COSEWIC
Assessment and Status Report

on the

Maleberry
Lyonia ligustrina

in Canada

ENDANGERED
2020

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:

COSEWIC. 2020. COSEWIC assessment and status report on the Maleberry *Lyonia ligustrina* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 39 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

Production note:
COSEWIC acknowledges Sean Blaney (Atlantic Conservation Data Centre) and Alain Belliveau (E.C. Smith Herbarium, Acadia University) for writing the status report on Maleberry, *Lyonia ligustrina*, in Canada, prepared with the financial support of the Nova Scotia Species at Risk Conservation Fund. This report was overseen and edited by Del Meidinger, Co-chair of the COSEWIC Vascular Plants Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la Lyonie faux-troène (*Lyonia ligustrina*) au Canada.

Cover illustration/photo:
Maleberry — Photograph by Alain Belliveau and Sean Blaney.

Catalogue No. CW69-14/800-2021E-PDF
ISBN 978-0-660-38736-9

COSEWIC
Assessment Summary

Assessment Summary – November 2020

Common name
Maleberry

Scientific name
Lyonia ligustrina

Status
Endangered

Reason for designation
This colonial deciduous shrub is part of a disjunct assemblage of Atlantic Coastal Plain flora. It is known from a single lakeshore site in a protected area in southern Nova Scotia separated by more than 245 km from the next nearest site across the Gulf of Maine. The Canadian population appears stable, but its very small size (approx. 33 mature individuals) and extremely local distribution (612 m^2) place it at risk. Although immediate threats are low, this population faces potential threats from off-road vehicle activity and invasive Glossy Buckthorn.

Occurrence
Nova Scotia

Status history
Designated Endangered in November 2020.

COSEWIC
Executive Summary

Maleberry
Lyonia ligustrina

Wildlife Species Description and Significance

Maleberry is a broad-leaved, deciduous shrub with multiple erect woody stems coming from branching rhizomes and reaching a height of 4 m. Leaves are 2-9 cm long, oval and generally pointed at both ends, with smooth or slightly toothed margins. The small, vase-shaped flowers are in elongate inflorescences in which individual flowers are on short stalks at the tips of the previous year's stems. Fertilized flowers develop into globe-shaped, woody capsules of 2-4 mm that split open along five sutures and remain on the shrub through the following growing season.

Maleberry is of special interest as an extremely rare species in Canada and as a classic example of a disjunct Atlantic Coastal Plain flora species in southern Nova Scotia. The Nova Scotia occurrence could be significant to northward colonization under a future warmer climate. Maleberry is host plant to a leaf tar spot fungus that may be restricted to the single Maleberry occurrence in Canada. Maleberry supports some host-specific insect species that could occur in Canada. It is also occasionally used as a landscape plant and a homeopathic remedy.

Distribution

Maleberry is restricted to the eastern United States with a single occurrence in southernmost Nova Scotia. It occurs from south-central Maine, northern Vermont and central New York to central Florida, eastern Texas and Oklahoma. Northward, occurrence is sparser west of the Appalachian Mountains. The variety *ligustrina* that occurs in Canada extends south and west to northern Alabama.

Habitat

The Nova Scotia population of Maleberry occurs in a fairly open, peaty lakeshore Red Maple swamp with scattered Red Spruce, Balsam Fir, Yellow Birch, and tall shrubs. In the United States, Maleberry occurs primarily in wetlands: swamps, shrub thickets, bogs – especially along the margins – river, stream, pond and lake shores, and sometimes rich fens. It also regularly occurs in upland woods and thickets, sometimes including disturbed habitats (old field, powerline and second-growth forest).

Biology

Maleberry is a long-lived perennial shrub that can reproduce from seed or vegetatively via spreading rhizomes. Generation time is difficult to determine from available information but may be around 20 years. Maleberry flowers in mid- to late July in Nova Scotia. It is primarily pollinated by bees, including some specialist pollen collecting species, and can be self-compatible. Fruit mature in late summer or early autumn and remain on the shrub through the winter, dispersing small seeds via wind and secondarily via water or perhaps within mud on animal fur or feathers.

Population Sizes and Trends

The Canadian population consists of 780 stems representing at least 33 mature individuals (and believed to be well under 250 mature individuals) over an area of 51 m by 12 m. No evidence of change in population size is known, and the population is anticipated to be stable through the future as long as potential threats from off-road vehicle activity and Glossy Buckthorn invasion are managed by the Nova Scotia Nature Trust.

Threats and Limiting Factors

Threats to Maleberry in Nova Scotia are limited because the only known occurrence is within a area owned by the Nova Scotia Nature Trust. Unauthorized off-road vehicle use and potential associated brush clearing could affect a small proportion of individuals along the population margin. Competitive exclusion from the invasive shrub Glossy Buckthorn is a potential threat in future decades. The nearest known occurrence is 45 km away, although it probably occurs even nearer. Expansion of Glossy Buckthorn will be slow acting over one to several generations and could be readily managed at the small known Maleberry occurrence.

Potential limiting factors in Canada are limited dispersal ability and seedling establishment, effects of leaf tar spot fungus, and browsing by Snowshoe Hare and White-tailed Deer.

Protection, Status and Ranks

Maleberry currently has no legal status in any jurisdiction of occurrence. Ohio (SH) and Vermont (S3S4) are the only jurisdictions aside from Nova Scotia in which ranks indicate some level of concern. Elsewhere the species is Secure or Apparently Secure (S4 or S5), or Unranked (SNR, for this species the absence of a rank probably indicates that it is generally considered secure).

