Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Kentucky Coffee-tree (*Gymnocladus dioicus*) in Canada

Kentucky Coffee-tree

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[1] http://sararegistry.gc.ca/default.asp?lang=En&n=24F7211B-1

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 recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years.

The Minister of the Environment and the Minister responsible for the Parks Canada Agency are the competent ministers for the recovery of the Kentucky Coffee-tree and have prepared this strategy, as per section 37 of SARA. It has been prepared in cooperation with the Ontario Ministry of Natural Resources, Essex Region Conservation Authority, St. Clair Region Conservation Authority and the Carolinian Canada Coalition.

Success in the recovery 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 strategy and will not be achieved by Environment Canada or the Parks Canada Agency, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Kentucky Coffee-tree and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment Canada or the Parks Canada Agency and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy 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

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EXECUTIVE SUMMARY

Kentucky Coffee-tree (*Gymnocladus dioicus*) is a moderate-sized canopy tree of the legume family, and is the only member of its genus in North America. Male and female flowers are generally produced on separate trees and, when fertilized, form a hard, dark, bean-like pod, which remains on the tree through the winter. However, the species spreads primarily through root suckers (ramets) and sexual reproduction is relatively infrequent.

In Canada, Kentucky Coffee-tree is found only in southern Ontario. Of 33 known native populations, 23 are considered extant, with an estimated total population of fewer than 500 mature native trees. It is designated Threatened in Canada under the *Species at Risk Act* (SARA).

Threats identified to the Canadian population of Kentucky Coffee-tree include, but are not limited to: land development, Double-crested Cormorant (*Phalocrocorax auritus*) nesting colonies, alteration of the water regime, alteration of the fire regime, cutting/removal of Kentucky Coffee-trees, planting of non-native Kentucky Coffee-trees and invasive species. The species is also limited by: small, geographically-isolated populations, low rates of sexual reproduction and limited dispersal ability. Given that in Canada the species is found at the northern extent of its North American range and is uncommon, it will likely always be vulnerable to natural and human-influenced stressors.

There are unknowns regarding the feasibility of recovery of Kentucky coffee-tree. In keeping with the precautionary principle, this recovery strategy has been prepared as per section 41(1) of SARA, as would be done when recovery is determined to be feasible. The population and distribution objectives for the Kentucky Coffee-tree in Canada are to: maintain the abundance and distribution of native extant populations occurring within natural settings (e.g., floodplain woodlands and woodland edges of marshes), augment extant native single-sex populations (i.e., populations that are not sexually-reproducing) occurring within natural settings to attempt to establish sexually-reproducing populations, if biologically and technically feasible, and maintain the remaining extant native populations that occur in landscaped or agricultural settings either *in situ* or through their incorporation into, or use in the establishment of, populations in natural settings. Broad strategies to be taken to address the threats to the survival and recovery of the species are presented in the section on Strategic Direction for Recovery (Section 6.2).

Critical habitat for Kentucky Coffee-tree is partially identified in this recovery strategy, based on the best available data. Critical habitat for Kentucky Coffee-tree is located on both federal and non-federal land. As more information becomes available, additional critical habitat may be identified where sites meet the critical habitat criteria.

One or more action plans for Kentucky Coffee-tree will be posted on the Species at Risk Public Registry by December 2021.

RECOVERY FEASIBILITY SUMMARY

Based on the following four criteria outlined in the draft SARA Policies (Government of Canada 2009), there are unknowns regarding the feasibility of recovery of Kentucky Coffee-tree. In keeping with the precautionary principle, a full recovery strategy has been prepared as per section 41(1) of SARA, as would be done when recovery is determined to be feasible. This recovery strategy addresses the unknowns surrounding the feasibility of recovery.

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

Yes. Twenty-three populations are believed to be extant in Canada and at least four of these have been confirmed as mixed-gender sexually-reproducing populations. Additional native stock is available from arboreta (e.g., University of Western Ontario) (Bowles pers. comm. 2010) and native plant nurseries, as well as potentially from populations in the northern United States, to supplement single-gender populations with opposite sex plants to improve rates of sexual reproduction. However, even when seeds are produced, natural seed dispersal is limited and germination is infrequent.

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

Yes. The species thrives in a variety of open and semi-open habitats in southwestern Ontario, and extensive areas of suitable habitat are currently unoccupied by the species. There are several habitat management techniques (e.g., thinning) available to create open canopy conditions amenable to seedling establishment.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

Unknown. The primary threats to the species (i.e., habitat loss to land development and cutting/removal of Kentucky Coffee-trees) can be mitigated through appropriate land use planning, site management and land securement. Several key populations currently occur on public lands managed for conservation purposes. It is unknown whether the impacts from Double-crested Cormorant (*Phalocrocorax auritus*) breeding colonies can be mitigated to the extent required to meet the population and distribution objectives.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

Unknown. Although enhancement of single-gender populations through reintroduction of individuals of the opposite sex can be used to improve rates of seed production and increase genetic diversity (within the seeds), there is little evidence of the successful germination of seeds in natural settings to establish the required sexually-reproducing populations to meet the population and distribution objective. However, the seeds germinate readily after scarification or soaking in an acid solution (Wiesehuegal 1935) and the species can easily be

propagated from root shoots and cuttings (Ambrose 1984). Double-crested Cormorant control methods have been developed; however, their effectiveness in producing impacts at the population level is not well established.

In Canada, Kentucky Coffee-tree occurs at the northern extent of its North American range; extreme southwestern Ontario. It is a rare component in naturally-occurring forest stands (USDA 2007) and will likely always be vulnerable to natural and human-influenced stressors.

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1. COSEWIC* SPECIES ASSESSMENT INFORMATION

Date of Assessment: November 2000

Common Name (population): Kentucky Coffee-tree

Scientific Name: *Gymnocladus dioicus*

COSEWIC Status: Threatened

Reason for Designation: An uncommon species in North America restricted in Canada to about 25 occurrences in southwestern Ontario. There individual trees or small scattered groups, primarily of single sex clones, survive with limited sexual reproduction and under threats from habitat degradation.

Canadian Occurrence: Ontario

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

* Committee on the Status of Endangered Wildlife in Canada

2. SPECIES STATUS INFORMATION

The global conservation rank for Kentucky Coffee-tree (*Gymnocladus dioicus*) is secure[3] (G5). In the United States, Kentucky Coffee-tree's primary range occurs in the Midwest; the national conservation status is currently secure (N5?[4]) (NatureServe 2011, Appendix B). In Canada, Kentucky Coffee-tree is found only in the province of Ontario; the national and subnational conservation ranks are imperilled[5] (N2 and S2, respectively) (NatureServe 2011). The species is considered introduced in Quebec (COSEWIC 2000).

Kentucky Coffee-tree is listed as Threatened[6] on Schedule 1 of the federal *Species at Risk Act* (SARA). In Ontario, Kentucky Coffee-tree is listed as Threatened[7] under the provincial *Endangered Species Act*, 2007 (ESA).

The percentage of the global range found in Canada is estimated to be less than 5%. The distribution of Kentucky Coffee-tree is very restricted in Canada, where it occurs at the northern extent of its North American range.

[3] Common, widespread and abundant.
[4] Question mark (?) denotes inexact numeric rank.
[5] At high risk of extinction or elimination due to a very restricted range, very few populations, steep declines or other factors.
[6] A wildlife species that is likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction.
[7] A species that lives in the wild in Ontario but is likely to become endangered if steps are not taken to address factors threatening to lead to its extinction or extirpation.

3. SPECIES INFORMATION

3.1 Species Description

Kentucky Coffee-tree is a moderate-sized canopy tree of the legume family, and is the only member of its genus in North America. Mature trees grow 18 to 30 m tall (USDA 2007) and may live up to 100 years or more. The species has stout, widely-spaced branches and a narrow crown, with large, doubly-compound leaves that can reach one metre in length, the longest of any tree in Canada. Kentucky Coffee-tree has a short growing period relative to other deciduous trees (Kozlowski and Ward 1957), with the leaves developing late in the spring and falling in early autumn; it is therefore leafless for half the year or more. The species spreads mainly through ramets[8] and sexual reproduction is relatively infrequent. Greenish-white flowers in terminal clusters appear in May and June, and expand after the new leaves emerge, with male and female flowers generally produced on separate trees. Fertilized flowers form a hard, dark, bean-like pod 12 to 20 cm long containing 4 to 8 dark brown seeds, which remains on the tree through the winter (Farrar 1995; COSEWIC 2000; USDA 2007).

Kentucky Coffee-tree has evolved a number of characteristics that make it relatively well-adapted to cope with a variety of natural and human-influenced stressors. These defences include toxic leaves and seeds (which are rarely consumed by herbivores, including livestock), hard-coated seeds (which deter both invertebrate and vertebrate herbivores), a capacity to reproduce and expand populations both sexually and vegetatively, and an ability to thrive in a variety of open to semi-open moist and upland habitats.

3.2 Population and Distribution

The primary range of Kentucky Coffee-tree in the United States is from the southern Great Lakes region east to New York State, south to Oklahoma and Arkansas with scattered populations as far south as Texas and north to North Dakota (Figure 1). It is considered rare or uncommon and is seldom abundant throughout its range (Ambrose 1983). In Canada, it occurs only in extreme southern Ontario, in Middlesex, Essex, Kent, and Lambton Counties (Figure 2). It has been introduced widely as an ornamental plant, from Texas to Quebec and in the states of northern New England. Introduced Canadian populations are not being considered in this recovery strategy because many do not contain the native genome or their genetic origin is uncertain, and many occur outside the native range of the species or in landscaped settings such as urban gardens; recovery actions target the native populations in Canada, which occur only in southwestern Ontario.

