurs in shallow soil over dry limestone on Lake Erie islands. On Pelee Island, Blue Ash has been documented in the following vegetation types (McFarlane pers. comm. 2014):

[13] Vegetation types based on the Ecological Land Classification System (Lee et al., 1998).

RBSA1-x[14] Alvar Shrub Rock Barren
RBTA1-7 Red Cedar Alvar Woodland grading to
RBTA1-1 Chinquapin Oak-Nodding Onion Treed Alvar
RBTB1-2 Hackberry Calcareous Tree Rock Barren
FOCS3-2 Dry-Fresh Red Cedar Calcareous Bedrock Coniferous Forest
MEMM3 Dry-Fresh Mixed Meadow (former agricultural fields)
FODM3-2 Dry-Fresh White Birch Deciduous Forest

In these areas it is generally associated with Hairy Wild Rye (*Elymus villosus*), Bottlebrush Grass (*E. patula*), Virginia Wild Rye (*E. virginicus*), Short's Aster (*Symphyotrichum shortii*), Fragrant Sumac, Chinquapin Oak, Black Walnut and dead White Ash (McFarlane pers. comm. 2014).

On Middle Island, Blue Ash has been documented in the following vegetation types (North South Environmental 2004; Dobbie and Allen pers. comm. 2014):

FOD7-5 Hackberry/Sugar Maple Forest
FOD4-3 Hackberry Forest
CUM/CUT Cultural Meadow/Cultural Thicket
Hackberry-Blue Ash-Common Hoptree Forest (No ELC Code)
Thicket/Young Hackberry Forest (No ELC Code).

In these areas it is generally associated with Common Hackberry, Common Hoptree (*Ptelea trifoliata*), Carex divulsa, Hairy Wild Rye, Short's Aster and Garlic Mustard.

Habitat Dynamics

Mills and Craig (2008) observed increased regeneration and higher growth rates in response to increased light levels, and Ambrose and Aboud (1983) speculated that habitat conditions that allow periodic creation of light gaps or that do not allow complete canopy closure may be necessary to ensure seedling survival. Therefore, suitable habitats will have been affected by periodic disturbances such as various weather events, which could include exceptionally high flood events, wind throw, and extreme drought (in sand or on shallow soils on alvars) (Ambrose and Aboud 1983; Reschke et al. 1999; Dougan and Associates 2007).

In addition, it is possible that some successional stages (between completely open habitat and completely closed forest) may be more suitable for Blue Ash establishment, due to a reduced presence of mice. Mice have been observed to dig down into the soil as much as 16 cm to chew on the roots of Blue Ash, resulting in girdling[15] of the roots and death of the tree (Mills and Craig 2008). Observations of open areas that have been reforested found no Blue Ash where there was open sod, likely due to the presence of mice, while areas that had grown in enough to shade out turf, meadow plants, and hawthorn (the point at which rodent populations begin to disappear), frequently contained Blue Ash regeneration (Mills and Craig 2008).

[14] The "x" in "RBSA1-x" demonstrates there is more than one type of Alvar Shrub Rock Barren, and Blue Ash might occur in any of them: Common Juniper Shrub Alvar Type (RBSA1-1), Creeping Juniper-Shrubby Cinquefoil Dwarf Shrub Alvar Type (RBSA1-2) and Scrub Conifer-Dwarf Lake Iris Shrub Alvar Type (RBSA1-3).
[15] Removal of the bark all the way around a tree (trunk, root or branch), resulting in damage or death

3.4. Limiting Factors

It is reported that Blue Ash trees must be at least 25 years old before they are able to set seed (USDA 2008). In addition, this species is known to have mast years where there is heavy fruiting and then may have several years in between mast years with little or no fruiting (Otis and Moran 2007). Otis and Moran (2007) surveyed Blue Ash populations throughout the entire Canadian range in 2006 and found only two populations with any seeds.