TECHNICAL SUMMARY

Lyonia ligustrina

Maleberry

Lyonie faux-troène

Range of occurrence in Canada (province/territory/ocean): Nova Scotia

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	20 years (roughly estimated; see **BIOLOGY**)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	No.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	N/A
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	N/A
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown; some decline possible over 60 years if Glossy Buckthorn becomes established and is not managed
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown; some decline possible over longer term if Glossy Buckthorn becomes established and is not managed
Are the causes of the decline a.clearly reversible and b.understood and c. ceased?	a. Yes (re: theoretical future decline); Glossy Buckthorn could be readily managed at the single small Maleberry site b. Yes, cause of (theoretical future) decline understood c. N/A (theoretical future decline)
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	4 km^2 (actual value 612 m^2 but rounded up to match IAO)
Index of area of occupancy (IAO) (Always report 2x2 grid value).	4 km^2

Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. N/A (one site known) Viable seeds are being produced and other apparently suitable habitats are available nearby.
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	0-1 location. Single small occurrence under one property owner and management regime. The small population is intrinsically at risk from stochastic effects.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	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 Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Long Lake, Yarmouth Co., NS	33 individuals; 780 total stems
Total	33 (33 is a conservative count, but the population is confidently estimated at less than 250; see **Abundance**)

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not assessed

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes. The calculated and assigned overall threat impact for the species across Canada is Low.

Threats that scored “Negligible” and “Unknown” in the Threats Calculator are not listed here.

i. Unauthorized Off-road Vehicle Use and Trail Expansion (IUCN Threat 6.1 Recreational Activities). Threat impact = Low.
ii. Invasive non-native/alien species/diseases (IUCN Threat 8.1. Threat impact = Low

What additional limiting factors are relevant?
Limitations on dispersal and/or establishment may be significant in restricting the distribution of Maleberry within Canada (see **Limiting Factors**).

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Common and secure in southern Maine and southward.
Is immigration known or possible?	Immigration is not known, but the species reached Nova Scotia, presumably via a route of 245+ km across the Gulf of Maine. This would be a rare event but could re-occur.
Would immigrants be adapted to survive in Canada?	Yes. Conditions in southern Nova Scotia appear similar to those in New England.
Is there sufficient habitat for immigrants in Canada?	Yes. Extensive unoccupied and apparently suitable habitat is present.
Are conditions deteriorating in Canada?[+]	Possibly. Over the long term (50-100 years), Glossy Buckthorn could become a threat over much potential habitat, although it could be managed within the single, small, known occurrence.
Are conditions for the source population deteriorating?[+]	No. Source populations are secure.
Is the Canadian population considered to be a sink?[+]	No.
Is rescue from outside populations likely?	No. Immigration of 200+ km across the Gulf of Maine is unlikely.

Data Sensitive Species

Is this a data sensitive species? No.

Status History

COSEWIC: Designated Endangered in November 2020.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Status and Reasons for Designation:

Recommended Status: Endangered	**Alpha-numeric codes:** D1
Reasons for designation: This colonial deciduous shrub is part of a disjunct assemblage of Atlantic Coastal Plain flora. It is known from a single lakeshore site in a protected area in southern Nova Scotia separated by more than 245 km from the next nearest site across the Gulf of Maine. The Canadian population appears stable, but its very small size (approx. 33 mature individuals) and extremely local distribution (612 m^2) place it at risk. Although immediate threats are low, this population faces potential threats from off-road vehicle activity and invasive Glossy Buckthorn.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No declines have been observed or are expected.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Both the EOO (4 km^2) and IAO (4 km^2) are below the thresholds for Endangered and the number of locations (0-1) is fewer than 5, but population is not severely fragmented, does not experience extreme fluctuations, and does not appear to be in decline.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals (33) is below the threshold for Endangered but there is no evidence of a continuing decline.
Criterion D (Very Small or Restricted Population): Meets Endangered, D1. Number of mature individuals estimated to be 33, is below the threshold of 250.
Criterion E (Quantitative Analysis): Not applicable. Analysis not conducted.

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 (2020)

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 and Climate Change Canada
Canadian Wildlife Service
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Canada

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

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in Canada

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Lyonia ligustrina* (Linnaeus) de Candolle
Original Description: *Vaccinium ligustrinum* Linnaeus, Sp. Pl. 1: 351. 1753
Synonyms (The Plant List 2019; IPNI 2019):
Vaccinium ligustrinum Linnaeus
Arsenococcus ligustrinus (Linnaeus) Small
Andromeda ligustrina Muhl.
Xolisma ligustrina (Linnaeus) Britton
Lyonia capraeifolia P. Watson
Lyonia salicifolia P. Watson

English vernacular name: Maleberry, He-huckleberry, Male-blueberry
French vernacular name: Lyonie faux-troène, Lyonie ligustrine
Aboriginal names: [unknown in Canada]
Genus: *Lyonia*
Family: Ericaceae (Heath Family)
Order: Ericales (APG 2016)
Major Plant Group: Angiosperms – Eudicots (APG 2016)

Maleberry varies considerably across its range. The varieties *typica* Fernald, *pubescens* (A. Gray) Bean & Rehder, *salicifolia* (P. Watson) DC., *capraeifolia* (P. Watson) DC. and *foliosiflora* (Michx.) Fern. have been described from the southern United States (IPNI 2019), with varieties *salicifolia* and *capraeifolia* having been separated at the species level in the past (IPNI 2019). Current treatments (Judd 2009 *in* Flora of North America; Weakley *et al*. 2015) merge all southern varieties within variety *foliosiflora* of the southeastern United States and treat plants from the Appalachian Mountains and northward as variety *ligustrina* (Judd 2009). The Canadian occurrence is variety *ligustrina* (VASCAN – Brouillet *et al*. 2019).

Morphological Description

Maleberry (Figure 1) is a broad-leaved shrub with multiple erect woody stems reaching heights of up to 4.5 m arising from a basal burl or elongated rhizomes. Leaves are 2-9 cm long, oval or obovate (egg-shaped in outline, widest toward the tip) and generally pointed at both ends, with smooth or slightly toothed margins. In Canada, Maleberry is deciduous but leaves can be semi-persistent in the southern variety *foliosiflora* (Judd 1981). Flowers are in racemes (elongate inflorescences in which individual flowers are on short stalks) arising at the tips of the previous year's stems. Flowers are about 4 mm wide by 4.5 mm long, with petals fused into a vase-shaped corolla that has five short lobes and narrows toward the tip. The fruit is a 2-3 × 2-4 mm, globe-shaped, woody capsule that splits

open along five sutures and remains on the shrub through the following growing season. This is one of the species' most distinctive features.