[8] Ramets are genetically identical individuals (i.e., clones) of a plant that has spread vegetatively (i.e., not through sexual reproduction).

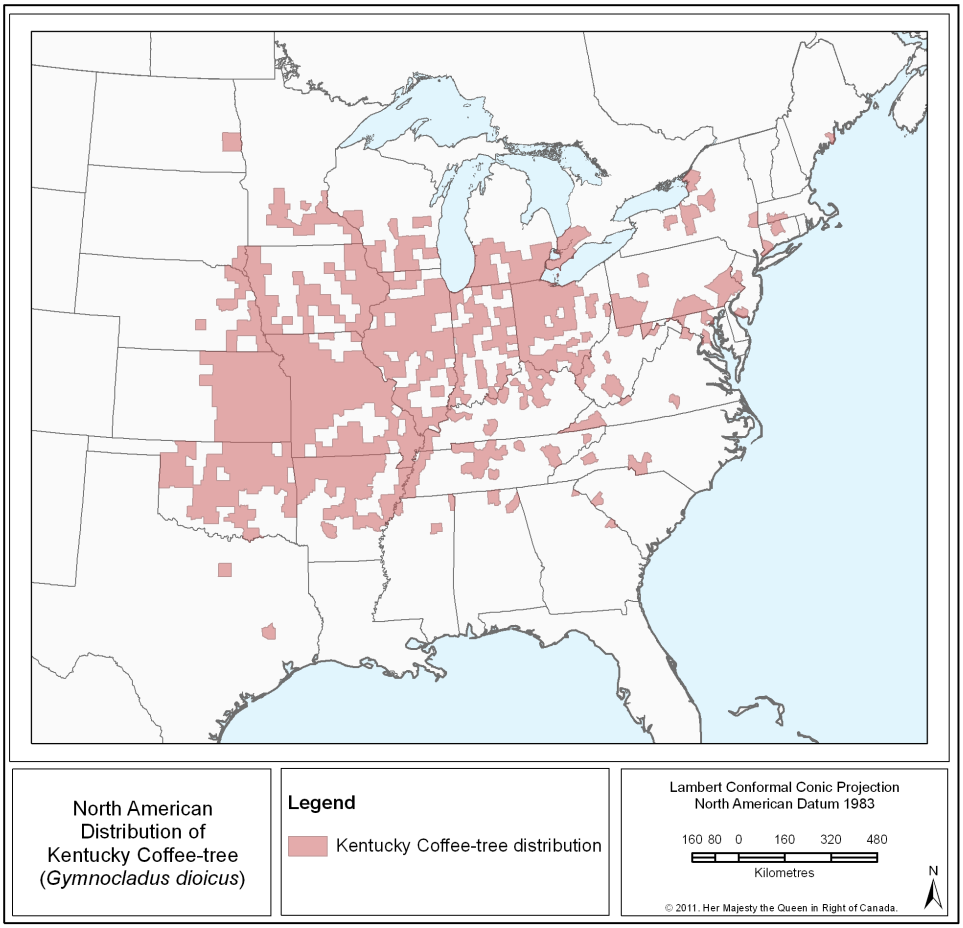

Figure 1. North American Distribution of Kentucky Coffee-tree (adapted from Kartesz 2011)

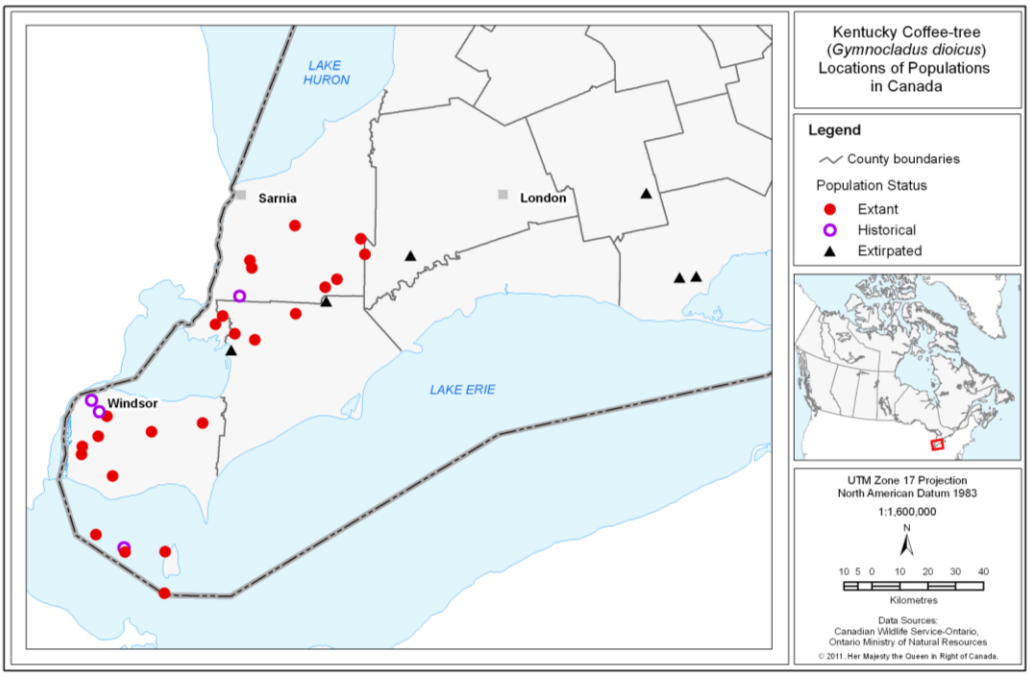

Figure 2. Locations of Kentucky Coffee-tree Populations in Canada

A total of 33 native populations[9] of Kentucky Coffee-tree have been documented in Ontario, of which only 23 were considered extant in 2010 (see Appendix C for list of populations, including status and sources of data). Four of the 33 populations have not been reported in more than 20 years and are categorized as historic. Six of the 33 populations have been extirpated, one of them in recent decades. Since Kentucky Coffee-tree is a conspicuous species, it is unlikely that many new native populations will be found in the province (COSEWIC 2000). With that being said, there is some indication that suitable habitat still exists at historic locations that have not been visited for many years (pre-1991) and that populations at these locations may remain extant. Habitat loss within its Ontario range has been very extensive over the past two centuries due to clearing for agriculture and urban land uses (Jalava et al. 2009), suggesting that declines in populations may be considerably greater than existing data indicate.

Kentucky Coffee-tree is rare or uncommon throughout its Canadian range in southwestern Ontario, with an estimated total abundance of fewer than 500 genetically-distinct mature trees. Almost all reproduction in Ontario is vegetative. In 2007, the largest population, located on East Sister Island, had over 1,200 saplings and seedlings, in addition to approximately 80 larger sized (>15cm dbh[10]) trees, most of which are considered to be clones. The only known sexually-reproducing populations (shown in bold in Appendix C) are located at Canard River Floodplain – Anderdon Township, Population #1 - Walpole Island First Nation, Crawford's Woods – Dover Township, East Sister Island – Lake Erie and Middle Sister Island – Lake Erie. However, when last visited in 1996, the Middle Sister Island population contained one live tree along with the previous years' seed pods; the reproductive status of this population is uncertain. Recent site visits (as of December 2011) indicate that fruit-bearing trees were present at the Shetland Kentucky Coffee-tree Woods - Zone Township population and the Petrolia - Enniskillen Township population; due to the timing of these surveys (i.e., winter), spring or summer site visits to confirm reproductive status are required. In addition, female trees are sometimes known to produce empty seed pods, as appears to be the case for the Petrolia – Enniskillen Township population.

Kentucky Coffee-tree is frequently planted as an ornamental tree, often from non-native stock originating in the United States. There are also several Canadian occurrences where it is believed the trees originated from transplanted local stock or were propagated from local seed. Many planted trees across southern Ontario are of unknown genetic origin and some occur well beyond the species known native range (e.g., Toronto, Hamilton and Ottawa). As a result, it can be difficult to ascertain whether trees are: native, planted from native stock, planted cultivars from the United States, or offspring of horticultural specimens that have spread into natural habitat. The non-native status of some of these populations has been determined by professional biologists or foresters, or based on habitat setting (natural vs. landscaped or agricultural). In other cases, provenance[11] information provided by landowners and/or whether trees are found

[9] For the purposes of this recovery strategy, a population can consist of a single tree or as a stand of trees. Populations are identified based on a separation distance of more than 1 km between individuals/stands. This distance is generally used in recognizing separate occurrences/populations in the COSEWIC, NatureServe and the Ontario Natural Heritage Information Centre records for immobile and/or vascular plants.

[10] Diameter at breast height (dbh) - a standard method of expressing the diameter of the trunk of a tree taken at 1.3 m above ground level.

[11] Place or source of origin.

within the historically-documented distribution of the species (e.g., no native populations are believed to have existed in Niagara Region, although populations have recently been documented there) has been used to determine origin. However, no comprehensive data on non-native populations in Ontario are available. Existing planted populations may be of some value to the recovery of the species (e.g., as sources of future seed stock) if they are known or suspected to be from Ontario stock. The information and objectives presented in this recovery strategy pertain to the 23 recognized native extant populations of Kentucky Coffee-tree in Canada.