In addition to the fact Blue Ash trees set seed very infrequently, the seedlings require light for successful establishment. Therefore, this species may have limited opportunities to reproduce if sufficient light gaps or other suitable open habitat is not available at the time when mature trees set seed.

4. Threats

4.1. Threat Assessment

The threat categories presented in Table 2 are in overall decreasing level of concern.

Table 2. Threat Assessment Table

Threat	Level of Concern[a]	Extent	Occurrence	Frequency	Severity[b]	Causal Certainty[c]
Exotic, Invasive or Introduced Species						
Emerald Ash Borer	High	Widespread	Current and Anticipated	Continuous	High	High
Habitat Loss or Degradation						
Loss of habitat from land conversion	Medium	Localized	Historical and Current	Recurrent	Moderate	High
Livestock grazing	Medium	Localized	Historical and Current	Continuous	Moderate	High
Disturbance or Harm						
Off-trail recreational activities	Medium	Localized	Current	Seasonal	Moderate	Medium
Change in Ecological Dynamics or Natural Processes						
Double-crested Cormorants	Medium	Localized	Current	Continuous	Low	High
Lack of natural disturbance	Low	Widespread	Current and Anticipated	Long-term	High	High
Over abundance of White-tailed Deer	Unknown	Localized	Current	Continuous	Unknown	Unknown

[a] *Level of Concern: signifies that managing the threat is of (high, medium or low) concern for the conservation of the species, consistent with the management objectives. This criterion considers the assessment of all the information in the table.*

[b] *Severity: reflects the population-level effect range-wide (High: very large population-level effect, Moderate, Low, Unknown).*

[c] *Causal certainty: reflects the degree of evidence that is known for the threat (High: available evidence strongly links the threat to stresses on population viability; Medium: there is a correlation between the threat and population viability e.g. expert opinion; Low: the threat is assumed or plausible).*

4.2. Description of Threats

Exotic, Invasive or Introduced Species

Emerald Ash Borer

Damage to or mortality of mature Blue Ash trees from infestations of the invasive Emerald Ash Borer have been documented in Canada (Kirk 2013; Carson 2014; Waldron pers. comm. 2014; McFarlane pers. comm. 2014).

The Emerald Ash Borer (*Agrilus planipennis* or EAB), is an exotic beetle, native to Asia, that was first discovered to be killing ash trees in southeastern Michigan and Windsor, Ontario in 2002 (Haack et al. 2002, Poland and McCullough 2006). Adult female beetles lay 50 – 90 eggs in the bark of ash trees. The larvae hatch and then feed under the bark, excavating serpentine-shaped galleries[16] in the inner growing tissue (phloem[17] and cambium[18]) of the tree. Extensive larval feeding disrupts transport of water and nutrients, girdles the tree, and ultimately results in tree death within one to three years (Poland and McCullough 2006). Presence of the EAB is often not detected until damage to trees is already extensive. The beetle is now present in almost all of southern Ontario and parts of Quebec (Canadian Food Inspection Agency 2014a).

There is some evidence that Blue Ash populations may withstand EAB infestation somewhat better than other Ash species. Blue Ash seems to be less attractive to Emerald Ash Borer than other species of Ash (Red, White, Black), according to some studies that tested both EAB feeding preference and choice of egg-laying locations (Anulewicz 2006, 2007, 2008; Pureswaran and Poland 2009). However, once other species of Ash within a given area are gone, the EAB may attack Blue Ash populations, which can then be severely affected by EAB (Kirk 2013; Carson 2014; Waldron pers. comm. 2014; McFarlane pers. comm. 2014).

Research at the Great Lakes Forestry Centre found that EAB did not do as well on Blue Ash as it did on other Ash species (Lyons pers. comm. 2014). Research at Point Pelee National Park (Carson 2014) showed evidence of infestation in some Blue Ashes, with most of the population remaining unaffected. A few trees with exit holes seemed to have healed; other trees had dead crowns, but healthy epicormic[19] shoots on the trunks. In another plot within the same park, Carson (2014) observed many Blue Ash trees not only surviving but thriving, despite the presence of infested and/or dead ash trees around them. On Pelee Island and in the City of Windsor, all ash trees of other species have died and the Blue Ash population is becoming more infested with EAB,

[16] Galleries: networks of tunnels created by insects when eating plant material.