Figure 1. Inflorescence, fruiting branch, and large shrub - approximately 4 m tall, of Maleberry (*Lyonia ligustrina*) from the Jack and Darlene Stone Conservation Lands, Long Lake, Nova Scotia. Photographs by Alain Belliveau and Sean Blaney.

Population Spatial Structure and Variability

Maleberry is known in Canada only from a single small population of 33 individuals within an area of 51 m x 12 m in southernmost mainland Nova Scotia. This locality is isolated from nearest known populations in southern Maine by about 245 km. No investigation of genetic diversity or distinctiveness of the species in Canada has been undertaken. As a small and highly isolated population likely founded from a single dispersal event, limited genetic diversity and inbreeding could be affecting the species in Canada (Gaston 2003; Blows and Hoffman 2005; Bridle and Vines 2007). The isolation of the Nova Scotia population could also have promoted adaptive divergence from American populations (Lenormand 2002), giving it a disproportionate significance to the species' genetic diversity (Channell and Lomolino 2000).

The species shows significant morphological variation, with two relatively well-defined varieties in the northern and southern parts of its range. A zone of morphological intergradation occurs between those varieties, predominantly in Alabama, northern Georgia, North Carolina, and South Carolina (Judd 2009).

Maleberry is known to be self-compatible (Rathcke 1988).

Species' Eligibility for Assessment

There are no issues of taxonomic uncertainty affecting assessment of the Canadian population of Maleberry.

Although Maleberry was not discovered in Nova Scotia until 2011 (AC CDC 2019), it is presumed to be a native species. The disjunction of Maleberry from southern Maine to southern Nova Scotia is widely shared with a large suite of Atlantic Coastal Plain species (Roland and Smith 1969; EC and PCA Canada 2015) and the single Canadian occurrence at Long Lake is just 200 m from Wilsons Lake, which supports one of the most important and diverse communities of Atlantic Coastal Plain-associated lakeshore flora in Nova Scotia (AC CDC 2019). Maleberry individuals at Long Lake are clearly many years old, with thick woody bases showing evidence of long-term resprouting (Blaney pers. obs. 2011). The species is in an undeveloped locality unlikely to have been subject to intentional or unintentional human introduction. Collection records (AC CDC 2019) give no indication that any botanists had previously visited the site, meaning the absence of records at Long Lake prior to 2011 can be explained by lack of search effort.

Designatable Units

Maleberry is known in Canada from a single small population occupying a very small area. The Canadian population is therefore considered a single designatable unit.

Special Significance

Maleberry is of special interest as an extremely rare species in Canada and as a classic example of a disjunct Atlantic Coastal Plain flora species in southern Nova Scotia. It is one of 30 such Atlantic Coastal Plain vascular plant species that are known in Canada only from Nova Scotia (ECCC 2016). The genetics of the Canadian population have not been investigated but the population's isolation could promote adaptive divergence from American populations (Lenormand 2002) giving it a disproportionate significance to the species' genetic diversity (Channell and Lomolino 2000). The Nova Scotia occurrence could be significant to northward colonization under a future warmer climate (Parmesan 2006).

Maleberry is host plant to a tar spot fungus (*Rhytisma decolorans* Fr. [synonyms: *Xylota andromedae-ligustrinae, Rhytisma andromedae-ligustrinae*; Wilson and Seaver 1907; Farr and Rossman 2019]), that may be restricted in Canada to the Long Lake, Nova Scotia Maleberry site (see **Interspecific Interactions**). Maleberry is also probably the only host plant for the Sharp-blotched Nola Moth (*Nola pustulosa*; not yet known in Canada), and is an important food source for four species of pollen specialist bees that are closely associated with the genus *Lyonia* and its relatives, only one of which is known from Canada (Fowler and Droege 2019).

Maleberry is unlikely to have had any significant human uses in Canada because of its scarcity, but elsewhere it is occasionally used as a landscape plant especially suited to moist, acidic soils (e.g., New Jersey Pinelands Commission 2015), as a homeopathic remedy of unspecified use (Remedia Homeopathy Manufactory 2018) and is known as a useful honey plant (North Carolina State Extension 2018). It is, however, also reported to be one of the species in the heath family that produces andromedotoxin (also known as acetylandromedol, grayanotoxin or rhodotoxin), a diterpenoid resin that can be poisonous to livestock and humans (Muencher 1939 in Judd 1981; Constable *et al*. 2017). Humans can be affected by "mad honey disease" after ingesting honey produced by bees that obtained nectar from toxin-producing plants or can be exposed through herbal teas or other natural products.

DISTRIBUTION

Global Range

Maleberry is restricted to the eastern United States, excluding the single occurrence in southernmost Nova Scotia (Figure 2). It occurs from south-central Maine, northern Vermont and central New York to central Florida, eastern Texas and Oklahoma. Northward within this range, occurrence is sparser west of the Appalachian Mountains. The variety *ligustrina* occurring in Canada extends south and west only to northern Alabama.