3.3 Needs of the Kentucky Coffee-tree

Kentucky Coffee-tree grows best on fertile loam soil with ample moisture, and tolerates alkaline soils and dry sandy soils. For sites around Lake Erie, Limbird et al. (1980) expand on the optimal set of conditions for this species to include shallow, coarse-textured sandy soils to gravelly soils, excessively well-drained and sloping sites and relatively infertile soils.

Kentucky Coffee-tree can thrive in a broad range of habitats; however, it is shade-intolerant and requires canopy openings for seedling establishment and success. In Ontario, the species typically grows in rich floodplain woodlands and woodland edges of marshes where open canopy conditions exist (COSEWIC 2000). These habitats are often susceptible to seasonal flooding, which inhibits canopy closure by competing tree species. Ramets appear to tolerate more shade than seedlings and often occur under partial shade. Populations on the Lake Erie islands are usually in shallow-soiled open Common Hackberry (*Celtis occidentalis*) dominated limestone woodland (COSEWIC 2000). At Walpole Island First Nation, the species is found at the woodland edges of prairie habitats (Bowles 2004) at former Anishnaabeg homesteads (Jacobs pers. comm. 2012). A frequently-grown ornamental, the species is quite tolerant of urban, suburban and agricultural environments and thrives in areas that provide ample light.

In order to reproduce sexually and allow for genetic exchange, Kentucky Coffee-tree requires the presence of both male and female flowering plants in a population. At least four Ontario populations of Kentucky Coffee-tree contain both male and female trees and produce seeds (Craig pers. comm. 2007). Reproduction at all other populations is limited to vegetative (i.e., clonal[12]) reproduction through ramets. The species has limited genetic diversity in the province compared to populations further south in the United States (Ambrose and Carey 1987).

Pollination is believed to be facilitated by insects (Ambrose 1983). The greenish-white flowers emit fragrance at night, attracting moths at night and bumble bees (*Bombus* spp.) at dusk (Ambrose and Kevan 1990). The possibility of pollination between single-sex clones separated by several hundred metres, upwards to approximately 500 metres, is possible (Ambrose and Kevan 1990). Kentucky Coffee-tree produces seeds with a hard, water-impermeable seed coat. The seeds require scarification[13] for germination to occur, yet no insect or rodent herbivores are known to have the ability to break the seed coat. This results in infrequent germination and probably accounts for the fact that the species is rare or uncommon throughout much of its extensive North American range (Yeiser 1983; Ball and Kisor 1985). It is estimated that less than

[12] Genetically identical to the individual from which it was derived.
[13] The piercing or breaking of the seed coat.

5% of seeds germinate naturally without being subjected to special treatment (Wiesehuegel 1935). On the other hand, Bowles (pers. comm. 2006) has noted that seed dormancy can be broken by submerging the seeds in water and subjecting them to freeze and thaw cycles in early spring, after which seeds germinate well. Jacobs (pers. comm. 2012) notes that submerging the seeds in water for approximately a month was sufficient to soften the outer seed coat to allow successful germination of seed. In addition, there is evidence that the germination of Kentucky Coffee-tree seeds can be stimulated by fire with the species sometimes found in large numbers in burned-over areas (Minnis 2005; Garren 1943; Horr 1927).

Kentucky Coffee-tree seeds are unable to germinate in shaded conditions. Ambrose (pers. comm. 2006) has observed that through vegetative growth, new stems produced in the understory can reach the canopy if partial canopy conditions exist; thus, with a pre-existing population, the species can spread vegetatively without a fully open canopy.

Because no native herbivores consume the toxic Kentucky Coffee-tree seeds, its dispersal ability is also greatly reduced. Since elephants in Asia and Africa devour similar seed pods in great quantities, it has been hypothesized that the now-extinct mastodon (*Mammut* spp.) may have consumed and dispersed the Kentucky Coffee-tree seeds (Barlow 2002). In fact, Kentucky Coffee-tree may have evolved its unique seeds, which seem unpalatable and even toxic to native fauna, specifically for mastodon-assisted dispersal (Barlow 2002). The fruit of the Kentucky Coffee-tree appears not to be well adapted to dispersal by water; they are not very buoyant, the pulp is sweet (indicating palatability), pods are large, and the seeds do not germinate under water and in fact sink after being immersed for prolonged periods of time (Zaya and Howe 2009). According to Barlow (2002), "this tree simply had to have had a capable herbivore associate to evolve the kind of fruit it still produces". Zaya and Howe 2009 support this and hypothesize that the entire life cycle of Kentucky Coffee-tree is a relict of processes and environments driven by extinct large mammals. A number of tropical legumes with similar seed pods are successfully dispersed by agents such as elephants (*Loxodonta* spp.) in West Africa and rhinoceroses (*Rhinoceros* spp. and *Dicerorhinus* spp.) in South Asia (Barlow 2002; Zaya and Howe 2009). However, comparative studies on other species of *Gymnocladus* that might provide more information on the Kentucky Coffee-tree's unique biology have not been conducted.

Despite the assertion made by Zaya and Howe (2009) that the Kentucky Coffee-tree seeds are not well-adapted to water dispersal, natural dispersal of seeds by rivers and streams is believed to be the only natural dispersal method available today; this may in part explain why the species is so frequently found on floodplains even though it otherwise grows well in upland environments. Evidence in Ontario supports this theory as individuals in downstream floodplains are suspected to have originated from the seed-producing trees in the upstream population (Ambrose 1983; Giroux pers. comm. 2011). However, confirmation of this would require genetic testing.

A correlation exists between current extant stands of Kentucky Coffee-tree and former Native American and Aboriginal settlements; thus, it is possible to infer that these cultures played a significant role in the perpetuation of the species and in shaping the tree's current distribution (VanNatta 2009). It is hypothesized that many of the floodplain populations of Kentucky Coffee-tree occurring in North America originated from abandoned human settlements of Native Americans, Aboriginal peoples and early European pioneers where the seeds were used as game

pieces and as a coffee substitute (after roasting to detoxify) (Curtis 1959; McClain and Jackson 1980; Zaya and Howe 2009). Some occurrences on Walpole Island First Nation are known to be found near former Anishnaabeg homesteads (Jacobs pers. comm. 2012). Canadian occurrences are noted to follow known travel routes used historically by Aboriginal peoples, which may in part explain the species presence in floodplains, as streams were natural corridors of movement for Aboriginal peoples (Jacobs pers. comm. 2012; McClain and Jackson 1980). Other traditional uses include jewelry, music, and medicine (VanNatta 2009).

Dispersal by water and deposition in moist floodplain habitats may also result in partial decay of the hard outer seed-coat, allowing for germination to take place (Barlow 2002). One study found that Kentucky Coffee-tree is one of the most vulnerable tree species to heavy flooding of rivers (Yin et al. 1994) and is only able to withstand infrequent flooding of short duration (McClain and Jackson 1980). However, heavy flooding may also assist in spreading seeds to new locations. The distance of potential dispersal is unclear. Seeds that were observed to have washed downstream from one population in the Sydenham River did not germinate successfully, despite seemingly appropriate habitat and light conditions (Craig pers. comm. 2007).

3.4 Biological Limiting Factors

Kentucky Coffee-tree populations in Canada are limited by low rates of sexual reproduction. Most extant populations consist of single-sex individuals; only a few sexually-reproducing populations currently exist that have both the male and female trees required for sexual reproduction (i.e., seed production). Lack of both sexes in most Ontario populations, and subsequent lack of reproduction by seed, is the likely factor explaining the historically restricted distribution in Ontario, where populations spread only locally through clonal reproduction (Ambrose 1983). As a result, the species is typically distributed as widely separated single trees or in small groves, further limiting genetic exchange.

Dispersal ability, and thus genetic exchange, is also limited by apparent lack of a dispersing agent. In addition, the hard impermeable seed coat and the lack of existing biological agents to successfully break it, results in infrequent germination; it is estimated that less than 5% of seeds germinate under natural conditions (Wiesehuegel 1935).

These factors, combined with severe habitat fragmentation due to development in southern Ontario, have resulted in geographically-isolated populations that are especially prone to loss of genetic diversity. This loss of genetic diversity in turn reduces plant fitness and increases the risk of extirpation by disease or other environmental stressors, human actions or stochastic events. Shade intolerance may also limit the ability of the Kentucky Coffee-tree to survive in areas undergoing natural succession, as seeds are unable to germinate in shaded conditions.

Given that in Canada the species is found at the northern extent of its North American range and is uncommon, it will likely always be vulnerable to natural and human-influenced stressors.