[17] Phloem: A living tissue in a vascular plant that transports organic food materials (e.g. sucrose) from the photosynthetic organ (leaf) to all the parts of the plant (Raven et al., 1992).

[18] Cambium: A tissue with actively dividing cells, found in vascular plants, responsible for secondary growth (increase in diameter of a plant organ resulting from cell division) (Raven et al., 1992; Dictionary of Botany, 2003).

[19] Epicormic buds are dormant buds present under the bark of some deciduous trees. Growth of shoots from these buds may be triggered if there is a loss of growth from the upper parts of the tree (Department of Forest Resources and Environmental Studies 2014).

however, Blue Ash trees are still surviving (Lyons pers. comm. 2014; McFarlane pers. comm. 2014; Rozell pers. comm 2014). Many sites in southwestern Ontario are just reaching the point where all other ash trees have died from EAB infestations, so the full impact of potential EAB infestations on Blue Ash in Canada is not yet known.

Studies in the U.S. also indicate that individual Blue Ash trees may withstand EAB infestation better than trees of other ash species. Working in southeastern Michigan woodlots, Tanis and McCullough (2012) compared the impacts of EAB on both Blue Ash and White Ash. At one site, 71% of the original 380 Blue Ash were alive, whereas only 29 saplings of the original 187 White Ash (15.5%) were alive. At a second site, 63% of the original 210 Blue Ash were living, whereas all 125 (100%) White Ash were dead. More than 80% of the Blue Ash studied from 2009 to 2011 had evidence of previous EAB infestation, but 87% still appeared healthy in 2011.

Despite promising indications of better resistance of Blue Ash trees to EAB than other ash species in North America, the full effects of EAB infestation on Blue Ash are still unknown. On Pelee Island, several larger Blue Ash are infested (Nature Conservancy Canada unpublished data 2014). Widespread damage or mortality of Blue Ash could quickly result in population declines for Blue Ash.

Different management practices to prevent, control and/or mitigate the effects of EAB (on all ash species) have been developed and applied in Canada and United States (for examples, see Appendix B).

Habitat Loss or Degradation

Loss of habitat from land conversion

Loss of habitat occurs when natural land is converted to agricultural fields, urban development, aggregate operations, or vineyards (Ambrose and Aboud 1983; White and Oldham 2000; Kirk 2013). Most of the original Carolinian forest in southwestern Ontario was historically lost to agriculture and urban development, and only isolated areas still remain (Allen et al. 1990; Elliott 1998; McAfee 2003). The loss of Carolinian forest habitats is a major factor in why many species have become at risk in Canada (Kerr and Cihlar 2004). The clearing of floodplain forests and conversion of these forests into agricultural fields, has reduced the amount of suitable habitat along the three river systems in which Blue Ash occurs in Ontario (Ambrose and Aboud 1983).

Ambrose and Aboud (1983) noted that two populations of Blue Ash trees were along roadsides and could potentially be lost to road work. It is not known whether this continues to be a current threat.

Livestock Grazing

Livestock grazing may result in destruction of seedlings and damage/changes to the understory/herbaceous layer of woodlands and forests (Ambrose and Aboud 1983; White and Oldham 2000; Kirk 2013). Changes in the understory diversity may lead to a more grassy ground layer, favouring the presence of rodents that eat Blue Ash seeds and kill seedlings and saplings by chewing the bark off roots, killing the tree (Mills and Craig 2008).

Mills and Craig (2008) speculated, based on studies conducted on St. Clair Region Conservation Authority lands, that the overall rarity of Blue Ash may be the result of historical agricultural practices that increased the presence of mice. Many woodlots were historically grazed by livestock and contained significantly more sod and, consequently, mice. As valley lands and floodplains (areas that can support Blue Ash) were some of the first lands converted to pasture, the influx of mice may have prevented Blue Ash from persisting in many areas of southwestern Ontario.

