COSEWIC
Assessment and Status Report

on the

Red Mulberry
Morus rubra

in Canada

ENDANGERED
2014

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Red Mulberry — Image credit: J.D. Ambrose.

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COSEWIC
Assessment Summary

Assessment Summary – November 2014

Common name
Red Mulberry

Scientific name
Morus rubra

Status
Endangered

Reason for designation
This small to medium-sized tree from Carolinian forests of southern Ontario has declined in numbers of mature individuals and subpopulations since the last COSEWIC assessment in 2000. Only 217 total individuals are known to occur in Canada, and only 105 of these are considered of reproductive age. Only four subpopulations have more than five reproductive individuals. The greatest threat to the species is hybridization with the non-native White Mulberry. Effects of twig canker diseases also contribute to declines. At two sites, nesting by Double-crested Cormorants poses a significant threat.

Occurrence
Ontario

Status history
Designated Threatened in April 1987. Status re-examined and designated Endangered in April 1999. Status re-examined and confirmed in May 2000 and November 2014.

COSEWIC
Executive Summary

Red Mulberry
Morus rubra

Wildlife Species Description and Significance

Red Mulberry is a small to medium-sized tree, 6-20 m high, occasionally reaching the lower forest canopy of forested floodplains, valleys and bottomlands. Mature trees have characteristic bark with loose, light greyish-tan elongate plates. Leaves are alternate, entire or 1-3 lobed, 9-24 cm long, and nearly as wide, with broad to heart-shaped bases, long tapered tips, coarsely toothed margins, with a rough, dull upper surface and milky sap. Flowers occur in yellowish-green (sometimes reddish) clusters, appearing as the leaves are expanding; trees are typically unisexual. Trees produce edible, sweet, red to dark purple fruits that superficially resemble elongate blackberries, 2-3 cm long.

Distribution

Red Mulberry is native across much of the eastern and central United States and southern Ontario in Canada. It ranges from Vermont to southern Florida, westward through New York, southern Ontario and Minnesota in the north, and west to Texas and the Gulf Coast in the south.

Habitat

In Ontario, Red Mulberry occurs in the Carolinian forests of southern Ontario. The species tends to occur in moist forest habitats in both sandy and calcareous soils in sites such as floodplains, river valleys, slopes of the Niagara Escarpment and swales in sandspits.

Biology

Red Mulberry is a wind-pollinated species with individual trees that can be unisexual or sometimes bisexual. Mulberries are late to leaf out in southern Ontario. Trees flower from late May to mid-June. The edible fruits mature in mid- to late July in southern Ontario and are dispersed by birds. Small mammals may also be significant dispersal agents.

Population Sizes and Trends

The total known Canadian population of Red Mulberry includes 217 individuals, only 105 of which are considered mature (over 10 cm in diameter at breast height), representing a 6.3% decline in the number of mature individuals since the last assessment, despite ongoing discovery of new trees at some sites. Red Mulberry is known from nineteen occurrences, only four of which have five or more mature individuals, and only five with more than ten total individuals. In addition, three of 19 subpopulations appear to have been extirpated since the last COSEWIC assessment in 2000, and steep declines in numbers of mature individuals are noted in two subpopulations.

Threats and Limiting Factors

Hybridization with White Mulberry appears to be the greatest threat to Red Mulberry in Canada. Diseases that cause twig cankers, blight and dieback also contribute to declines. Double-crested Cormorants and invasive exotic plants also have a negative impact on some Red Mulberry subpopulations in the Erie Islands. Deer browsing of young saplings and gastropod grazing of young seedlings reduce recruitment of Red Mulberry in populations where these herbivore populations are high. All of these threats are likely to be exacerbated by historical habitat loss and ongoing degradation, resulting in a fragmentation of suitable habitat.

Protection, Status, and Ranks

Red Mulberry was initially assessed as Threatened by COSEWIC in 1987 and reassessed as Endangered in 2000 and 2014. The species is listed on SARA Schedule 1, and a finalized federal Recovery Strategy was published in 2011. Red Mulberry is listed as Endangered under the Ontario *Endangered Species Act, 2007*. All of the larger populations are at least in part on public lands that are managed to some extent for conservation.

TECHNICAL SUMMARY

Morus rubra

Red Mulberry Mûrier rouge

Range of occurrence in Canada: southwestern Ontario

Demographic Information

Generation time The range given that takes into consideration the average age of first fruiting (10 years) to peak fruiting (30).	15-30 yrs.
Is there an observed continuing decline in number of mature individuals?	Yes
Observed percent reduction in total number of mature individuals over the last 10 years. Survey effort insufficient to estimate 10 year decline.	unknown
Projected percent reduction in total number of mature individuals over the next 10 years. Available data are not suitable for projections.	unknown
Observed percent reduction in total number of mature individuals over 25 years. Severe declines in some populations, more stable in others. Overall declines of 6.3 % (mature) and 14.6 % (all sizes) since most recent surveys (mostly around 2000) despite finding new individuals in previously unexplored areas	6.3%
Are the causes of the decline clearly reversible and understood? Threats are known, but it is not clear that management can remove the threat of hybridization, and the canker disease remains poorly characterized.	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (Niagara Falls to Windsor)	18,700 km²
Index of area of occupancy (IAO)	104 km²
Is the total population severely fragmented? Historical habitat loss has led to isolated patches of suitable habitat, separated by distances that are likely to exceed pollen and seed dispersal.	Yes
Number of locations Hybridization with White Mulberry: 1-2 locations Double-crested Cormorants: 2 locations	Likely 3-4
Is there an observed continuing decline in extent of occurrence?	No
Is there a projected continuing decline in index of area of occupancy? Most occurrences have fewer than 5 total individuals.	Yes