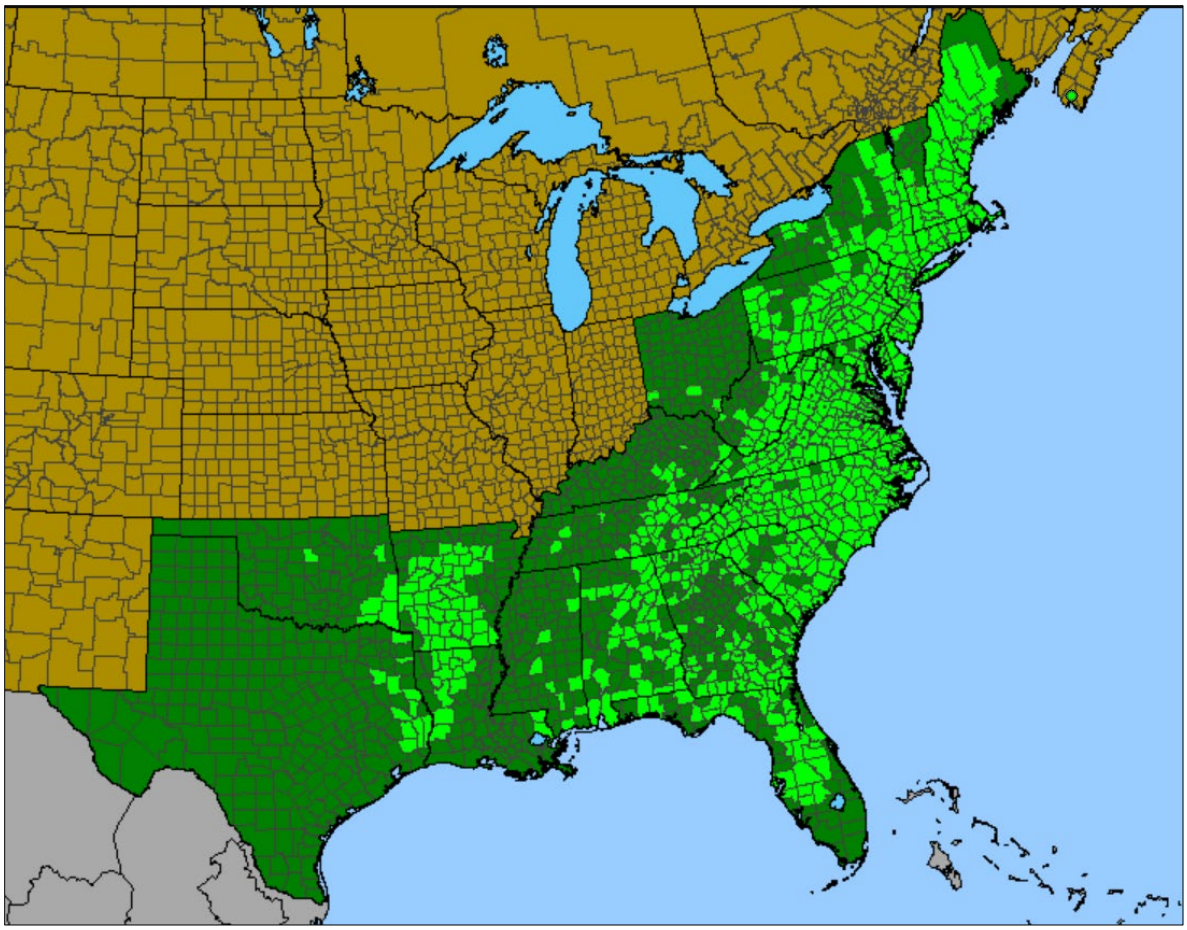

Figure 2. Global range of Maleberry (*Lyonia ligustrina*), modified from Kartesz (2015). State level distribution is indicated in dark green. Counties in the United States with documented occurrences are shaded pale green. The Nova Scotia occurrence is indicated with a pale green dot. The variety *ligustrina* found in Canada extends south to the southern Appalachian Mountains in northern Alabama.

Canadian Range

Within Canada, Maleberry is only known from 51 m x 12 m within the Nova Scotia Nature Trust's Jack and Darlene Stone Conservation Lands near the shore of Long Lake, northeast of Yarmouth in southwesternmost Nova Scotia (Figure 3). Botanical effort has been sufficient to clearly indicate that the species is very rare in Canada, but potential areas in which additional occurrences might be found are discussed under **Search Effort**.

Figure 3. Canadian occurrence of Maleberry (red polygon under the arrow) at Nova Scotia Nature Trust's Jack and Darlene Stone Conservation Lands (pink outline), Long Lake, Yarmouth County, Nova Scotia [Editorial note: This figure has been removed to protect precise location information. Please contact the COSEWIC Secretariat if you require this information.]

Figure 4. Maleberry habitat at the Jack and Darlene Stone Conservation Lands, Long Lake, Nova Scotia in 2011, viewed from the lake (above) and from within the densest part of the population near the lakeshore – swamp transition zone (below).

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) of Maleberry in Canada, calculated using the standard COSEWIC minimum area convex polygon method (COSEWIC 2015), amounts to only 612 m^2. Index of area of occupancy (IAO) is 4 km^2 in Canada, representing a single 2 km x 2 km grid square. COSEWIC (2015) guidelines stipulate that EOO cannot be less than IAO, thus EOO is rounded up to 4 km^2 to match the IAO.

Search Effort

The peaty shoreline, wetland and swamp habitats occupied by Maleberry are very common in the Maritimes. Substantial unsurveyed potential habitat exists within the zone having the greatest prevalence of disjunct Atlantic Coastal Plain flora (Nova Scotia, south of a line roughly between the town of Digby on the Bay of Fundy and Halifax on the Atlantic Coast). Potentially climatically suitable areas for Maleberry also extend through most of Nova Scotia, Prince Edward Island and southern New Brunswick (based on occurrence in northern New Hampshire, Plant Hardiness Zone 4a or 3b; USDA-ARS 2012; McKenney *et al*. 2014).

Maleberry extends fairly close to the Canadian border in New York at the eastern and western ends of Lake Ontario, and in Vermont, New Hampshire, and Maine (Kartesz 2015 – although some border area occurrences mapped therein are questioned by state botanists, Cameron pers. comm. 2019; Popp pers. comm. 2019). Among the adjacent Canadian regions, southeastern Ontario probably offers the greatest potential for occurrence of Maleberry because of extensive acidic peaty wetlands on the southern extension of the Canadian Shield, low elevation and fairly warm climate, and southern and Atlantic Coastal Plain elements present in the flora (Catling 1985; Brownell *et al*. 1996).