4. THREATS

4.1 Threat Assessment

Table 1. Threat Assessment Table

Threat*	Level of Concern[1]	Extent	Occurrence	Frequency	Severity[2]	Causal Certainty[3]
Habitat Loss or Degradation						
Land Development	High	Widespread	Historic / Current	Continuous	High	High
Double-crested Cormorant Nesting Colonies	High	Localized	Current	Seasonal	High	High
Disturbance or Harm						
Cutting / Removal of Kentucky Coffee-trees	High	Widespread	Historic / Current	Continuous	High	High
Changes in Ecological Dynamics or Natural Processes						
Alteration of the Water Regime (e.g., flood control)	Medium	Localized	Unknown	Continuous	Moderate	Medium
Alteration of the Fire Regime (e.g., fire suppression)	Low / Medium	Localized	Current	Continuous	Moderate	Medium
Exotic, Invasive, or Introduced Species/Genome						
Planting of Non-native Kentucky Coffee-trees	Medium	Widespread	Current	Continuous	Unknown	Low
Terrestrial Invasive Plants (e.g., Dog-strangling Vine)	Low / Medium	Widespread	Anticipated	Continuous	Unknown	Low

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

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

[3] *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).*

**Threat categories are listed in approximate order of decreasing significance based on existing information and knowledge.*

4.2 Description of Threats

Land Development
Although Kentucky Coffee-tree has probably been uncommon in Ontario's temperate forest for many decades due, in part, to limited sexual reproduction, an apparent lack of dispersal agent and being at the northern extent of its North American range, extensive deforestation has also occurred within the species' limited range in southwestern Ontario. Many Kentucky Coffee-tree stands have undoubtedly been lost over the decades through development (e.g., urbanization, industrial, road and agricultural), and a number of local extirpations have been confirmed (Appendix C). Habitat fragmentation through conversion to agriculture and urban land uses has left the remaining populations, which in some cases consist of individual trees, isolated from other populations. Land conversion has also limited the amount of habitat where new colonization could occur near extant populations.

Double-crested Cormorant Nesting Colonies
Double-crested Cormorant (*Phalocrocorax auritus*) populations in the Great Lakes underwent dramatic declines throughout the 1960s and into the 1970s due predominantly to toxic contaminants affecting reproductive success (Weseloh and Collier 2005). Over the past 30 years, Ontario's cormorant population has increased dramatically (Weseloh et al. 1995; Jalava et al. 2008). Reduced toxin levels in the Great Lakes are unlikely the sole factor responsible for the increase in cormorant numbers (Weseloh and Collier 2005). There appear to be four additional factors implicated in the rise of the cormorant population:

1. the species was added to U.S. *Migratory Bird Treaty Act* bird list in 1972, that prohibited killing or harassment of the birds during their annual life cycle,
2. human-induced changes (e.g., accidental and intentional introduction of exotics; over fishing; changes in water quality) in aquatic communities in the breeding range,
3. development of aquaculture (e.g., catfish farms) in the south (especially Mississippi Delta region) that provided a new food source, and
4. creation of additional breeding and foraging habitat (e.g., reservoirs; dredge spoil islands) (Wires et al. 2001).

In the Great Lakes, human-induced alterations to fish populations have created an imbalance in predator-prey dynamics and species composition resulting in conditions amenable to Double-crested Cormorant success. The dramatic cormorant increase was probably augmented by a rise in the numbers of smaller fish (not native to the Great Lakes), such as Rainbow Smelt (*Osmerus mordax*) and Alewife (*Alosa pseudoharengus*), which serve as the species' primary food source (Weseloh and Collier 2005). Since the 1970s, these smaller prey fish have been much more abundant than they were 30 to 40 years earlier due to declines of predatory fish species. The predatory fish species were declining in part because of years of heavy fishing, the invasion of the Sea Lamprey (*Petromyzon marinus*) and the loss of spawning areas (Weseloh and Collier 2005).

In 1981, six cormorant nests were first observed on East Sister Island, which expanded to a reported 6,028 nests by 2004. A similar colonization has occurred on Middle Island, beginning with three nests in 1987 and peaking at 6,635 nests in 2002. From 2003 to 2010, numbers of

cormorant nests have fluctuated, but have averaged about 5,000 nests each year on each of the islands.

Cormorants impact trees in their breeding locations through physically breaking branches, stripping foliage for nesting material (Korfanty et al. 1999) and through the deposition of guano on trees, leaves and soil which can affect photosynthesis and soil chemistry (Hebert et al. 2005; Hobara et al. 2001). The increase in the number of nesting cormorants since the 1980s has led to a corresponding increase in the damage and subsequent death of trees on Middle Island and East Sister Island, including mature Kentucky Coffee-trees (Hebert et al. 2005; Koh 2005). Koh (2005) reported 15% overall tree mortality on East Sister Island, as well as a 50% tree crown dieback in the upper canopy and 51% branch damage in living trees (all species). Koh (2005) noted that these findings were consistent with previous research using infrared photography that showed canopy openings had become significantly greater between 2001 and 2003 on East Sister Island (Hebert et al. 2005). This same type of analysis has shown a 41% loss of healthy canopy vegetation on Middle Island between 1995 and 2006 (Hebert et al. 2005; Hebert pers. comm. 2006). In addition, Emerald Ash Borer (*Agrilus planipennis*) was discovered on East Sister Island and has been implicated in the decline of mature ash (*Fraxinus spp.*) trees and further decreases in canopy cover (Dobbyn pers. comm. 2011).

Large colonies of nesting Double-crested Cormorant threaten Kentucky Coffee-tree populations on Middle Island and East Sister Island. In 2007, many Kentucky Coffee-trees on these islands (13 trees and approximately 500 saplings on Middle Island and 80 trees and >1,200 saplings on East Sister Island) were showing signs of stress including extensive damage to the surrounding vegetation (Jalava et al. 2008; Dobbyn in prep.). Damage to saplings is generally the result of the deposition of cormorant guano (droppings) whereas older trees are damaged directly by nesting activities (Dobbyn pers. comm. 2011). It should be noted, however, that opening of the canopy can create the open conditions that favour the establishment of ramets of Kentucky Coffee-tree. This has likely contributed to the increase of saplings observed on East Sister Island and may continue to stimulate vegetative reproduction on these islands (Dobbyn pers. comm. 2011).

Cutting / Removal of Kentucky Coffee-trees

Kentucky Coffee-trees that exist in floodplains, on roadsides and/or part of a fencerow are particularly vulnerable to clearing while trees occurring as part of a forest stand are more vulnerable to canopy closure due to forest succession (COSEWIC 2000). Because the leaves and seeds of Kentucky Coffee-tree are toxic to livestock, many were likely historically removed by farmers. Removal of trees has occurred more recently at some populations on private land; in at least one instance, this reduced the population to a single-sex occurrence (see Appendix C). Ambrose (pers. comm. 2006) notes that the maintenance activities of some road and railway crews may threaten many single-clone stands along roadsides, railroad embankments and hedgerows; two trees are reported to have been removed by the road maintenance crew in the early 1970s in Sombra township (Craig pers. comm. 2007). While roadside populations are at risk of eradication by right-of-way maintenance they likely include important genetic diversity in addition to that found in the very few sexually-reproducing populations.

Alteration of the Water Regime

Drains, dams and other flood control measures upriver from floodplain occurrences can threaten Kentucky Coffee-tree populations occurring in this habitat type. Periodic seasonal flooding is a critical factor influencing forest composition, productivity and distribution of forest communities within large river-floodplain ecosystems (Yin et al. 1994). Forest succession along the flood gradient is strongly influenced by the long-term flow regime or average annual flood pattern, as well as unusual hydrologic events such as extreme droughts and floods that are not seasonal or predictable (Yin et al. 1994). Natural flood cycles help to maintain open and semi-open canopy conditions required by the species and may also assist in spreading seeds to new locations. However, alteration to the natural hydroperiod may result in changes to the forest community leading to succession to closed-canopy forest, rendering habitat unsuitable for Kentucky Coffee-tree.

In addition to changes in the forest structure, individual Kentucky Coffee-trees were shown to be one of the most susceptible species to mortality from heavy and prolonged flooding (Yin et al. 1994). The species is only able to withstand infrequent flooding of rather short duration (McClain and Jackson 1980).

Planting of Non-native Kentucky Coffee-trees

As noted, Kentucky Coffee-tree is a popular ornamental tree, particularly in the United States, where it has been introduced as such to several states outside of its native range. Its planting is frequently encouraged for urban parklands because of its hardiness and relatively rapid growth rate. Municipal plantings (May pers. comm. 2006), garden plantings (NHIC 2006) and reintroduction efforts by local nature clubs (e.g., WENC 2006) and other groups, have occurred at a number of locations in southern Ontario. The genetic sources of these planted stocks are often unknown and when the trees mature, their genetic material may spread into native Ontario populations thereby diluting the local gene pool. The widespread belief is that native populations are the best source for plantings because they are genetically adapted to local biophysical conditions. However, Buck (pers. comm. 2010) has noted that genetic diversity of Kentucky Coffee-tree is believed to be relatively low across its range in North America, so the introduction of non-native stock may not have as great an impact on the local gene pool as some fear.

Alteration of the Fire Regime

Alteration of the fire regime, through fire suppression, can contribute to forest succession leading to closed-canopy conditions not optimal for Kentucky Coffee-tree growth. This may cause local extirpation of Kentucky Coffee-tree by preventing seedling establishment, due to lack of solar radiation on the forest floor required for seed germination (White and Oldham 2000). In addition, closed-canopy conditions would inhibit the growth of Kentucky Coffee-tree ramets. This would not likely be an issue for those populations located within the flood prone areas where the disturbance regime is more likely related to flooding rather than fire, or those areas exposed to lake storms where blow downs are common and result in the creation of forest openings.