Is there an observed continuing decline in number of populations? Three subpopulations had no individuals in 2011 surveys and are presumed extirpated.	Yes
Is there an observed continuing decline in number of locations?	No
Is there an observed continuing decline in area, extent and/or quality of habitat? Most habitat loss is historical with remaining subpopulations mostly in protected areas. The factors degrading habitat, such as the presence of White Mulberry and Double-crested Cormorants, while present for the last three generations, continue to impact habitat quality.	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Individuals in each subpopulation

Subopulation/occurrence	**No. Mature* Individuals**
Chatham-Kent: Rondeau	11
Essex: Fish Point	8
Stone Rd. Alvar	1
East Sister Island	3
Middle Island	0
Point Pelee	2
Anderson/Kingsville	0
For the Birds	1
Mailloux Woods	1
Mitchell's Woods	1
LaSalle	0
Halton: Clappison to Waterdown	5
Hamilton: Berry to Rock Chapel	64
Niagara: Ball's Falls	2
Niagara Glen/Pkwy	4
St. Davids	2
Total, mature* individuals	**105**
Total individuals (all size classes)	**(217)**
Subopulations presumed extirpated since last update	
Niagara: Pendale [DEAD]	1
Leawood Court [NOT FOUND]	1
Essex: Ojibway [NOT FOUND]	1
* over 10cm dbh	

Quantitative Analysis

Probability of extinction in the wild.	Not done

Threats (actual to populations and habitats)

Hybridization with non-native White Mulberry
Twig canker diseases
Nesting by Double Crested Cormorant on Middle Island and East Sister Island
Habitat loss and degradation
Other invasive exotic plant species (in addition to White Mulberry)
Grazing of seedlings and juveniles by herbivores, especially deer and gastropods

Rescue Effect (immigration from outside Canada)

Status of outside populations? Of 35 jurisdictions reporting natural occurrence, four northern states report it to be imperiled to vulnerable and one possibly extirpated, and 20 SNR (not ranked). Only eight states report it as secure or apparently secure (NatureServe, 2013). These populations show similar impacts of hybridization with White Mulberry and cankers.	
Is immigration known or possible? Low population numbers in adjacent Michigan, Ohio and New York suggest a very low probability of cross-border dispersal.	Unlikely
Would immigrants be adapted to survive in Canada? Yes, from populations in adjacent states.	Probably
Is there sufficient habitat for immigrants in Canada? Although suitable habitat has been reduced, current sites are sparsely occupied.	Limited
Is rescue from outside populations likely? Long-distance dispersal may be possible, but there is a high probability that immigrants would represent additional White Mulberry hybrids. In addition, recruitment success is low.	No

Status History

COSEWIC: Designated Threatened in April 1987. Status re-examined and designated Endangered in April 1999. Status re-examined and confirmed in May 2000 and November 2014.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	B2ab(ii,iii,iv,v); C2a(i); D1

Reasons for designation:
This small to medium-sized tree from Carolinian forests of southern Ontario has declined in numbers of mature individuals and subpopulations since the last COSEWIC assessment in 2000. Only 217 total individuals are known to occur in Canada, and only 105 of these are considered of reproductive age. Only four subpopulations have more than five reproductive individuals. The greatest threat to the wildlife species is hybridization with the non-native White Mulberry. Effects of twig canker diseases also contribute to declines. At two sites, nesting by Double-crested Cormorants poses a significant threat.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not met. Trend data are insufficient to quantify declines.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B2ab(ii,iii,iv,v). IAO is below threshold, there are fewer than 5 locations and the population is considered severely fragmented. There are observed declines in IAO, number of subpopulations and mature individuals, and inferred declines in habitat quality.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C2a(i). The total number of mature individuals is below the threshold and no subpopulation contains more than 250 mature individuals.
Criterion D (Very Small or Restricted Total Population): Meets Endangered D1. The total number of mature individuals is below 250.
Criterion E (Quantitative Analysis): Not met. No quantitative analysis available.

PREFACE

Red Mulberry has continued to decline since the last update in 2000; three single-tree sites were lost in this time. Larger subpopulations in Essex County and the Niagara Region are showing significant declines. Recovery action is needed immediately on these latter subpopulations on federal and provincial lands to prevent local extirpation. Recovery actions are underway on the large Hamilton subpopulation along the Niagara Escarpment, with periodic surveys, White Mulberry culls and initiation of propagation trials, all led by staff of the Royal Botanical Gardens. Red Mulberry was the subject of a recent PhD thesis, including an analysis of hybridization and its impact (Burgess, 2004). Parks Canada issued a recovery strategy in 2011, which included designation of critical habitat.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2014)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada

Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific name: *Morus rubra* L.

Synonyms: *Morus rubra* var. *tomentosa* (Rafinesque) Bureau

Common names: Red Mulberry, Mûrier Rouge

Family name: Moraceae, mulberry family

Major plant group: Eudicot, flowering plant

A new species of Mulberry, *M. murrayana*, was recently described in the U.S. based primarily on leaf size variation in a population from Kentucky (Galla *et al.*, 2009). Nepal *et al.* (2012) summarize morphological and molecular data, and conclude that specimens identified as *M*. *murrayana* are in fact part of the natural variation of Red Mulberry. The species is also not considered valid by A. Reznicek, University of Michigan (pers. comm., Feb. 8, 2012). Burgess also questions the validity of this new species (pers. comm. 2012). The proposed new species does not occur in Canada.

Morphological Description

Red Mulberry is a small to medium-sized tree, 6-20m high, occasionally reaching the lower forest canopy of forested floodplains, valleys, moist slopes in mixed hardwood forests. The bark of mature trees possesses loose, light greyish-tan elongate plates that are irregularly elongate (Figure 1). Leaves are alternate, entire or 1-3 lobed, 9-24cm long, nearly as wide, with broad to heart-shaped bases and long, tapered tips. Leaves have coarsely serrate margins, and a thin, rough texture with dull upper surfaces, and milky sap (Figure 2). Flowers occur in yellowish-green (sometimes reddish) pendulous catkins, appearing at the time of early leaf expansion. The catkins are unisexual, with male and female catkins usually occurring on different trees but sometimes on the same tree. Fruit are a multiple of drupes, 2-3 cm long, cylindrical, turning red to dark purple as they ripen, and are sweet and edible.