Although undiscovered occurrences may exist, Maleberry is clearly very rare even in the immediate vicinity of the single known occurrence. Special efforts to locate other occurrences have been made since 2011, but none have been found. All freshwater lakes downstream of Long Lake on the Kiack Brook system[1] have been comprehensively surveyed, with effort made to cover areas away from the shores where peaty lakeshore wetlands graded into swamp forest. Because it is a known hotspot for Atlantic Coastal Plain flora, search effort for rare lakeshore plants has been especially intense in the vicinity of the known Maleberry occurrence. Of the 40 natural freshwater lakes (defined as water bodies with their longest side at least 500 m long) within 10 km of Long Lake, 31 have been comprehensively surveyed by experienced botanists since 2000 and an additional four have been visited but not comprehensively surveyed in that period (AC CDC 2019).

If Maleberry were at all widespread in southern Nova Scotia, the extent of botanical survey effort suggests it would have been found elsewhere. It is a large and fairly distinctive species that would be recognized as distinct even to a botanist of only moderate experience. AC CDC (2019) and COSEWIC (2012) document site visits to 402 lakes in

[1] Springhaven Duck Lake, Pothiers Millpond, Hog, Marcel, French Clearwater, Mingo Beck and Duck lakes; the brackish Eel Lake also partly surveyed.

southern Nova Scotia south of 44.67°N (the latitude of Halifax; out of 1,450 named lakes and ponds in that area, Natural Resources Canada 2003). Of these, 220 were visited up to 2000. Fieldwork since 2000, predominantly by Atlantic Canada Conservation Data Centre (AC CDC) and Mersey Tobeatic Research Institute (MTRI) (see references in COSEWIC 2012) has been more intensive, with 263 lakes visited, including 186 lakes not visited prior to 2000. A substantial portion of the 186 newly visited lakes have had comprehensive coverage of their shorelines for rare plants.

HABITAT

Habitat Requirements

The Long Lake population of Maleberry occurs in a fairly open, peaty lakeshore Red Maple (*Acer rubrum*) swamp with scattered Red Spruce (*Picea rubens*), Balsam Fir (*Abies balsamea*), Yellow Birch (*Betula allegheniensis*) and tall shrubs (predominantly Winterberry Holly – *Ilex verticillata* and Mountain Holly – *Ilex mucronata*) with the liana Smooth Greenbriar (*Smilax rotundifolia*, an especially characteristic species of the Atlantic Coastal Plain flora zone in Nova Scotia). Co-occurring herbaceous and low shrub species noted were Tussock Sedge (*Carex stricta*), Cinnamon Fern (*Osmunda cinnamomea*), Swamp Dewberry (*Rubus hispidus*), and Creeping Snowberry (*Gaultheria hispidula*). The Maleberry extends in from the peaty, open lakeshore of a small bay up to the edge of upland habitat at the base of a low drumlin.

Judd (2009) describes the habitat of var. *ligustrina* as “moist to dry, acid woods and thickets, stream or pond margins, acid swamps or bogs, grassy and/or heath balds”. Most of the herbarium specimens having habitat descriptions that are available through the Consortium of Northeast Herbaria (CNH 2019; n = 171 different habitat descriptions) fit within those categories. Additional habitats noted include interdune wetlands (see also Lortie *et al*. 1991), saltmarsh margins and various disturbed habitats (old field, pasture, hedgerow, powerline and second-growth forest) and calcareous fens and seepage swamps (verified by Marcus pers. comm. 2019). Powerlines were also specifically mentioned by Maine and Vermont botanists (Cameron pers. comm. 2019; Marcus pers. comm. 2019). A strong majority of specimens are associated with wetlands (121 of 142 habitat descriptions that were clearly assignable to wetland or upland habitats), especially toward the north edge of the range. The mean latitude of specimens coming from dry habitats (41.765°N, northernmost from southern New Hampshire at 42.985°N) was significantly more southerly than the mean for wet habitats (42.529°N, northernmost from south-central Maine at 44.325°N; Student’s two-tailed T-test, P = 0.000755). Maleberry is classified as a Facultative Wetland species in all regions of occurrence in the United States’ National Wetland Plants List (Lichvar *et al*. 2016), meaning that it will “usually occur in wetlands (67%-99% probability), but may occur in non-wetlands”.

The CNH data included numerous examples of occurrence in unshaded, partially shaded and closed canopy habitats and Judd (1981) notes it as intermediate in shade tolerance but growing best in light. Specimen information and multiple references

(summarized in Carey 1994) frequently mention occurrence in shrubby transition zones between forest and wetlands or clearings. Swamp, peatland and shoreline records are also well represented. Frequently mentioned associate species included Red Maple, Eastern Hemlock (*Tsuga canadensis*), Atlantic White Cedar (*Chamaecyparis thyoides*), Sweet Pepperbush (*Clethra alnifolia*), birch species, especially Yellow Birch, Black Spruce (*Picea mariana*), hollies (*Ilex verticillata* and *Ilex mucronata*), blueberry species, especially Highbush Blueberry (*Vaccinium corymbosum*) and sphagnum mosses (*Sphagnum* spp.).

The habitats occupied in New England suggest potential for occurrence in a broader range of wetland habitats than many other Atlantic Coastal Plain-affiliated species which are restricted in Nova Scotia to the shores of larger lakes.