Terrestrial Invasive Plants (e.g., Dog Strangling Vine)

Although competition from terrestrial invasive plants has not been specifically documented as a threat to Kentucky Coffee-tree in Ontario, vigilance should be exercised in relation to this potential threat. Of particular concern are the two species of Dog-strangling Vine

(*Cynanchum rossicum* and *C. louiseae*), which are allelopaths, emitting chemicals that inhibit or prevent growth of other plant species. These aggressive species have invaded many upland and floodplain habitats in southern Ontario, recently expanding to within the native range of Kentucky Coffee-tree in Canada (Pridham and Irvine 2008). Although Dog-strangling Vine infestation would likely not kill existing trees, by competing for habitat this species could prevent seedling establishment and expansion of populations to new sites. Kudzu (*Pueraria montana* var. *lobata*), native to Asia, is an aggressive vine that is able to climb over top of trees and saplings, smothering them and eventually leading to death (Berisford et al. 2006). In addition, the species can grow into large, dense monocultures that can lead to increased shading which would be detrimental to Kentucky Coffee-tree seeding establishment and ramet growth. Particularly susceptible are edge trees; many occurrences of Kentucky Coffee-tree in Ontario consist of trees found along edge habitats. Although not documented at any Kentucky Coffee-tree populations, Kudzu has been reported at one location along the Lake Erie shoreline (Dobbyn pers. comm. 2011).

5. POPULATION AND DISTRIBUTION OBJECTIVES

Based on currently available information, 15 of the 23 extant native populations of Kentucky Coffee-tree in Canada occur within natural settings[14] (e.g., floodplain woodlands and woodland edges of marshes), with an additional six in landscaped or agricultural settings (e.g., agricultural fields, roadside ditches, lawns and fencerows) and two within undetermined settings (Appendix C). At least 4 of the 15 extant populations within natural settings are mixed-gender and sexually-reproducing with an additional two populations that require confirmation of sexual-reproductive status. The remaining single-sex populations within natural settings are currently limited to vegetative reproduction (clonal).

Although all individual trees are protected under the *Species at Risk Act* (on federal lands) or Ontario *Endangered Species Act, 2007* (on non-federal lands), the focus of recovery efforts is targeted to native, extant populations, primarily those in natural settings. Therefore, the population and distribution objectives for the Kentucky Coffee-tree in Canada are to:

- maintain extant native populations within natural settings at their current abundance and distribution;
- augment extant single-sex native populations (i.e., populations that are not sexually-reproducing) occurring within natural settings to attempt to establish sexually-reproducing populations, if biologically and technically feasible, and;
- maintain the remaining extant native populations that occur in landscaped or agricultural settings either *in situ* or through their incorporation into, or use in the establishment of, populations in natural settings.

[14] Natural settings are areas with habitats that can be described as largely unmanaged and subject to minimal anthropogenic influences. Although this equates primarily to natural vegetation types (e.g., swamp, marsh, forest, woodland, prairie and savannah), as described by the Ecological Land Classification (Lee et al. 1998 and listed above), it is also includes cultural woodlots.

The habitat surrounding populations of Kentucky Coffee-tree occurring in landscaped or agricultural settings, such as roadside ditches and fencerows within agricultural fields, are not considered to be necessary to the recovery of the species. These habitat types do not offer the proper conditions required for self-sustainability due to human activities that would inhibit natural population expansion and dispersal. The species is noted for its ability to persist (Zaya and Howe 2009) but roadside and fencerow trees have limited long-term viability and few chances to repopulate natural habitat (COSEWIC 2000). However, the individual trees within these populations may contain important genetic material that could be used to supplement the genetic diversity of populations occurring within natural habitat (e.g., through the transplanting of ramets) and may therefore be important to recovery. Populations within these settings may be maintained either: *in situ* (particularly in the case of the larger fencerow populations); by incorporating their genetic material into existing populations that require augmentation through the transplanting of ramets or cuttings (particularly in the case of single roadside and backyard trees); through the establishment of populations within natural settings using these populations as source trees, if determined to be biologically and technically feasible; or any combination of the above measures.

One of the main limiting factors for Kentucky Coffee-tree is the lack of reproduction by seed. Augmenting single-sex populations, particularly with opposite-sex individuals (to achieve sexual reproduction) but also same-sex individuals (to improve abundance and ensure both sexes are represented), will lead to improved genetic diversity and increased seed production (including increased probability of successful germination of seeds) which in theory will allow the species to naturally colonize nearby suitable habitat and establish self-sustaining populations. Single-sex populations currently occurring within natural settings (e.g., floodplain woodlands and woodland edges of marshes) will be augmented with both opposite-sex and same-sex individuals as these populations contain the suitable habitat necessary to allow for expansion of the population once sexual reproduction is achieved.

In Canada, Kentucky Coffee-tree occurs near the northern extent of its North American range. The species is restricted to southwestern Ontario and occurs only as a rare component in naturally-occurring forest stands (USDA 2007).

6. BROAD STRATEGIES AND GENERAL APPROACHES TO MEET OBJECTIVES

6.1 Actions Already Completed or Currently Underway

The following actions relating to the recovery of Kentucky Coffee-tree in Ontario have been completed or are underway:

1. Periodic surveys have been performed for various populations of Kentucky Coffee-tree in Ontario. Most recently, detailed surveys have been performed on East Sister Island by Ontario Parks and on Middle Island by Jalava et al. (2008).

2. In the mid-1980s, Carolinian Woodlands Recovery Team members J. Ambrose (pers. comm. 2006) and G. Waldron undertook *inter situ* plantings on Essex Region Conservation Authority (ERCA) properties from ramets divided from local clonal stands. The ramets were planted in conservation areas in edges of natural areas, often adjacent to river courses, so that the trees, as they matured, could cross pollinate and drop seed pods into the water or nearby suitable habitats. One of the planted sites was destroyed by parking lot construction; one was compromised by the planting of non-locally-sourced Kentucky Coffee-trees nearby; some are still doing well (Ambrose pers. comm. 2011). The results of this project are currently undetermined as it is uncertain whether observed growth is from seed (i.e., sexual reproduction) or from vegetative (i.e., clonal) growth.

3. Of the 23 extant occurrences in Ontario, six occur in protected areas that receive targeted management actions: three occur on conservation authority lands; one occurs at Point Pelee National Park (Middle Island) where Double-crested Cormorant control measures are being undertaken; one population occurs on East Sister Island Provincial Nature Reserve; and one occurs within an Agreement Forest that is now owned by Southwest Middlesex municipality.

4. A management plan has been developed for East Sister Island. Ontario Parks is preparing a background document that summarizes a number of studies to investigate the overall effects of cormorants on the island ecosystem (Dobbyn pers. comm. 2007, 2011). In 1997, the Ontario Ministry of Natural Resources (OMNR) completed a "*Review of the Population Status and Management of Double-crested Cormorants in Ontario*" in response to increasing cormorant populations, and public demand for information and management options (OMNR 1997). Since 1997, the scientific community, and provincial and federal agencies have increased the knowledge base with respect to cormorant biology, population dynamics, environmental impacts, and future management challenges. An updated document reports on this new knowledge, and expands on the information presented in the 1997 review document (OMNR 2006).

5. A cooperative restoration program involving Walpole Island First Nation and the Sherwood Fox Arboretum of the University of Western Ontario (UWO) has been established to restore or increase native populations at priority locations such as Walpole Island First Nation (Jacobs pers. comm. 2012). A single female tree close to a clone of male trees at Walpole Island First Nation is being monitored as part of the habitat restoration program (Bowles 2004; Bowles pers. comm. 2006, 2010; Jacobs pers. comm. 2012).

6. The University of Guelph Arboretum has a living gene bank of many of the Ontario populations of Kentucky Coffee-tree collected in the mid 1980s (Ambrose pers. comm. 2007).

7. The largest confirmed sexually-reproducing population, the Canard River Floodplain – Anderdon Township population, occurs on public land (Canard Valley Conservation Area owned by the Essex Region Conservation Authority); the site was identified for the focus of habitat restoration activities, as part of a larger Biodiversity Conservation Strategy (BCS) for the Essex Region (ERCA 2002). Partners in the BCS project include the Essex Region Conservation Authority, Environment Canada, Ontario Great Lakes Renewal Foundation and Ontario Power Generation (Lake Erie LaMP 2002). In 2008, seeds from this Kentucky Coffee-tree population were collected and grown in a nursery for two years. In 2011, a total of 141 seedlings were planted within three sites in the Canard Valley Conservation Area (Giroux pers. comm. 2011).

8. Various conservation documents and conservation action plans (CAPs), including the Carolinian Woodland Recovery Strategy (Jalava et al. 2009; Jalava and Mansur 2008), the draft Walpole Island Ecosystem Recovery Strategy (Bowles 2005), the Essex Forests and Wetlands CAP (Essex Forests and Wetlands CAP Team 2009) and the Short Hills CAP (Jalava et al. 2010), have been developed that identify Kentucky Coffee-tree recovery activities, such as inventory and monitoring, establishing mixed-gender populations, habitat restoration and site securement, as priority strategic actions. The CAP program is coordinated by the Carolinian Canada Coalition and local partners, and implementation of Kentucky Coffee-tree related activities has been initiated by Essex Region Conservation Authority (Lebedyk pers. comm. 2011). Recovery actions described in the draft Walpole Island Ecosystem Recovery Strategy included raising awareness in the community about species at risk, including Kentucky Coffee-tree, as well as habitat restoration and plantings. Pamphlets, calendars, newsletter articles, posters and other promotional material have been used to raise awareness of species at risk in the Walpole Island First Nation community.

9. Walpole Island First Nation is currently developing an ecosystem protection plan based on the community's traditional ecological knowledge (TEK).