Identification of Red Mulberry is complicated by the presence of the naturalized Asian White Mulberry (*Morus alba*) in much of southern Ontario. The two species occur together at most Red Mulberry sites, and hybrids are readily formed between the two. Many field guides show illustrations that are ambiguous and do not help to distinguish Red Mulberry from White Mulberry and from their intermediate hybrids. Descriptions that are considered accurate and representative of pure Red Mulberry include: Waldron (2003), Braun (1961), Harlow and Harrar (1969), Peattie (1950), Tomlinson (1980) and the following web sites: Carolina Nature 2013; OMNR 2013.

Figure 1. Red Mulberry bark from a mature tree (Waterdown). Image credit: J.D. Ambrose.

Figure 2. Red Mulberry leaves and fruit (Ball's Falls). Image credit: J.D. Ambrose.

White Mulberry has smaller leaves, which lack the surface roughness and acuminate tips, and tend to be of a thicker texture. Flowers and fruit are shorter and rigid rather than pendulous. The bark tends to be more firm and ridged and has a distinctive orange tint seen between the bark ridges on young and mid-age trees and on the roots, often exposed in nearshore locations.

Population Spatial Structure and Variability

Red Mulberry was probably never common or abundant in Canada. Known occurrences are clustered into two regions in southwestern Ontario. The first cluster occurs along sand spits and occasionally alvars at the western end of Lake Erie, in Essex County, and in Chatham-Kent, with smaller outlying occurrences inland on calcareous clay-loam soils. The second set is in the Niagara region. The Essex-Chatham-Kent occurrences tend to be in more open and sandy areas, while those in the Niagara region occur along the moist, calcareous slopes of the Niagara Escarpment. These two clusters may represent different migration routes from the core part of the range in the U.S., or they may be the remnants of a previously connected set of occurrences along the northern shore of Lake Erie.

Most known occurrences include very small numbers of individuals; only five of Parks Canada's (2011) nineteen sites included more than ten individuals of all size classes. Considering only individuals over 10 cm dbh, only two sites have more than ten individuals. Therefore, it is doubtful if more than a few of occurrences of Red Mulberry in Canada represent true biological populations, with the ability to interbreed and sustain themselves, and it may be more appropriate to consider the Canadian population as a single metapopulation, with local extirpations and recolonizations. Nonetheless, in this report, we refer to sites separated by more than 1 km as subpopulations, to avoid confusion of applying occurrences to sites with few individuals and subpopulations to sites with the potential for being self-sustaining.

The other key factor affecting the population structure of Red Mulberry is its documented frequent hybridization with White Mulberry, a non-native species introduced from Asia in the 1600s. White Mulberry is naturalized in North America where it has become more common than Red Mulberry in many parts of the Red Mulberry distribution, including southern Ontario. Hybridization between the two species in Ontario has been under study (Burgess *et al.* 2005; Burgess and Husband 2008), and is described in more detail below, under **Interspecific Interactions**.

Designatable Units

A single designatable unit is recognized in Canada. Subpopulations and individuals all occur in the Mixedwood Plains Ecozone, and are confined to a relatively small area in southwestern Ontario known locally as the Carolinian Zone. While there are ecological differences between sites in the Niagara Region and those on the shore of Lake Erie, there is no evidence to support genetic or ecological differences between individuals in these two nearby areas.

Special Significance

Red Mulberry is one of a number of Carolinian tree species that reach the northern limits of their distribution in extreme southwestern Ontario. It is also a species with a high level of habitat specificity, as indicated by its "coefficient of conservatism" rank of 10 (NHIC 2004). Red Mulberry is the only species in the Mulberry family, Moraceae, that is native to Canada. It is of such localized occurrence that it has only minor significance as a food source for wildlife or humans. It is difficult to establish in less than ideal habitats so it is rarely seen in cultivation.

Traditionally, it was used for a number of ailments by First Nations people, primarily as a bark or root infusion for various digestive system ailments. The sap was used for skin conditions and the berries eaten fresh or dried and preserved for later use (Moerman 2013).

DISTRIBUTION

Global Range

Red Mulberry is native across much of the eastern and central United States and southern Ontario in Canada, from Vermont to southern Florida, westward through New York, southern Ontario and Minnesota in the north, and west to Texas and the Gulf Coast in the south (Figure 3.).