Habitat Trends

There has been limited indication of habitat change at the Long Lake Maleberry site since 2011. Alain Belliveau (pers. obs. 2011-2019) has visited the site five times during that period and notes that as of April 2019 most Eastern Hemlocks, previously representing about 20% of the tree cover in the upland forest adjacent to the Maleberry swamp, are now dead or dying because of the introduced insect pest, Hemlock Woolly Adelgid (*Adelges tsugae*). This seems unlikely to cause significant negative impacts on Maleberry, which might benefit temporarily from increased light levels around the population margins. Belliveau (pers. obs. 2011-2019) also noted that as of April 2019, off-road vehicle use on the branch of trail that passes along the edge of the Maleberry occurrence was minimal, with a large fallen tree that had been present for about a year blocking further trail access about 100 m beyond the Maleberry. Belliveau documented fairly intensive unauthorized off-road vehicle use elsewhere within the Jack and Darlene Stone Conservation Lands causing large ruts and puddling away from the Maleberry on the left branch of the same trail network. If these off-road vehicle users were motivated to re-open the Maleberry trail to access its end point on the Tusket River between Wilsons and Bennetts lakes, impacts to Maleberry habitat could occur (see **Threats**). The property owner, the Nova Scotia Nature Trust, has noted no other significant changes (Firth pers. comm. 2019). As a protected area managed by the Nova Scotia Nature Trust, other significant changes to the Maleberry site are not anticipated through the future, with the exception of the anticipated arrival in the coming decades of the invasive Glossy Buckthorn (*Frangula alnus*), currently known from 45 km away at Barrington to the south and 57 km away at Beverley Lake, Digby County to the north. If unmanaged, Glossy Buckthorn could ultimately reduce Maleberry habitat quality through shading, but it could be readily managed within the small Maleberry occurrence by manual removal (see **Threats**).

There is an extensive network of old forest harvest trails on the property, some patches of young, regenerating forest, and one area of Red Pine (*Pinus resinosa*) plantation, but forest harvesting on the Maleberry site has been light, involving removal of scattered trees along the population margins for firewood or lumber about 20 years ago (Belliveau pers. obs. 2011-2019). The older hemlocks at the wetland margins suggest continuous forest cover on site for 100 years or more (Belliveau pers. obs. 2011-2019).

Habitat of (theoretical) nearby subpopulations may have been influenced by construction, in 1929 and shortly thereafter, of hydroelectric and headpond dams at Lake Vaughan, Raynards Lake, and Gavels Lake. These dams flooded the original shores of a chain of lakes along the Tusket River from just above tidewater up to Bennetts Lake, 2.1 km west of the Long Lake Maleberry occurrence. Merritt Fernald, North America's pre-eminent taxonomic botanist of the early 20th century, collected on the affected lakes in 1920 and 1921 before the flooding and did not find Maleberry, so although suitable habitat was undoubtedly lost, Maleberry may have never occurred on the flooded lakes.

BIOLOGY

Life Cycle and Reproduction

Maleberry is a long-lived perennial shrub. There is no published information on longevity, but individual stems are up to 4.5 m height and about 3 cm diameter in Canada. A stem of 1.5 cm diameter at 0.6 m above the ground from the Nova Scotia population had 13 growth rings, suggesting that the largest stems in Canada (about 3.0 cm) may be 30-50 years old (Belliveau pers. obs. 2011-2019). Vegetative reproduction is via sprouting from sturdy branched rhizomes just below the soil surface, and rhizomatous clones could be much older than 20 years. Generation time (average age of individuals reproducing either vegetatively or by seed; COSEWIC 2015) is difficult to accurately estimate (see discussion of mature individuals under **Abundance**). The generation time of the clumps or patches of stems treated in this report as individuals is likely 20+ years (Blaney pers. obs. 2011; Belliveau pers. obs. 2011-2019).

In the northern part of its range Maleberry flowers in mid-summer, with plants having already dropped some corollas with seed capsules developing noted in Nova Scotia on July 28, 2013 (Belliveau pers. obs. 2011-2019). Rangewide flowering dates are April to early July (Judd 1981). Rathcke (1988) found that Maleberry was one of the latest flowering species among a guild of 14 co-occurring shrubs studied for five years in Rhode Island (12th or 13th each year out of 14 species). She observed flowering between June 19 and July 15 and found that annual mean flowering date varied from June 24 to July 8 with July 4 as the overall mean. Longevity of individual flowers ranged from 1 to 6 days (median and mode of 4 days) and longevity was not reduced following pollination. In Canada, only a small proportion of stems have been observed flowering in any one year (estimated 20-30 out of 780 in 2018, observed April 2019, Belliveau pers. obs. 2019). Maleberry is primarily pollinated by bees (see **Interspecific Interactions**). Rathcke (1988) found that it was not pollen limited, with seeds produced per flower increasing slightly but not significantly with experimental pollen augmentation. She also determined that Maleberry was completely self-compatible. Fruiting time has been reported as September – October in the Carolinas (Radford *et al*. 1968) and November – December in Rhode Island (Rathcke 1988). Viable seeds were still present in the previous year's capsules in April 2019 in Nova Scotia (Belliveau pers. obs. 2011-2019) so dispersal from the parent plant may occur over six months or more.

Most likely modes of seed dispersal are wind, flowing water and within mud clinging to animals or off-road vehicles (see **Dispersal and Migration**). Longevity of seeds is unknown, but seeds are probably short-lived based on their small size and lack of strong seed coats, and on seed bank studies where Maleberry was identified in the above-ground vegetation but not recorded in seed bank germination trials (Cohen *et al.* 2004; Bolin 2007). Seed stratification and germination requirements are poorly documented but available propagation recommendations are to sow seeds in spring after overwintering at room temperature (Lady Bird Johnson Wildflower Center 2019).

Physiology and Adaptability

Published habitat descriptions, information on specimens and opinions solicited from United States botanists for this report indicate that Maleberry has a broad tolerance of varying moisture regimes, light levels and climate, and can grow on many soil types including peat, sand, till and thin soils on rock outcrops. As is typical of many species in the heath family, an association with acidic soils is frequently noted, which could be caused by some combination of calcium toxicity and limited ability to obtain iron or phosphorus in basic soils (Marrs and Bannister 1978 and references therein). In southern Vermont Maleberry occurs in calcareous fens and Black Ash (*Fraxinus nigra*) swamps in areas with marble bedrock (Marcus pers. comm. 2019), suggesting a broad pH tolerance as well.