10. Mitigation, in response to Kentucky Coffee-tree removal at a subdivision developed in Ancaster, Ontario, involved the establishment of mixed-gender population(s) in Essex through strategic planting and site restoration (Pickett pers. comm. 2011) in association with the aforementioned Essex Forests and Wetlands CAP.

6.2 Strategic Direction for Recovery

Table 2. Recovery Planning Table

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches
All threats	High	Inventory and Monitoring	• Develop and implement a standardized monitoring protocol to be distributed to organizations/individuals involved in Kentucky Coffee-tree monitoring programs. • Inventory and monitor all extant populations for which recent (i.e., within 3 years) data are unavailable and historic sites where suitable habitat still exists; confirm population status and habitat setting (i.e., natural vs. landscaped or agricultural), where required. • At extant sites characterize habitat, assess threats and investigate reproductive status.
All threats and limiting factors such as low rates of sexual reproduction and infrequent germination of seeds	High	Augmentation	• Determine natural germination rates / requirements and develop techniques (e.g., site preparation or manual seed coat scarification / treatment) to increase germination rates; determine proportion of existing native population originating from seed. • Contingent on the above findings, assess threats and site conditions to determine the feasibility (or need) of augmenting populations in natural settings at extant locations. • If feasible, plant ramets (or seedlings) from native sources at single-sex populations in natural settings with the intent of establishing mixed-gender populations.
Land Development	High	Protection and Stewardship	• Collaborate with land trusts, public agencies and First Nations to identify and secure key sites through easements, purchase or other stewardship approaches.
Land Development; Alteration of the water regime; Alteration of the fire regime; Double-crested Cormorant nesting colonies; Cutting of trees; Terrestrial invasive plants	Medium	Habitat Management and Threat Mitigation	• Develop Best Management Practices (BMP) to distribute to appropriate groups (e.g., municipalities, conservation authorities, First Nations, landowners, right-of-way maintenance crews, etc.) with guidelines for appropriate forest, watershed and land-use management (i.e., prevention of succession to closed canopy forest, techniques for road and rail maintenance, identification of the species and its habitat). • Continue to develop and apply appropriate management practices to reduce Double-crested Cormorant impacts to levels that allow for the growth / maintenance of Kentucky Coffee-tree populations and other species at risk (e.g., Wild Hyacinth) at Lake Erie islands. • Remove invasive species from Kentucky Coffee-tree habitat, where necessary.
All threats	Medium	Habitat Restoration	• Determine feasibility of restoration of degraded habitat in vicinity of extant occurrences. • Integrate restoration planning and activities with partner agencies and groups such as conservation authorities and other non-governmental organizations, First Nations and federal and provincial government agencies.
All threats	Medium	Outreach and Education	• Conduct outreach and/or educational activities with key audiences to encourage conservation and protection of the tree and its habitat. • Encourage the transfer and archiving of Traditional Ecological Knowledge (TEK)

Planting of non-native Kentucky Coffee-trees; Terrestrial invasive plants	Low	Knowledge Gaps	• Assess viability of Kentucky Coffee-tree populations in Ontario. • Determine (if possible) the genetic origins of native and planted populations and existing nursery populations, including the effect of genetic exchange between planted and native trees where they occur in close proximity. • Monitor the spread of Dog-strangling Vine and other invasive species and investigate effective removal/ control techniques.

7. CRITICAL HABITAT

7.1 Identification of the Species' Critical Habitat

Critical habitat for Kentucky Coffee-tree in Canada is identified in this recovery strategy to the extent possible, based on available data. It is recognized that the critical habitat identified below is insufficient to achieve the population and distribution objectives for the species. The Schedule of Studies (Section 7.2) outlines the activities required to identify additional critical habitat necessary to support the population and distribution objectives of this species.

Based on the criteria below, critical habitat is identified for certain extant native populations of Kentucky Coffee-tree that exist within natural settings (e.g., floodplain woodlands and woodland edges of marshes) to allow for natural dispersal and expansion of populations and to provide suitable habitat in the vicinity of populations to allow for possible augmenting of populations with opposite-sex individuals. The identification of critical habitat for Kentucky Coffee-tree is based on habitat suitability and site occupancy by Kentucky Coffee-tree. Although critical habitat will not be identified for extant native populations, or sites within an extant native population, occurring in landscaped or agricultural settings, these trees may contain important genetic material for recovery and, depending on where they occur, are either protected under the prohibitions listed in the *Species at Risk Act* (on federal lands) or the *Endangered Species Act*, 2007 (on non-federal lands).

Sites where Kentucky Coffee-tree has been planted as part of a restoration program will not be considered for critical habitat identification until it can be determined that the plantings are successful. Determination of restoration success and viability, as measured through plant vigour and fitness, must precede identification of critical habitat at restoration sites at this time. Critical habitat may be identified at restoration sites following long-term monitoring to determine success, extent of suitable habitat and site occupancy.

7.1.1 Suitable Habitat

Kentucky Coffee-tree can thrive in a broad range of deciduous woodlands with rich, usually moist soils. It is shade-intolerant, requiring canopy openings for seedling establishment. Root shoots appear to tolerate more shade than seedlings, often occurring under partial shade. Elliott (pers. comm. 2011) noted that even minor canopy gaps in the forest caused by natural or human disturbance can be vegetatively colonized by Kentucky Coffee-tree, and that vegetative (i.e., clonal) growth through ramets is believed to be the species' primary regeneration strategy. Required conditions are often found in the deciduous floodplain woodlands and woodland edges of marshes where Kentucky Coffee-tree typically grows in Ontario. These habitats are often susceptible to seasonal flooding, which inhibits canopy closure by competing tree species and may allow for dispersal of seeds within the floodplain. Populations on the Lake Erie Islands are usually in shallow-soiled open Common Hackberry-dominated limestone woodland (COSEWIC 2000). At Walpole Island First Nation the species is found at the woodland edges of prairie habitats (Bowles 2004) at sites of former Anishnaabeg homesteads that have since reverted to prairie (Jacobs, pers. comm. 2012).

Kentucky Coffee-tree appears to be associated more with site conditions (e.g., open canopy) than with specific species compositions. Deciduous woodland and woodland floodplain habitat as well as more open habitats such as tallgrass prairie and savannah, and moist habitats such as swamp, fen, bog and marsh are all considered suitable. Agricultural or landscaped areas such as agricultural fields, roadside ditches, fencerows and lawns are not considered suitable habitat as populations occurring within these human-modified environments have limited long-term viability and few chances to repopulate natural habitat (COSEWIC 2000).

7.1.2 Site Occupancy

Site Occupancy Criterion: A site is considered occupied when a native Kentucky Coffee-tree has been observed between 1992 and 2011 in suitable habitat. If a field survey by a qualified individual (e.g., forester or biologist) determines that no living Kentucky Coffee-tree plants (e.g., ramets, saplings or trees) are extant at a site, the site is considered unoccupied.

A site is defined by a boundary drawn at a radial distance of 20 m around a known observation of a native extant Kentucky Coffee-tree. The 20 m distance is applied to each observation, with spatially overlapping areas merged together to form larger sites.

A radial distance of 20 m is based on a critical root radius definition which is calculated as 1.5 feet of radius for each inch of the diameter at breast height (dbh) of a tree (or 18 cm per one cm of the dbh) (Johnson 1999). Given that the maximum-recorded dbh for Kentucky Coffee-tree in Canada is 106.2 cm (Waldron 2003), the critical root radius is then calculated to be 20 m (106.2 cm x 18 cm = 19.1 m rounded up to the nearest 5 metres). The critical root radius is used to define a zone surrounding the tree to prevent damage or disturbance (such as soil compaction) to the roots, dripline[15] and soil.

Site occupancy is determined using observations of native occurrences collected between 1992 and 2011. The 20-year window is consistent with the NatureServe (2011) and Ontario's Natural Heritage Information Centre (NHIC) (2010) threshold for considering populations to be extant versus historic, and allows for inclusion of a number of native populations that likely persist but which have not been recently surveyed.

A site must contain at least one living Kentucky Coffee-tree plant (which may include ramet, sapling or tree), and can include apparently dead individuals (based on visual observations), believed to be native in origin, and located in suitable habitat. Apparently dead, standing snags are included because ramets are often observed in the vicinity of individuals which otherwise appear to be dead. Any sites containing plants that are considered horticultural specimens, and those clearly planted in landscaped settings such as urban gardens, are not considered to be occupied for the purposes of identifying critical habitat.

Limited information is available on the configuration of individuals within Kentucky Coffee-tree populations. Given that the current primary regeneration strategy is by ramets, expansion of a population will occur within the vicinity of the 'parent' tree as ramets originate from existing

[15] The area beneath a tree defined by the outermost circumference of the tree's canopy where water drips from the tree's foliage onto the ground.

roots. Based on this and until additional information is available, the suitable habitat within a 20 m radial distance is thought to be sufficient to allow for the establishment and growth of ramets. The 20 m radial distance should also provide suitable habitat for any restoration plantings which may occur at a site as well as potential germination sites for those trees currently able to produce seeds and those that will produce seeds in the future. In addition, many of the individuals comprising Kentucky Coffee-tree populations are seedling- and sapling-sized individuals (<5 feet tall) for which the 20 m radial distance, which exceeds the critical root radius for this size class, should provide ample area for growth as the tree matures.