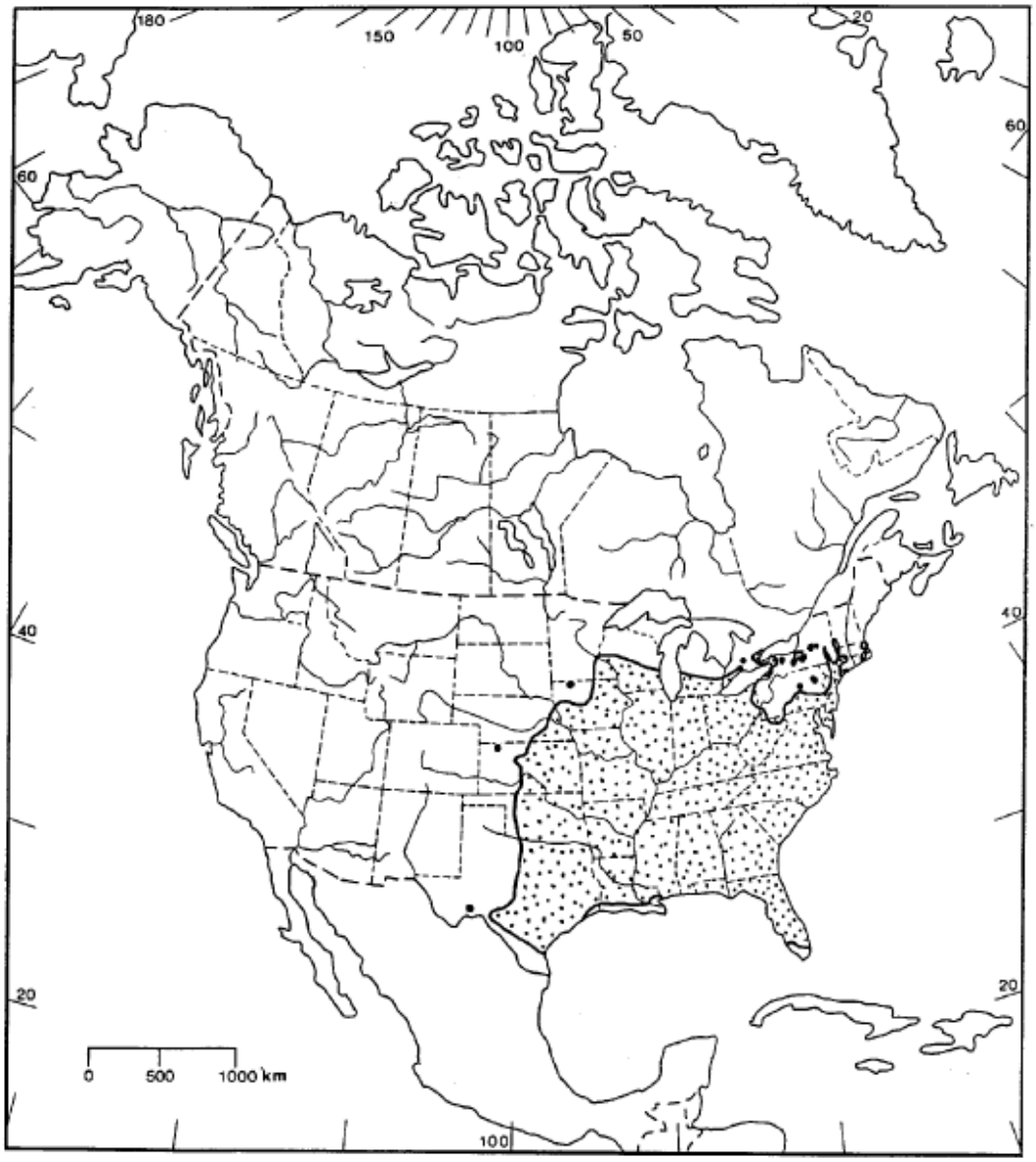

Figure 3. Generalized range of Red Mulberry in North America (after Little 1971).

Canadian Range

Red Mulberry is restricted to the Carolinian Zone of southern Ontario (Figure 4, Table 1), where it occurs in the municipality of Chatham-Kent and Essex County, in small moist forest remnants near Windsor to the sand spits of Point Pelee, Pelee Island, and Rondeau, and the alvar woodlands of Pelee, Middle and East Sister islands. Historically, there were additional mainland forest habitat occurrences, but these appear to have been lost with land clearing and habitat degradation (Ambrose 1987).