Disturbance or Harm

Off-trail Recreational Activities

Bird-watching, hiking, and use of all terrain vehicles off established trails in some locations, may cause trampling of seedlings and disruption to habitat (Kirk 2013). This threat is especially of concern in areas that are easily accessible to the public, such as some conservation areas.

Change in Ecological Dynamics or Natural Processes

Double-crested Cormorants

On Middle Island, damage to trees and nitrification of soils occurs from Double-crested Cormorant (*Phalacrocorax auritus*) guano (excrement) and nesting activities. Between 1995 and 2006, cormorant nesting caused a 41% loss of healthy forest canopy as well as significant changes to understory vegetation and soil chemistry (Dobbie 2008). On-going management has reduced Double-crested Cormorant nest densities and resulted in significantly reduced impacts to island vegetation since 2008. The number of Blue Ash on Middle Island has increased, however the impacts from cormorant nesting have resulted in a shift from large, mature trees to an increased number of smaller trees and seedlings (Dobbie pers. comm. 2014a).

Lack of Natural Disturbance

In floodplain forests, lack of natural disturbance (such as periodic flooding/high water levels) leads to impacts on forests, such as the drying out of soils and a closed canopy with no light-gaps, reducing Blue Ash regeneration (Ambrose and Aboud 1983). This threat often results from control of waterflow or changes to the flow of smaller streams within larger watersheds (Kirk 2013).

In xeric[20] habitats (alvars, dunes) lack of disturbance (such as extreme droughts) leads to increased vegetation from succession, making habitat unsuitable for Blue Ash (Ambrose and Aboud 1983, McFarlane pers. comm. 2014).

Overabundance of White-tailed Deer
High densities of white-tailed deer (*Odocoileus virginianus*) may prevent forest regeneration, due to excessive browsing on seedlings and saplings (Koh et al., 2010). High populations of White-tailed Deer occur at some Blue Ash sites, such as Point Pelee National Park (Dobbie pers. comm. 2014b). However, the effects of deer browsing on Blue Ash are currently unknown.

5. Management Objective

The management objective for Blue Ash is to maintain the current distribution and abundance of the Canadian population of Blue Ash.

6. Broad Strategies and Conservation Measures

6.1. Actions Already Completed or Currently Underway

At least six populations of Blue Ash are located on federal (Point Pelee National Park) and provincial (Lighthouse Point, Fish Point, and Komoka Provincial Nature Reserves) parks, which are managed for the conservation and effective management of native species. There are also populations in conservation areas and other lands managed by the St. Clair Region, Upper Thames River, or Essex Region Conservation Authorities. In addition, Blue Ash occurs on conservation lands owned by the Nature Conservancy Canada, Ontario Nature, and the Thames Talbot Land Trust.

The Great Lakes Forestry Centre of the Canadian Forest Service conducts research on the Emerald Ash Borer and coordinates a national committee to provide scientific information on EAB to policy makers. The Great Lakes Forestry Centre is also conducting research into biological control[21] for EAB. In 2013, at one site in southern Ontario, researchers conducted a trial release of a parasitoid (*Tetrastichus planipennisi*) to attack EAB larvae. In 2014, trial releases were performed at five additional sites, four sites in Ontario and one in Quebec. In the fall of 2014, researchers will begin sampling to assess establishment of the parasites at the sites from 2013. They have not yet observed (as of September 2014) any positive effect on ash survival (Lyons pers. comm. 2014b). However, this is to be expected as biological control often takes a number of years to have an effect on pest populations. For example, releases of *Tetrastichus planipennisi* in the U.S. began in 2007; nevertheless only in 2013 researchers started observing population increases (~25%) in the parasitoid. The

[20] Xeric: an environment that is very dry; contains very little moisture.
[21] Biological control usually involves introducing a natural predatory organism that feeds on or otherwise limits the invasive species in their natural home range.