Maleberry is considered a facultative wetland plant across its United States range (in wetlands 67% to 99% of the time, Lichvar *et al*. 2016). Specimen information indicates frequent occurrence in wet to saturated soils of peatlands and marshes, with several specimens indicating large abundance or dominance along the wetter lagg zone at bog margins (CNH 2019; see also Motzkin *et al*. 1991). It is also noted as somewhat characteristic of ridge top balds (Whittaker 1956) and is regularly present in mesic to dry upland forests, regenerating fields and sand barrens (Judd 1981; CNH 2019; Nichols pers. comm. 2019). There is an interaction between tolerance of dry conditions and climate, with a greater restriction to wetlands in cooler northern areas (see **HABITAT**). Maleberry grows best in full sun but is shade tolerant (Judd 1981) and can occur under a closed forest canopy (Carey 1994 and references therein; CNH 2019).

Maleberry is fire-tolerant, sending up shoots from its woody base and rhizomes if aboveground parts are burned (Judd 1981). It can colonize certain other disturbed habitats: flood scour zones along major rivers in Pennsylvania (Grund pers. comm. 2019) and a variety of human disturbed habitats such as roadside ditches, old pasture and powerlines (CNH 2019).

Maleberry's climate envelop extends from Plant Hardiness Zone 9b in central Florida (minimum winter temperatures of -3.9°C to -1.1°C) to Zone 4a or 3b at Mount Washington, New Hampshire (Arnold Arboretum, accession 01072342, in CNH 2019) where minimum winter temperatures are -37.2°C to -31.7°C (USDA-ARS 2012). The southern Nova Scotia population is within a narrow band of Plant Hardiness Zone 6b (minimum winter temperatures of -20.6°C to -17.8°C), one of the warmest areas in eastern Canada (McKenney *et al*. 2014).

Dispersal and Migration

Seeds of Maleberry are small, light, elongate and flattened (0.98 mm long by 0.2 mm wide in Nova Scotia; Jean pers. comm. 2019). The flattened shape of the seeds likely contributes to dispersal by wind and water. Seeds can likely float for at least a short period after dispersal from the parent plant and seed movement in flowing water is likely significant for dispersal within watersheds (Gurnell *et al*. 2008).

Judd (1981) suspected that wind dispersal was the primary mode by which ancient *Lyonia* species reached the Caribbean islands where they have speciated extensively, but he noted that "Long distance dispersal events must be very rare… since the majority of seeds fall within a short distance of the parent plant (pers. obs.)". In Nova Scotia, seeds were collected from the previous year's capsules in early April (Belliveau pers. obs. 2011-2019) and dispersal could take place over an even longer period as seed capsules remain on the shrubs for up to a year after maturing.

Maleberry has been reported as being animal dispersed (Boerner 1981, and subsequent citations of that work), but this is likely an error based on the common name including "berry". Boerner (1981) listed Maleberry among a group of "animal-dispersal shrub and pioneer tree species" but gave no direct evidence of animal dispersal. Maleberry fruit have no obvious characteristics to promote attractiveness to animals and there appear to be no other references to internal vertebrate-mediated dispersal of Maleberry seeds. Dispersal of the small seeds of Maleberry within mud on the feet, fur or feathers of birds and mammals is more likely to be an important means of dispersal at the scale required for the species to have reached Nova Scotia (e.g., Vivian-Smith and Stiles 1994; Figuerola and Green 2002).

Maleberry can also move on the scale of tens to hundreds of metres over time via rhizomatous spread, with rhizome length between aerial stems reported to be up to 4 m (Laycock 1967 in Carey 1994). As discussed in **Interspecific Interactions**, genetic dispersal via pollen is mediated by pollinating insects, primarily bees.

Interspecific Interactions

Plants in the heath family are strongly dependent upon mycorrhizal relationships for the acquisition of otherwise inaccessible nutrients from soil organic matter (Vohník 2012). These can involve complex fungal communities within the roots including species from both phylum Ascomycota and phylum Basidiomycota (Allen *et al.* 2003; Walker *et al*. 2011). In the only study specifically investigating Maleberry mycorrhizae (Cooke *et al*. 2004, in Connecticut, only one individual sampled), Maleberry was one of only seven out of 89 species in 75 genera in which vesicular-arbuscular mycorrhizae were not detected.

Maleberry is host to the leaf tar spot fungus *Rhytisma decolorans* that is likely the tar spot species occurring frequently on Maleberry leaves at Long Lake (Figure 5; Blaney pers. obs. 2011; Belliveau pers. obs. 2011-2019; see **Limiting Factors**). It is also known on three

related heath shrubs in the United States (Piedmont Staggerbush – *Lyonia mariana*, Swamp Dog-Laurel – *Leucothoe axillaris* and Fetterbush – *Leucothoe racemosa*, none of which occurs in Canada). Thus, the Long Lake record, if indeed this species, is presumably the first Canadian record of this fungus.

Figure 5. Maleberry leaves with tar spot fungus (likely *Rhytisma decolorans*, a host-specific species that will be new for Canada if identity is confirmed). This fungus is common within the Long Lake occurrence.

Maleberry flowers are visited by a wide diversity of insects, with bumble bees (*Bombus* species; Common Eastern Bumble Bee, *B. impatiens*, specifically documented) and a diversity of smaller bees reported as the primary pollinators (Rathcke 1988; Essenberg 2019). Flower size in Maleberry gives information about nectar production rates to visiting bumble bees (Essenberg 2019). Sam Droege (pers. comm. 2019) notes that Maleberry is an important plant for many bee species and Fowler and Droege (2019) listed four pollen collecting bees that are specialists of Maleberry and related heath species:

Melitta melittoides (Family Melittidae, subgenus *Cilissa*)
Andrena kalmiae (Family Andrenidae, subgenus *Scrapteropteris*)
Perdita novaeangliae (Family Andrenidae, subgenus *Alloperdita*)
Colletes productus (Family Colletidae) – recorded on *Lyonia, Vaccinium*

Of these, only *Andrena kalmiae* is known from Canada (ECCC 2016). Maleberry is also listed as an important nectar plant for the Oak Hairstreak butterfly (*Satyrium favonius ontario*) in New Jersey where the butterfly is a state Special Concern species (Conserve Wildlife Foundation of New Jersey 2019).