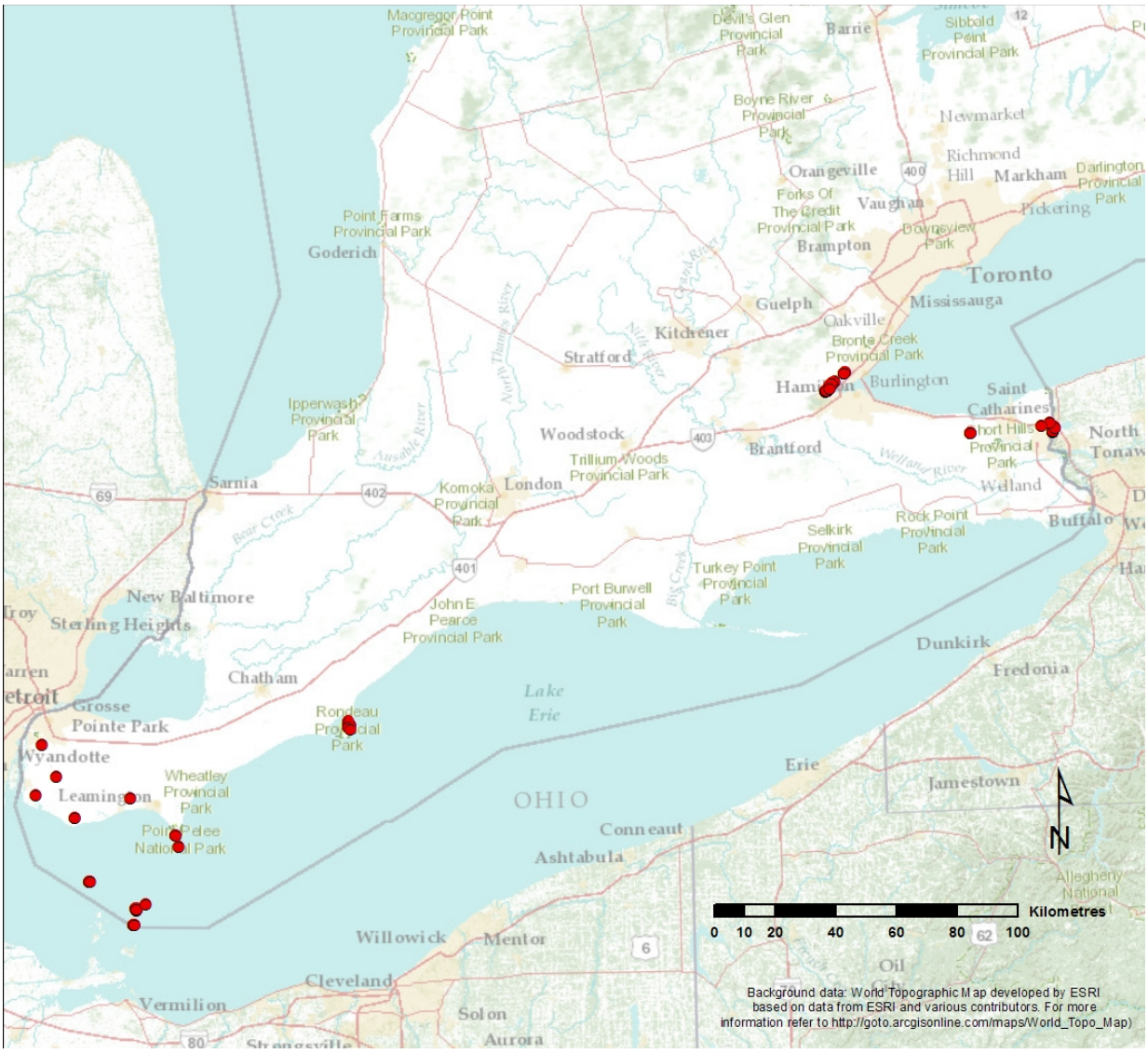

Figure 4. Canadian distribution of Red Mulberry; red dots are extant subpopulations or individuals (COSEWIC technical staff 2013).

Table 1. Number of Red Mulberry Individuals (in each subpopulation).

Subpopulation/ Occurrence	Ownership****	2011: Mature* (total) Ind.	Previous mature* (total)	Observer, date previous obs.**	Change in mature ind.	Change in total ind.
Chatham-Kent Rondeau Prov. Park	Ontario Parks	11 (15)	5 (15)	JA, 1999	+6	0
Essex Region Pelee Island: Fish Point	Ontario Parks	8 (17)	6 (37)	JA, 1999	+2	-20
Stone Rd. Alvar	Essex Region CA	1 (1)	2 (2)	JA, 1987	-1	-1
East Sister Island	Ontario Parks	3 (3)	1 (9)	KB, 2000	+2	-6
Middle Island	Parks Canada	0 (6)	0 (8)	JA & KB, 2001	0	-2
Point Pelee	Parks Canada	2 (3)	10 (22)	JA, 1999	-8	-19
Anderson/ Kingsville	Private	0 (1)	0 (1)	DJ, 2001	0	0
For the Birds/ Colchester	Private	1 (2)	2 (2)	DJ, 2001	-1	0
Mailloux Woods/ Big Creek	Private	1 (1)	1 (1)	GW, 2000	0	0
Mitchell's Woods/ Canard River	Private	1 (1)	1 (1)	GW, 2001	0	0
LaSalle	Lasalle/ private	0 (1)	1 (1)	JA (1999)	-1	0
Ojibway [NOT FOUND]***	Unknown	0	? (1)	DJ, 2001	0	-1
Halton*:* Clappison to Waterdown	Cons. Halton	5 (11)	6 (8)	RBG, 2001	-1	+3
Hamilton: Berry to Rock Chapel	Cons. Halton	64 (126)	58 (113)	RBG, 2001	+6	+13
Niagara*:* Ball's Falls	Niagara Peninsula CA	2 (5)	4 (8)	JA, 1987	-2	-3
Niagara Glen/Pkwy	Niagara Parks/ Hydro One	4 (22)	11 (21)	JA, 1999	-7	+1
St. David's	Private	2 (2)	2 (2)	JA, 2004	0	0
Pendale [DEAD]***	Brock Univ.	0	1 (1)	JA, 1999	-1	-1
Leawood Court [NOT FOUND]***	Private	0	1 (1)	PC, 2010	-1	-1
Totals		**105 (217)**	**112 (254)**		**-7/112 -6.3%**	**-37/254 -14.6%**

* Mature individuals defined as >10cm dbh

** JA = J. Ambrose, KB = K. Burgess, DJ = D. Janas, GW = G. Waldron, RBG = Royal Botanical Gardens, PC = Parks Canada.

*** Three sites are presumed extirpated because no living individuals of any size class were located.

**** Land ownership/ management from Parks Canada (2011).

Along the Niagara Escarpment, significant subpopulations of Red Mulberry occur in the Niagara Glen and in wooded areas on the Niagara parkway lands above, at Balls Falls and the south-facing slopes of the escarpment from Waterdown to Dundas, with individual trees in other sites between these. Additional sites of White Mulberry with hybrids have been noted (Ambrose, 1987), indicating that Red Mulberry likely occurred here in the past. One of these hybrid sites occurs in western Toronto within the historical range that at one time extended to Whitby. This and other historical sites appear to no longer support pure populations of Red Mulberry.

Red Mulberry is recorded as an exotic in British Columbia (NatureServe 2013). This non-native occurrence is not considered part of the wildlife species in Canada, and is excluded from the assessment.

Extent of Occurrence and Area of Occupancy

The extent of occurrence for Red Mulberry in Canada is estimated at 18,700 km^2, and the index of area of occupancy is 104 km^2.

Search Effort

During the 2011 fieldwork for this update, areas of the Niagara Escarpment with suitable habitat near known sites were explored by the report writers, and additional individuals were found and reported in the totals of Table 1. Most other areas of larger documented subpopulations have been well surveyed in the past; only occasional new individuals were found within these areas. Approximately 23 person-days were spent in the field for this update. Additional time was spent by Ontario Parks staff surveying East Sister Island.

HABITAT

Habitat Requirements

In Ontario, Red Mulberry occurs in both sandy soils of forested sites near Lake Erie in Hackberry-Red Cedar-Sugar Maple woodlands and calcareous soils in Sugar Maple-Basswood-White Ash-Red Oak-Hackberry-Ironwood woodlands of the Niagara Escarpment and Erie Islands. Red Mulberry tends to occur in moist forest habitats, such as slopes and benches in the Niagara Escarpment where moisture levels remain high, in floodplain and river valleys, and on swales of the sandspits of Point Pelee, Fish Point on Pelee Island and Pointe aux Pins at Rondeau Provincial Park. Remnant sites and past distribution records suggest that it also occurred more frequently in moist forests beyond the escarpment and lakeshore sites, but most of these were lost with land clearing, which has occurred to an extreme in Essex County and Chatham-Kent. One small remnant moist forest near LaSalle represents a habitat that was likely more significant in the past. It currently supports a single Red Mulberry, plus a diversity of White and hybrid mulberries.