National Tree Seed Centre at the Atlantic Forestry Centre in New Brunswick is collecting ash germplasm so that it will be available to restore ash populations once environmental control measures for EAB are developed or trees resistant to the insect are bred (Natural Resources Canada 2014).

Blue Ash seed has been collected at Point Pelee National Park and sent to the National Tree Seed Centre (Dobbie pers. comm. 2104a). In Point Pelee National Park, Blue Ash trees are being monitored, so that in mast years some seeds can be collected for donation to the National Tree Seed Centre and for use in park restoration programs. Under the Middle Island Conservation Plan (Dobbie 2008) Parks Canada began cormorant reductions, nest removal, and placement of deterrents on Middle Island in 2009. So far, the number of nests has been reduced by more than 1000 and the monitoring program has demonstrated that the loss of healthy forest canopy cover on Middle Island has been significantly reduced. Although tree mortality rates have declined, the high cormorant nest densities on the island are still causing substantial damage to the forest canopy and management actions are continuing (Dobbie and Allen, pers. comm. 2014).

Since 2011, Point Pelee National Park has restored and maintained over 13 ha of savannah within the park through clearing of thickets, removal of invasive plants, and conducting prescribed fires. Significant numbers of Blue Ash seedlings have now been recorded growing in newly restored areas, even in areas where very few adult trees had been recorded previously. This savannah restoration is expected to benefit Blue Ash and will be continuing with a goal of restoring an additional 10 ha by 2019 (Dobbie and Allen, pers. comm. 2014).

On Pelee Island, the Nature Conservancy Canada (NCC) is working to remove invasive species from alvar habitats including those where Blue Ash is present. Stewardship actions include removal of invasive and Eurasian species such as Garlic Mustard (*Alliaria petiolata*), Orchard Grass (*Dactylis glomerata*), Canada Bluegrass (*Poa compressa*), and Herb Robert (*Geranium robertianum*), as well as shrubs such as Common Lilac (*Syringa vulgaris*), Multiflora Rose (*Rosa multiflora*) and Tartarian Honeysuckle (*Lonicera tatarica*). In addition, NCC is working to restore agricultural land to natural meadow, and Blue Ash may be part of some of these restorations (McFarlane pers. comm. 2014).

The St. Clair Region Conservation Authority (SCRCA) completed a major inventory and study of all Blue Ash sites on their lands (Mills and Craig 2008). As well, SCRCA completed forest management actions to create canopy openings to encourage Blue Ash regeneration and sapling growth (Payne pers. comm. 2014).

Seed is also collected from the trees planted in the University of Guelph Arboretum and distributed for native-tree plantings (University of Guelph 2014).

Blue Ash is included in some conservation action plans being undertaken by Carolinian Canada Coalition and its partners (Koscinski et al. 2014; Jalava pers. comm. 2014).

6.2. Broad Strategies

Broad strategies to achieve the management objective include:

- Determine the abundance of Blue Ash at known sites in Canada and monitor changes in the distribution and abundance of Blue Ash;
- Fill knowledge gaps that address the species' threats and benefit the species' conservation;
- Support stewardship activities and outreach programs that mitigate threats and conserve suitable habitat.