7.1.3 Application of the Kentucky Coffee-tree Critical Habitat Criteria

Critical habitat for Kentucky Coffee-tree is identified in this recovery strategy as the suitable habitat (Section 7.1.1) within the site boundary as per the Site Occupancy Criterion (Section 7.1.2). Critical habitat is the suitable habitat (Section 7.1.1) within a 20 m radial distance of extant native Kentucky Coffee-trees, observed between 1992 and 2011, occurring in natural settings.

Application of the critical habitat criteria to available information identified 26 sites containing critical habitat across 12 populations in Canada (Table 3). It is important to note that the coordinates provided are a cartographic representation of the sites where the critical habitat can be found. Critical habitat for Kentucky Coffee-tree occurs within the 1 x 1 km standardized Universal Transverse Mercator (UTM) grid where the critical habitat criteria and methodology described in section 7.1 are met. Unsuitable habitat features such as existing human-made features (e.g., existing infrastructure, including homes, buildings, roads) and landscaped and agricultural areas (e.g., agricultural lands and roadside ditches) within the site boundary are not necessary for the survival or recovery of the species and are therefore not critical habitat. In addition, unvegetated shorelines within the Lake Erie sites would not be considered critical habitat as it is unlikely that the species will establish in these areas.

The UTM grid is a standardized national grid system that indicates the general geographical area containing critical habitat and can be used to highlight areas that contain critical habitat (e.g., by land-use planners, landowners, or during an environmental assessment). To respect provincial data-sharing agreements, as well as best practices for reducing further risks to the species and its habitat, locational information is presented as 1 x 1 km UTM grids (Table 3). In addition to providing these benefits, the 1 x 1 km UTM grid may represent the accuracy of the best available information (e.g., occurrence or suitable habitat/biophysical features) for certain locations (e.g., the location would require field verification to improve the accuracy). In several instances, populations have not been visited for ten or more years and even for several of the locations recently visited, Global Positioning System (GPS) data is not available for the individual trees. More detailed information on the location of critical habitat, to support protection of the species and its habitat, may be requested on a need-to-know basis by contacting Environment Canada – Canadian Wildlife Service at enviroinfo@ec.gc.ca.

Critical habitat is currently not identified for the Walpole Island First Nation populations or the Sydenham River, Florence, Euphemia Township population. The Sydenham River, Florence population has an accuracy of only 1km which is not adequate to identify critical habitat;

furthermore, the area was searched but the species was not found in 1996 and 1997. Although the continued presence of Kentucky Coffee-tree has been confirmed for the Walpole Island First Nation populations (see Appendix C), the information available to Environment Canada is from 1986 and the specific location of the trees is unclear. Once adequate information is obtained (i.e., detailed location, extent of populations and suitable habitat), additional critical habitat will be identified and may be described within an area-based multi-species at risk action plan developed in collaboration with the Walpole Island First Nation.

Table 3. Grids Containing Critical Habitat for Kentucky Coffee-tree (*Gymnocladus dioicus*) in Canada. Critical habitat for Kentucky Coffee-tree occurs within these 1 x 1 km standardized UTM grids where the criteria described in section 7.1 are met.

1 x 1 km Grid ID[1]	UTM Zone	Province/ Territory	Easting[2]	Northing[2]	Number of Critical Habitat Site Centroids within the Grid[3]	Total Critical Habitat Site Area[4] (ha) within the Grid	Population	Land Tenure[5]	County
17LG33_34	17	Ontario	333000	4634000	1	2	Middle Sister Island, Lake Erie	Non-federal	Essex
17LG33_35	17	Ontario	333000	4635000	0	1			
17LG36_55	17	Ontario	335000	4665000	2	1	Canard River Floodplain, Anderdon Township	Non-federal	Essex
17LG36_56	17	Ontario	335000	4666000	1	1			
17LG36_65	17	Ontario	336000	4665000	1	1			
17LG43_50	17	Ontario	345000	4630000	1	10	East Sister Island, Lake Erie	Non-federal	Essex
17LG43_60	17	Ontario	346000	4630000	0	2			
17LG51_95	17	Ontario	359000	4615000	4	1	Middle Island, Lake Erie	Federal	Essex
17LG51_96	17	Ontario	359000	4616000	1	1			
17LG61_05	17	Ontario	360000	4615000	1	1			
17LG61_06	17	Ontario	360000	4616000	2	1			
17LH80_48	17	Ontario	384000	4708000	0	2	Crawford's Woods, Dover Township	Non-federal	Chatham-Kent
17LH80_49	17	Ontario	384000	4709000	0	1			
17LH80_58	17	Ontario	385000	4708000	1	14			
17LH80_59	17	Ontario	385000	4709000	0	1			
17LH83_70	17	Ontario	387000	4730000	1	13	Wilkesport, Sombra Township	Non-federal	Lambton
17LH83_80	17	Ontario	388000	4730000	1	1			
17LH93_12	17	Ontario	391000	4732000	2	2			
17LH93_04	17	Ontario	390000	4734000	0	2	Bear Creek, Avonry, Sombra Township	Non-federal	Lambton
17LH93_05	17	Ontario	390000	4735000	1	11			
17MH01_65	17	Ontario	406000	4715000	0	3	Sydenham River, Dresden, Camden Township	Non-federal	Chatham-Kent
17MH01_66	17	Ontario	406000	4716000	0	3			
17MH01_75	17	Ontario	407000	4715000	0	3			
17MH01_76	17	Ontario	407000	4716000	1	4			

17MH04_78	17	Ontario	407000	4748000	0	1	Petrolia, Enniskillen Township	Non-federal	Lambton
17MH04_79	17	Ontario	407000	4749000	1	2			
17MH22_18	17	Ontario	421000	4728000	2	1	Sheltand Kentucky Coffee-tree Woods, Zone Township	Non-federal	Lambton
17MH33_17	17	Ontario	431000	4737000	1	2	Grey Tract, Brooke / Mosa Township	Non-federal	Middlesex
17MH34_02	17	Ontario	430000	4742000	1	11	Sydenham River, Alvinston, Brooke Township	Non-federal	Lambton
17MH34_03	17	Ontario	430000	4743000	0	1			
				Total	**26**	**92 ha**			

[1] Grid ID is based on the standard UTM Military Grid Reference System (see http://www.nrcan.gc.ca/earth-sciences/geography-boundary/mapping/topographic-mapping/10098), where the first 2 digits represent the UTM Zone, the following 2 letters indicate the 100 x 100 km standardized UTM grid, followed by 2 digits to represent the 10 x 10 km standardized UTM grid. The last 2 digits represent the 1 x 1 km standardized UTM grid containing all or a portion of the site containing critical habitat. This unique alphanumeric code is based on the methodology produced from the Breeding Bird Atlases of Canada (See http://www.bsc-eoc.org/ for more information on breeding bird atlases).

[2]The listed coordinates are a cartographic representation of where critical habitat can be found, presented as the southwest corner of the 1 x 1 km standardized UTM grid containing all or a portion of the site containing critical habitat. The coordinates may not fall within critical habitat and are provided as a general location only.

[3] A value of "0" means the grid contains a portion of (a) critical habitat site(s) but not the site centroid.

[4]The area presented is that of the site boundary (rounded up to the nearest 1 ha); an approximation based on a maximum extent that may contain critical habitat within the grid square. The actual area of critical habitat may much less depending on where the criteria for critical habitat are met. Refer to section 7.1 for a description of how critical habitat within these areas is defined. Field verification may be required to determine the precise area of critical habitat.

[5]Land tenure is provided as an approximation of the types of land ownership that exist at the sites containing critical habitat and should be used for guidance purposes only. Accurate land tenure will require cross referencing critical habitat boundaries with surveyed land parcel information.

7.2 Schedule of Studies to Identify Critical Habitat

Table 4. Schedule of Studies

Description of Activity	Rationale	Timeline
Undertake field visits to assess the precise location and extent of extant populations (observed >1991) occurring in natural settings where critical habitat has yet to be identified. Determine extent of suitable habitat at these locations.	Population locations and extent of surrounding suitable habitat are required to delineate additional critical habitat.	2014-2021

7.3 Activities Likely to Result in the Destruction of Critical Habitat

Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat was degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single activity or multiple activities at one point in time or from the cumulative effects of one or more activities over time (Government of Canada 2009).

Examples of activities that are likely to result in the destruction of critical habitat include but are not limited to the following:

- Activities that result in impermeable surface conditions (e.g., construction of roads or buildings) thereby altering the biophysical conditions required for the species to survive and/or reducing the available critical habitat to expand its populations;
- Activities that cause rutting, soil compaction and erosion (e.g., use of heavy equipment and motorized vehicles), making soil conditions unsuitable for seedling and ramet establishment;
- Activities that alter the water regime of floodplain and riverside populations (e.g., construction of dams, water diversion in upstream portions of the watershed) affecting changes to the natural hydroperiod. These changes could potentially result in permanent flooding, loss of intermittent/seasonal water fluctuations required to maintain open conditions in the floodplain or forest succession and eventual canopy-closure and thereby inhibit seedling and ramet establishment. In addition, changes to the water levels nearby seed-producing trees may affect natural seed dispersal and the conditions required for successful germination of seeds (i.e., immersion in water).

8. MEASURING PROGRESS

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives. Every five years, success of recovery strategy implementation will be measured against the following performance indicators:

- The abundance of Kentucky Coffee-tree at extant native populations occurring within natural settings in Canada has not decreased;

- The distribution of extant native populations occurring within natural settings in Canada has not decreased;
- If determined to be biologically and technically feasible, extant single-sex native populations (i.e., populations that are not sexually-reproducing), occurring within natural settings, have been augmented to establish sexually-reproducing populations;
- Extant native populations in landscaped or agricultural settings have been maintained.