Habitat Trends

Habitat loss has been significant in the Carolinian Zone of extreme southwestern Ontario; Essex County has less than 5% forest cover (ERCA, 2002); the Essex Region Conservation Authority is leading efforts to restore forest cover. However, without significant forest protection legislation in Chatham-Kent, new forest clearing can be seen most years along the highways. The largest subpopulation occurs where habitat is protected along the Niagara Escarpment.

Following the first COSEWIC assessment for this species (Ambrose 1987), White Mulberry was culled as part of the management of Point Pelee and Fish Point subpopulations. Judging by the regrowth of White Mulberries in these parks there appears to have been little recent management.

BIOLOGY

Red Mulberry is a minor tree component of moist forests in their noted specific habitats. Typically they occur in the understory, only occasionally reaching into the canopy. They are late to leaf out in southern Ontario and are conspicuous by their absence of leaves during late spring. Early leaf and catkin expansion have been observed between 15 and 24 May, with pollen release recorded between 27 May and 14 June, as the leaves continued to expand (Ambrose 1987). Fruits mature in mid- to late July in southern Ontario and are dispersed by birds. Small mammals may also be significant dispersal agents. Seedlings were observed in late August along shaded moist path edges of Point Pelee where fruit had fallen a month earlier.

In dynamic habitats where forest openings frequently occur, such as Point Pelee and Fish Point, young saplings have been observed. While the species is considered to be shade tolerant (OMNR, 2000), openings within the forest canopy appear to promote recruitment.

Very few trees are observed over 30cm dbh. With the occurrence of a variety of twig blight diseases causing twig cankers (McLaughlin and Greifenhagen 2002, see **Threats and Limiting Factors**), decline and mortality are often seen in the larger trees. Fewer than half of the 217 known Red Mulberries in Ontario are over 10 cm dbh.

Life Cycle and Reproduction

Red Mulberry is wind-pollinated. Anthers of White Mulberry are noted as explosively releasing their pollen (Taylor *et al.* 2010), but it is not known whether this mechanism is shared with Red Mulberry. Individual trees can be unisexual or (infrequently) bisexual with catkins usually having all male or all female flowers; occasionally catkins that are primarily female have a few male flowers (Sargent, 1965). Fruits mature in mid-summer, and some seeds will germinate soon after dispersal, in late summer if moisture conditions are suitable. Trees may reach reproductive maturity by age 10, with optimal fruiting at 30

(OMNR 2000). Burgess *et al.* (2008) considered individuals reproductive with the trunk diameter > 3 cm dbh. First year seedlings have been observed in moist gravelly trail edges under a partial forest canopy. For the purposes of this report, individuals are counted as mature when they reach 10 cm dbh, a size when they are more likely to persist in the lower canopy even though they may flower at smaller sizes. While there is no estimate of generation time for Red Mulberry, an approximate range of 15-30 years is likely, based on ages of first and peak flowering.

Physiology and Adaptability

Red Mulberry appears to thrive in a narrow range of habitats, primarily those with partial shade and moist soils that don't experience droughty conditions, although it is occasionally found on alvars where reliable moisture is the exception.

Collected seeds can be dried, stored and germinated in the following spring without any pre-germination treatment (Kock 2008). Spring germinants tend to survive better over winter than those that are germinated from fresh seeds in July (Sean Fox pers. comm. nd.); this may partially explain why there is low recruitment in natural stands.

Dispersal and Migration

Birds are likely the primary dispersal agents, especially beyond the local forest where the trees occur (Stapanian 1982). Mammals likely play a role in local dispersal.

Interspecific Interactions

Hybridization with White Mulberry

White Mulberry was introduced to North America from China in the 1600s, and has since become naturalized over much of the native distribution of Red Mulberry. The two species are not especially closely related (Nepal and Ferguson 2012), but they nonetheless are capable of interbreeding and producing viable offspring.

Burgess *et al.* (2005) analyzed genetic and morphological variation in six populations, including four populations where Red and White Mulberry individuals were growing within 25 m of one another (sympatric sites) and two allopatric sites (Ball's Falls and Royal Botanical Gardens), where White Mulberry was not present within 25 m of Red Mulberry. Of the 184 individuals that they sampled at the four sympatric sites, 53 were found to be pure Red Mulberry (29%), with the majority classified as hybrids (n=98, 53%), and the remainder as pure White Mulberry (n= 33, 18%). In addition, they found that most hybrids (67%) were genetically more like White Mulberry than Red Mulberry, suggesting that at least some of the hybrids are not F1s, but include later generation hybrids as well. Their sampling strategy was designed to maximize sampling of pure Red Mulberry individuals, and consequently may have overestimated hybrids and underestimated pure White Mulberry individuals (Burgess *et al.* 2005). As a result of this work, a few of trees previously counted as Red Mulberry were determined to be hybrids and were excluded from subsequent

surveys **(see Population Sizes and Trends)**.

Pathogens and Herbivory

A number of opportunistic organisms were found in trunk cankers in different Ontario sites, indicating a decline in these trees in response to stressful situations rather than a specific virile pathogen (McLaughlin and Greifenhagen 2002). Herbivory is another interaction in this species (see **Threats and Limiting Factors**).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

All 19 previously documented occurrences were resurveyed in 2011, going to the precise locality using the GPS coordinates recorded from past surveys. The condition, size, presence or absence, identity and locality of each tree were recorded. The presence of seedlings and White Mulberries were also noted. For those subpopulations under current periodic observation, such as the Niagara Escarpment occurrences managed by the Royal Botanical Gardens, only sampling was done and the RBG data were incorporated into the report (Table 1). Previously undocumented trees within the sites were recorded as new. Where there appeared to be ideal habitat with no recorded trees, such as along the Niagara Escarpment near Waterdown, these areas were surveyed as well.