6.3. Conservation Measures

Table 3. Conservation Measures and Implementation Schedule

Conservation Measure	Priority[a]	Threats or Concerns Addressed	Timeline
Determine the abundance of Blue Ash at known sites in Canada and Monitor Changes in the Distribution and Abundance of Blue Ash			
Survey and monitor status and abundance of known and newly discovered populations within the species' native range in Ontario.	High	Status of species and its habitat	2016 to 2026
Develop and implement a standardized survey monitoring program for naturally-occurring populations of Blue Ash to: - regularly complete population surveys and health assessments of Blue Ash occurrences; and - assess habitat conditions and impact of threats (e.g. EAB) at occupied sites.	High	Status of species and its habitat; Emerald Ash Borer	2016 to 2026
Fill knowledge gaps that address the species' threats and benefit the species' conservation			
Monitor effects of EAB on Blue Ash and spread of EAB into new Blue Ash areas.	High	Emerald Ash Borer	2016 to 2026
Evaluate appropriateness of existing EAB control protocols (e.g., chemical treatment, including those in the U.S., and forest management measures) and evaluate/implement protocols and management measures that will aid in the conservation of Blue Ash in Canada.	High	Status of species and its habitat; Emerald Ash Borer	2016 to 2026
Identify and assess planted populations of Blue Ash across Ontario to act as potential sources of genetically-resistant trees for future restoration efforts and research purposes, and reduce the risk of EAB impacts.	Medium	All threats	On-going
Study disturbance regimes in alvar habitat of Blue Ash: investigate response to fire and to manual removal of woody vegetation.	Low	Lack of Natural Disturbance	By 2021
Support stewardship activities and outreach programs that mitigate threats and conserve suitable habitat			
Develop Best Management Practices for Blue Ash to aid in mitigation and promote the conservation of Blue Ash and its habitat.	High	Emerald Ash-Borer	2016-2021
Encourage the implementation of BMPs by forest managers, municipal planners, aggregate operators, private landowners, vineyard operators, and agricultural producers.	High	Emerald Ash-Borer	2016-2021
Continue management actions to reduce damage from Double-crested Cormorants.	Medium	Double-crested Cormorants	2016-2021

Conservation Measure	Priority[a]	Threats or Concerns Addressed	Timeline
Encourage land managers of protected, conservation and private areas to discourage off-trail recreational activities by implementing various outreach activities (e.g.: erecting barriers and signage, monitoring off-trail vehicle use, etc).	Low	Off-trail recreational activities	2016-2026

[a] "Priority" reflects the degree to which the measure contributes directly to the conservation of the species or is an essential precursor to an measure that contributes to the conservation of the species. High priority measures are considered those most likely to have an immediate and/or direct influence on attaining the management objective for species. Medium priority measures may have a less immediate or less direct influence on reaching the management population and distribution objectives, but are still important for management of the population. Low priority recovery measures will likely have an indirect or gradual influence on reaching the management objectives, but are considered important contributions to the knowledge base and/or public involvement and acceptance of species.

7. Measuring Progress

The performance indicators presented below provide a way to define and measure progress toward achieving the management objective. Every 5 years, success of management plan implementation will be measured against the following performance indicator:

- Current distribution and abundance of the Canadian population of Blue Ash is maintained.
- Best Management Practices are developed and implemented promoting the conservation of Blue Ash and its habitat.
- Threats to the Canadian population of Blue Ash are reduced, including the threat from Emerald Ash Borer, wherever feasible.

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Appendix A: Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[22]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy's[23] (FSDS) goals and targets.

Conservation planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that implementation of management plans may inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the management plan itself, but are also summarized below in this statement.

Management of Blue Ash and reduction of threats to alvar and dunes will have benefits for many other native species that require these extremely rare habitats. Some examples include the threatened species Kentucky Coffee Tree (*Gymnocladus dioicus*) and Common Hoptree, as well as Cliff Conobea (*Leucospora multifida*) and Nodding Onion (*Allium cernuum*), both imperiled in Ontario (S2). In addition, removal of invasive grasses, such as Orchard Grass and Canada Bluegrass, and restoration of native species leading to a natural alvar ecosystem, are expected to benefit all alvar species, not just Blue Ash. Reduction of trampling from foot traffic in dunes and alvar will also benefit all species present.

On Middle Island, reduction of Double-crested Cormorants and the associated damage from their nesting activities and guano will benefit all forest trees and the entire forest ecosystem as a whole. It will also be beneficial to other colonial water bird species, such as Great Blue Heron (*Ardea herodias*) and Black-crowned Night Heron (*Nycticorax nycticorax*) by reducing competition for nesting sites. Certainly, there will be negative impacts to cormorants from such management actions. However, Double-crested Cormorant numbers have increased greatly in the last 20 years and current numbers are the highest recorded in the history of the Great Lakes region (Wires and Cuthburt 2006 cited in Dobbie 2008). Negative impacts to cormorants at Middle Island are not expected to have any overall effects on the species or even on regional populations in Lake Erie.