9. STATEMENT ON ACTION PLANS

One or more action plans will be posted on the Species at Risk Public Registry for the Kentucky Coffee-tree by December 2021.

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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*[16]. 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.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also 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 strategy itself, but are also summarized below in this statement.

Protecting and restoring the riparian and associated woodland habitat of this species and the natural heritage systems within which they are found will benefit many other species and ecosystem functions of the heavily-impacted Carolinian life zone. Riparian habitat protection and restoration will be particularly compatible with the recovery efforts of the Canard River, Sydenham River and Thames River watersheds. Management of habitat at populations on the Lake Erie islands may benefit the threatened Wild Hyacinth (*Camassia scilloides*), which also occurs in woodland habitat; however, efforts for Kentucky Coffee-tree recovery could be focused along woodland edges where early successional forests could be encouraged. Maintenance or enhancement of open canopy conditions will not be beneficial to shade-tolerant and forest-interior species. Control of Double-crested Cormorant nesting populations on Middle and East Sister Islands will not benefit that species, but will benefit the native vegetation that their ammonia-rich excrement kills, including the trees in the area where they nest. Some negative effects to other species are noted, however overall benefits to the environment through recovery actions directed toward the Kentucky Coffee-tree are considered to be positive.

[16] http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1

APPENDIX B: SUBNATIONAL CONSERVATION RANKS OF KENTUCKY COFFEE-TREE IN THE UNITED STATES

List and description of various conservation status ranks for the Kentucky Coffee-tree in the United States (from NatureServe 2011).

	Global (G) Rank	National (N) Rank (United States)	Sub-national (S) Rank
Kentucky Coffee-tree (*Gymnocladus dioicus*)	G5 (Secure – common; widespread and abundant)	N5? (Secure - common; widespread and abundant with inexact numerical rank)	Alabama (SNR) Arkansas (SNR) Connecticut (SNR) Delaware (SNA) District of Columbia (SNR) Georgia (SNR) Illinois (SNR) Indiana (SNR) Iowa (S4) Kansas (SNR) Kentucky (S5) Maine (SNA) Maryland (S1) Massachusetts (SNA) Michigan (S3S4) Minnesota (SNR) Mississippi (S2) Missouri (SNR) Nebraska (SNR) New Jersey (SNA) New York (S1) North Carolina (SNA) North Dakota (SNR) Ohio (SNR) Oklahoma (SNR) Pennsylvania (S4) South Carolina (SNR) South Dakota (S2) Tennessee (SNR) Texas (SNR) Virginia (S3) West Virginia (S4) Wisconsin (S2)

S1: Critically Imperilled; S2: Imperilled; S3: Vulnerable; S4: Apparently Secure; S5: Secure; SNA: Not Applicable; SNR: Unranked.

APPENDIX C: NATIVE POPULATIONS OF KENTUCKY COFFEE-TREE IN CANADA

Sexually-reproducing populations are bolded. Sources: Bowles pers. comm. 2007, Craig pers. comm. 2007, Jalava et al. 2008, Mills and Craig 2008, Dobbyn in prep., NHIC 2010, Woodliffe pers. comm. 2010, Giroux pers. comm. 2011, Jacobs pers. comm. 2011, Dobbyn pers. comm. 2011, Jong pers. comm. 2011, Jalava pers. comm. 2011 and Payne pers. comm. 2012

Population Name	County	Rank*	Last Observed	Population Status	Abundance	Habitat Setting
Shetland Kentucky Coffee-tree Woods, Zone Township	Lambton	A	2011	Extant	74 trees, 120 saplings and 123 seedlings/ramets plus 18 dead trees and saplings including 12 fruit-bearing trees (reproductive status requires confirmation)	Natural
Canard River Floodplain, Anderdon Township	Essex	B	2010	Extant	Three sub-populations: 14 trees (15.5-72 cm dbh); 2 trees (36 and 42 cm dbh) and 18 saplings or ramets (1.5-14 cm dbh); 9 trees (16.4-53 cm dbh) and 8 saplings or ramets (1.4-4.6cm dbh).	Natural
Middle Sister Island, Lake Erie* **	Essex	B	1996	Extant	One live tree observed in 1996 with two of previous years' seed pods on ground	Natural
Grey Tract, Brooke / Mosa Township	Lambton / Middlesex	BC	2007	Extant	34 trees (10-36 cm dbh), as well as sapling- and seedling-sized ramets	Natural
East Sister Island, Lake Erie	Essex	C	2007	Extant	>1200 mostly young saplings and seedlings (<5 cm dbh average); 47 trees with dbh >20 cm and 34 trees with dbh >15 cm	Natural
Population #1, Walpole Island First Nation	Lambton	C	2011	Extant	Two sub-populations along river: one male clone of ~ 95 trees and sapling-sized ramets; one female clone of ~5 trees and a sapling.	Natural
Population #2, Walpole Island First Nation	Lambton	C	2011	Extant	~20 trees	Natural
Sydenham River, Alvinston, Brooke Township	Lambton	C	1993	Extant	20 trees (45-65 cm dbh)	Natural

Population Name	County	Rank*	Last Observed	Population Status	Abundance	Habitat Setting
Crawford's Woods, Dover Township	Chatham-Kent	C	2002	Extant	"Three or four small stands"	Natural
Sydenham River, Florence, Euphemia Township	Lambton	CD	1993	Extant	6 trees (45-50 cm dbh)	Natural
Middle Island, Lake Erie	Essex	D	2007	Extant	6 trees, 37 tree- or sapling-sized ramets, 147 sapling-sized ramets and 78 seedling-sized ramets in 2007	Natural
Petrolia, Enniskillen Township	Lambton	D	2011	Extant	Two sub-populations: 51 trees (2 dead) and 9 saplings (9 dead) including 14 fruit-bearing trees with empty seed pods	Natural
Wilkesport, Sombra Township	Lambton	D	2005	Extant	Two sub-populations: >200 ramets with some sapling-sized (8-10 cm dbh); "several" trees (10-30 cm dbh)	Natural
Bear Creek, Avonry, Sombra Township	Lambton	D	1999	Extant	2 trees	Natural
Sydenham River, Dresden, Camden Township	Chatham-Kent	D?	2005	Extant	28 trees (15-30 cm dbh)	Natural
Essex, Maidstone Township	Essex	C	1994	Extant	100-200 ramets along 28 m strip	Landscaped or Agricultural
Harrow, Colchester Township	Essex	C	1994	Extant	28 trees + 10 sapling-/ seedling-sized ramets	Landscaped or Agricultural
Texas Road, Anderdon Township	Essex	CD	1994	Extant	Total of 171 trees (all trees under 5 ft.)	Landscaped or Agricultural
Highway 40, Dover Township	Chatham-Kent	D	2010	Extant	1 tree (60 cm dbh)	Landscaped or Agricultural
Comber, Tilbury West Township	Essex	E	1994	Extant	30 - 40 trees (< 5 ft)	Landscaped or Agricultural
Paquette and Lukerville, Anderdon / Sandwich Township	Essex	E	1994	Extant	Two sub-populations: Paquette has a total of 140 trees (51 < 5 ft., 26 6-10 ft., 52 11-15 ft., 10 16-25 ft., and 1 +25 ft.), Lukerville a total of 121 trees	Landscaped or Agricultural

Population Name	County	Rank*	Last Observed	Population Status	Abundance	Habitat Setting
Pelee Island, Lake Erie	Essex	C	2010	Extant	Two sub-populations: 6 trees + 70 sapling- / seedling-sized ramets; one large tree	To be confirmed
Pelton, Sandwich Township	Essex	E	1994	Extant	A total of 773 trees (700 <5ft., 40 6-10 ft., 20 11-15 ft., 4 16-25 ft., and 9 +25 ft.)	To be confirmed
North Harbour Island, Lake Erie	Essex	H	1987	Historic	"Several" trees	N/A
Devonwood Conservation Area, Sandwich Township	Essex	H	1977	Historic	1 young tree	N/A
City of Windsor	Essex	H	1981	Historic	3 mature trees, all male	N/A
Sydenham River, Wallaceburg, Sombra Township	Lambton	H	1982-1992	Historic	1 tree	N/A
Thames River Floodplain ANSI**, Ekfrid / Dunwich Township	Elgin / Middlesex	X	1978	Extirpated	~50 trees (15-20 cm dbh)	N/A
Florence, Zone / Dawn Township	Lambton	X	1950	Extirpated	Unknown	N/A
Bear Creek, Mitchell's Bay, Dover Township	Chatham-Kent	X	1950s	Extirpated	Unknown	N/A
Norwich, Norwich Township	Oxford	X	1927	Extirpated	Unknown	N/A
Forestville Creek, Forestville, Charlotteville Township	Norfolk	X	1955	Extirpated	Unknown	N/A
Dedrick's Creek, St. Williams, Walsingham Township	Norfolk	X	1950	Extirpated	Unknown	N/A

* Rank refers to the Natural Heritage Information Centre quality ranks based on the estimated viability or probability of persistence of the occurrence: A – Excellent, B – Good, C – Fair, D – Probably not viable, E – Verified extant, H – Historical, X – Extirpated and ? – Rank or status uncertain.
** ANSI – Area of Natural and Scientific Interest
*** Sexual reproductive status of this population requires confirmation