Abundance

Currently 217 Red Mulberries are known in Ontario; only 105 of these are over 10cm dbh, and therefore counted as mature individuals. Many of these are newly recorded trees in sites that were not well explored in the past. Of the subpopulations that have a long history of survey, some are experiencing severe decline, as much as 80% in 10 years (Point Pelee: from 10 to 2 mature individuals). The largest and healthiest region including subpopulations of Red Mulberry extends from Waterdown to Dundas along the south-facing section of the Niagara Escarpment (Halton and Hamilton subpopulations in Table 1). It contains 137 trees of all sizes, 63% of known individuals in Ontario (66% of mature individuals). The Royal Botanical Gardens (RBG) is actively managing subpopulations on RBG and adjacent lands.

Although there are several scattered occurrences of Red Mulberry in southern Ontario, only four subpopulations currently have five or more mature individuals; two additional subpopulations, Point Pelee and Niagara Glen, no longer are in this category because of losses of individuals since the last report (Ambrose 1999). Most subpopulations are mixed with White Mulberry and hybrids.

Several historical sites appear to no longer support Red Mulberry. While the precise localities of many previously reported sites is not known (i.e., only the name of the nearest city or town is documented), no current records exist and natural areas in this region have been extensively surveyed within the past 30 years, including for the initial COSEWIC report (Ambrose 1987), and as part of numerous local inventories, such as the Environmentally Sensitive Area studies. Many of these historical sites were likely cleared for agriculture or urban development. One recent record at Delaware (near London), a recognized natural area, was resurveyed more recently without this species being found. Two subpopulations in the Niagara region, each with a single tree, are recorded as recently lost, one (Pendale) was part of a larger subpopulation lost to a shopping centre development over 25 years ago. A third recent loss appears to have occurred in Essex (Ojibway).

Fluctuations and Trends

Most subpopulations tend to be small and localized (Table 1). Little information exists on population sizes prior to the original COSEWIC status report (Ambrose, 1987). Comparing population sizes from the first update and surveys done soon after with the current counts shows a major decline in mature individuals at the once large subpopulation at Point Pelee (from 10 to 2 mature individuals, 22 to 3 total individuals) and at Niagara Glen (from 11 to 4 mature individuals, 21 to 22 individuals in total). Considering all observations over the two survey periods, there is an overall observed decline of 6.3% in mature individuals (from 112 to 105), and a 14.6 % decline across all size classes (from 254 to 217, Table 1). It should be noted that these declines are detected despite the discovery of additional trees at some sites, which are presumed to have been present but overlooked in previous surveys. For example, the Waterdown to Dundas area was only partially known in 1999 (Ambrose 1999) and many new trees were found along this slope (O'Hara 2000; Thuring and Smith 2001; McGoey 2011), and new sites were found soon after that report. Based on extirpation of historical sites and declines in known extant subpopulations with a few decades of records, this species appears to be declining in occurrences and numbers (Table 1).

Rescue Effect

Although long-distance dispersal may be possible for Red Mulberry, populations in bordering states are also subject to hybridization with White Mulberry. While the frequency of hybrid offspring has not been studied outside Ontario, it seems likely that many of the seeds that might arrive by long-distance dispersal would be hybrids. In addition, given low levels of recruitment from native seed set, natural processes of migration through seed dispersal are not likely to result in significant increases to the Canadian population.

THREATS AND LIMITING FACTORS

Habitat Loss and Degradation

Historically, habitat loss and degradation in the Carolinian Zone (Reid, 2002), where very little forest cover remains and what does remain is highly fragmented, are likely to have been the first factors to impact Red Mulberry in Canada.

Hybridization with White Mulberry

Hybridization with White Mulberry is likely to be the most significant threat to continued persistence of Red Mulberry in Canada (Burgess *et al.*, 2005, 2006, 2008). Because White Mulberry is more abundant than Red Mulberry and the two species freely intercross, most of the pollen rain that reaches female flowers of Red Mulberry is from hybrids or pure White Mulberry individuals. Burgess *et al.* (2008) examined the effect of White Mulberry removal on the production of pure Red Mulberry versus hybrid offspring at two sites (Rondeau and Fish Point subpopulations). They estimated that pure Red Mulberry pollen represented roughly 8% of the pollen produced at the two sites. Removal of White Mulberry and hybrid individuals from a 50 m diameter area around a focal Red Mulberry individual resulted in a 14% increase in the production of pure Red Mulberry seed by focal Red Mulberry trees (from 23% to 37% pure Red Mulberry offspring in control versus removal plots), indicating that the presence of White Mulberry significantly decreases the production of Red Mulberry offspring (Burgess *et al.* 2008). The Royal Botanical Gardens staff are monitoring subpopulations on and adjacent to their lands, and actively managing for Red Mulberry at these sites (including culling White Mulberries on their lands). They are also propagating the pure Red Mulberry trees through controlled pollinations and rooting of cuttings (Natalie Iwanycki, pers. comm. 2013; McGoey 2011). Culling of the observed White Mulberry on adjacent public roadways and private lands would be desirable. While Ontario Parks and Parks Canada did some management after the first COSEWIC report, that activity appears less active now. Ontario Parks is monitoring the various subpopulations in provincial parks and has applied for funding for White Mulberry culling but this has not been approved (Jennifer Chambers, pers. comm., 2013). Parks Canada is concentrating its White Mulberry culling in areas designated for restoration in the park (Valerie Minelga, pers. comm., 2013).