[22] http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[23] www.ec.gc.ca/dd-sd/default.asp?lang=En&n=F93CD795-1

Control of EAB with chemicals is done in a highly localized way where chemicals are injected directly into specific individual trees, rather than being broadcast over greater areas. Chemicals that are approved for use in Canada for this purpose are only those that have been found to have little or no impact on non-target species, that are not mobile into the greater ecosystem, or that have short durations of activity. The primary chemical used for trunk injections is TreeAzin (azadirachtin), extracted from seeds of the Neem tree (*Azadirachta indica*), a species native to India. TreeAzin is regulated as a Class 4 insecticide (the least hazardous that is available commercially) (BioForest Technologies 2014).

Management actions will be timed appropriately and done when they do not interfere with the needs of other species. For example, management actions to increase light in deciduous forest or to remove competing vegetation on alvar are expected to be done outside the season for nesting birds. Selective management to increase light for Blue Ash seedlings is expected to require very minimal cutting, not a significant change to the forest, and management for Blue Ash should not be a reason to harvest Carolinian Forest as the amount of management required is not intended to be great enough to provide an economic return. For this particular action, it is expected that forest managers will assess each situation on a case by case basis since a variety of other species with differing needs may be present.

Appendix B: Control of the Emerald Ash Borer

In Canada, management practices to prevent, control, or mitigate the effects of EAB (on all ash species) currently focus on slowing the spread of EAB into unaffected areas by preventing the movement of firewood and wood products and on proper disposal of infested material (Canadian Food Inspection Agency 2014a). Forest management practices to control EAB in larger areas have generally involved removal of ash trees to limit food for EAB (Michigan Department of Natural Resources 2012). However, removal of ash trees was found to result in only localized reduction of EAB populations and to have only limited effectiveness in reducing the spread of EAB to new areas (Mercader et al. 2011). In a Canadian example, in 2004, 150,000 ash trees were removed in southwestern Ontario to create an ash free zone as a barrier to the spread of EAB, yet EAB had moved beyond this zone by January 2005 (Canadian Food Inspection Agency 2014b). Furthermore, ash removal may actually increase the speed at which EAB impacts occur (Knight et al. 2013).

In Canada, the only permitted chemical control of EAB is trunk-injection of insecticide into individual trees (Urban Forest Innovations Inc. 2014; Lyons pers. comm. 2014). Three insecticides are permitted in Canada for this type of use: TreeAzin (azadirachtin 5%), Confidor 200 SL (imidacloprid 17.1%), and Acephate (ACECAP 97). The average cost of treatment using TreeAzin may range from $4-7 per cm DBH, or $160-280 for a 40 cm DBH tree, every two years (Urban Forest Innovations Inc. 2014). Studies in urban municipalities compared the cost of preventative treatment to the cost of removal of diseased or dead ash trees (other species, not Blue Ash) and concluded that preventative actions were cost-prohibitive (McKenney and Pedlar 2012; McKenney et al. 2012). However, in the case of Blue Ash, a species at risk, chemical control of some individual forest trees could be further evaluated and considered as a management option, to help keep at least some selected mature Blue Ash trees healthy. Trees which are treated and healthy can then serve as future seed sources and aid in the species' conservation and recovery.

In the U.S., integrated pest management (IPM) practices to control EAB were summarized by Herms et al. (2009). Several application methods with different chemical products were evaluated including soil injections or drenches, trunk injections, lower trunk sprays, and protective cover sprays applied to the trunk, main branches, and foliage (Herms et al., 2009), however, these products and practices are not approved for use in Canada. The movement of pesticides into surrounding ecosystems and the impacts of chemicals on other organisms must be considered to ensure that this possible EAB management option does not result in threats to the long-term health of Blue Ash or any other species (see Appendix A).