Disease

Diseases that cause twig cankers, twig blight and dieback are known to affect Red Mulberry in Ontario (Parks Canada Agency, 2011), but their contribution to overall rates of decline have not been quantified across all subpopulations. Disease organisms causing twig cankers have devastated populations in West Virginia (O. Loucks, pers. comm.,1998; Little, 1995). The twig and trunk cankers observed at Point Pelee and other subpopulations have been shown to be caused by a number of opportunistic organisms (McLaughlin and Greifenhagen, 2002) rather than a single pathogen. Various stressors have been suggested as increasing susceptibility to infection, including pollution, drought, and poor soil fertility (Parks Canada Agency 2011).

Browsing and Grazing

Browsing and grazing reduce recruitment within subpopulations where deer, gastropods and other herbivore populations are high. Eight species of native gastropods were collected at Point Pelee (identified by T. Pearce, University of Michigan), but their abundance and impacts across the range of Red Mulberry in Canada.

Double-crested Cormorants are severely degrading forest habitats on the Erie Islands and are a direct threat to subpopulations of Red Mulberry on Middle and East Sister islands. Parks Canada has been supporting the culling of nesting cormorants on Middle Island, resulting in no increases of nesting birds; they are also removing cormorant nests on Red Mulberry trees and installing deterrent scarecrows (Valerie Minelga, pers. comm., 2013). Ontario Parks continues to monitor the situation on East Sister Island Nature Reserve and developed a management plan in 2009, but no management action had yet taken place by 2011 (M. Cairns, pers. comm., 2011).

Invasive Plant Species (in addition to White Mulberry)

Invasive exotic plants are another threat that needs to be carefully monitored; Dog Strangling Vines (*Cynachum* spp.) are beginning to appear in the Waterdown area and are known elsewhere along the escarpment. Garlic Mustard (*Alliaria petiolata*) is common in most forest habitats in southern Ontario and it likely impedes seedling establishment.

Number of Locations

Considering hybridization as the most serious threat to Red Mulberry, the entire Canadian population (with the possible exception of Middle Island and East Sister Island, discussed below) is perhaps best considered a single location. The potential for management (culling) of White Mulberry and hybrids at specific sites or by particular land managers could be used to argue for the existence of more locations, but the overall abundance of White Mulberry and the lack of ongoing management activities is the basis for treating all subpopulations as a single location. A possible exception exists with the two subpopulations managed by the Royal Botanical Gardens (Halton and Hamilton subpopulations), which could be considered a second location based on attempts to manage for Red Mulberry, including removal of White Mulberry and hybrid individuals. At both East Sister Island and Middle Island, nesting of Double-crested Cormorants may constitute the most significant threat to Red Mulberry persistence. Middle Island is under the jurisdiction of Parks Canada, while East Sister Island is managed by Ontario Parks, and therefore, these two subpopulations would be considered 2 locations. In summary, the best available information leads to designation of 1-4 locations for Red Mulberry.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Red Mulberry is currently listed as “Endangered” under SARA Schedule 1, and under the Ontario’s *Endangered Species Act, 2007* (ESA). In the United States it is ranked as Endangered in Connecticut and Massachusetts, and Threatened in Michigan and Vermont (USDA, 2012).

Ten of the 19 known occurrences, including all but one of the sites with two or more mature trees observed since 1999, are on public land and managed to some extent for conservation (Table 1). The land managers are aware of this species and have participated in species recovery planning. Currently the Royal Botanical Gardens is the only institution that appears to be actively and effectively subpopulations.

In 1997, the Ontario Ministry of Natural Resources contracted the preparation of a RENEW format Recovery Plan (Ambrose, 1998) for the full range of the species in Ontario. A finalized national recovery strategy was completed in 2011 and includes description of critical habitat (Parks Canada Agency, 2011).

Non-Legal Status and Ranks

Red Mulberry is ranked as Imperiled in Ontario (S2) and Canada (N2); Critically Imperiled in Vermont (S1) and Massachusetts (S1), Imperiled in Michigan (S2) and possibly extirpated in Minnesota (SH) (NatureServe, 2013).

Habitat Protection and Ownership

Habitat protection and ownership are indicated in Table 1, which shows that ten subpopulations occur on public lands including federal (2 subpopulations), Ontario provincial (3 subpopulations) and regional or municipal conservation offices (7 subpopulations).

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

John D. Ambrose received his M.Sc. and Ph.D. degrees in Botany from the University of Michigan and Cornell University, respectively. He began his study of the biology of woody plants in the late 1970s while at the University of Guelph Arboretum. He has authored twelve COSEWIC status reports as well as other papers relating to the biology of rare species and their conservation, served on the COSEWIC Plants Subcommittee and Forest Gene Conservation Association board, and was the founding chair of the Ontario Chapter of the Society for Restoration Ecology.

Gerry Waldron holds B.Sc. and M.Sc. degrees in biology from the University of Guelph. Beginning with the International Biological Programme in 1971, he has 42 years of experience in the areas of field biology, environmental planning and impact studies. He has worked with the Committee on the Status of Endangered Wildlife in Canada, Parks Canada, Ontario Ministry of Natural Resources, Essex Region Conservation Authority, Natural Habitat Restoration Program, and Tallgrass Ontario. He is the author of two land management manuals and four books of natural history as well as many other publications, both technical and popular.

Paul O'Hara is a botanist, landscape designer and native plant gardening expert. Since 1991, Paul has worked in a wide variety of horticulture, habitat inventory, ecological restoration, and native plant gardening capacities in both the private and public sectors. His SAR work includes 2 years as Endangered Species Technician at Royal Botanical Gardens where he worked on Red Mulberry, Few-flowered Clubrush and Hoary Mountain Mint. He has also contributed to SAR Update Status Reports (with Gerry Waldron and John Ambrose) on Wild Camassia, Flowering Dogwood, Dwarf Hackberry, Cucumber Magnolia, and Red Mulberry. Paul is the owner/operator of Blue Oak Native Landscapes, a business dedicated to creating beautiful natural landscapes in the spaces where we live, work and play.

COLLECTIONS EXAMINED

Herbarium specimens were examined at various regional herbaria for the original 1987 COSEWIC status report, but were not consulted as part of this update.