The use of Maleberry as larval host plant by the Sharp-blotched Nola Moth was carefully documented by McCabe (1997). This moth, not yet known from Canada (Pohl *et al*. 2018) but with a range extending to southern Maine (Moth Photographers Group 2019), is likely largely or entirely dependent on Maleberry because species in the genus are usually monophagous (McCabe 1997) and because its documented range (Moth Photographers Group 2019) corresponds very closely with that of Maleberry. There is also a leaf-mining micromoth in the family Gracillariidae reported from Maleberry in Massachusetts, from which a parasitic wasp in the family Eulophidae was raised (BugGuide 2013). The Gracillariidae genus *Phyllocnistis* is known from Fetterbush Lyonia (*Lyonia lucida*) (BugGuide 2016).

Maleberry is recorded as a host plant for the caterpillars of six additional moth species (Natural History Museum 2019): Chain-dotted Geometer (*Cingilia catenaria*; Geometridae), Huckleberry Sphinx (*Paonias astylus*), Apple Sphinx (*Sphinx gordius*, including *S. poecile*), Clemons' Sphinx (*Sphinx luscitiosa*), a palm moth *Chrysoclista villella* (Elachistidae, subfamily Agonoxenidae), and Azalea Caterpillar Moth (*Datana major*; Notodontidae). The first four of these species are known from Nova Scotia (Pohl *et al*. 2018; AC CDC 2019). All these species are also recorded as having numerous additional host plant species, except for *Chrysoclista villela*, which has no other host plant entries, though its Canadian distribution includes only British Columbia (Pohl *et al*. 2018) where no *Lyonia* species occur.

Browsing by White-tailed Deer (*Odocoileus virginianus*) and Snowshoe Hare (*Lepus americanus*) have been noted at the Long Lake occurrence with Snowshoe Hare browsing accounting for many of the dead stems noted at the site (Belliveau pers. obs. 2011-2019; see **Limiting Factors**). Maleberry appears to be a less favoured browse species for White-tailed Deer and Moose (*Alces americanus*; Faison 2006). Maleberry was noted as "ignored" in the winter diet of deer in Massachusetts (Hosley and Ziebarth 1935), was listed among "Species reported to be most deer-resistant" for New Jersey in Heinrich (1995) and was rated in the "Third Choice" category in evaluations of woody species' palatability for White-tailed Deer in eastern Texas, behind 52 species in the First and Second Choice categories (Lay 1967; Hutchison 2010). Deer browse on Maleberry also appeared less frequent than on other shrubs at the Nova Scotia site (Belliveau pers. obs. 2011-2019).

Maleberry represented 10.2% of the winter diet of wild Eastern and New England cottontails (*Sylvilagus floridanus* and *S. transitionalis*) in Massachusetts, but it was only the 18th most favoured twig species in an associated study of the preferences of captive cottontails (Dalke and Sime 1941). Maleberry leaves formed a small portion (0.45%) of the fall diet of Meadow Voles (*Microtus pennsylvanicus*) in abandoned cranberry fields in New Jersey, but no consumption was recorded in other seasons (Shenko 2014). There appears to be no literature on use of Maleberry by birds.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

In 2011 AC CDC botanists Sean Blaney and David Mazerolle followed occurrence of the species from the lakeshore swamp edge to the end of the occurrence, counting individual clumps observed, but not comprehensively counting stems. A comprehensive shoreline inventory of Long Lake, Springhaven Duck Lake, and the small pond between the two lakes determined that Maleberry was limited to the single site on Long Lake. All the lakes downstream from Long Lake on Kiack Brook to tidewater had comprehensive shoreline surveys completed in 2012, and Bennetts Lake (1.25 km away) and Wilsons Lake (0.24 km away) in the Tusket River watershed have had multiple comprehensive shoreline surveys because of their numerous other species at risk. As described under **Search Effort**, most other lakes within 10 km have also been comprehensively searched along their shorelines.

Alain Belliveau walked through the Long Lake site in April 2019, defined its boundaries by GPS and completed a comprehensive count of all stems that was more thorough than the 2011 visit, but he did not attempt to group these into mature individuals.

Abundance

The 2019 count is 33 individuals where a mature individual is a large stem or distinct clump of stems that is generally separated from others by several metres or more and is considered capable of surviving on its own. At those distances, rhizome connections could be severed by treefall events or rhizome senescence.

The population consists of 21 “distinct clumps” having 39 stems, and a denser patch consisting of 12 large stems or stem clumps and about 729 smaller rhizome-derived stems (about 741 stems) over 32 m x 10 m for a total of 33 clumps and about 780 stems. The small suckering shoots were mostly not flowering, were often crowded several to a square metre, and may not have been capable of surviving on their own. These are not counted here as individuals (COSEWIC 2019), but uncertainty around the extent to which stems are connected, how well they could survive on their own if severed, and how frequently rhizome connections would be naturally severed makes a precise count impossible. The count of 33 individuals can probably be considered a conservative estimate but given the small size of the area involved and the probable infrequency of natural severing of the thick rhizomes, a population count exceeding 250 would likely be too high.

Fluctuations and Trends

Comparison of 2011 and 2019 counts, and discussion between the observers (Sean Blaney in 2011 and Alain Belliveau in 2019) suggest the population is stable. Differences from 2011 to 2019 in the boundaries of the area occupied were within the expected error range of a handheld GPS, the main clumps of stems appear to be in the same places, and there have been no major changes to the occupied habitat (Belliveau pers. obs. 2011-2019).

Rescue Effect

Maleberry most likely reached Nova Scotia by a long-distance dispersal event across the Gulf of Maine, but such events are unlikely to be frequent enough to constitute a significant rescue effect. The nearest known subpopulations in southern Maine are 245 km away from the Long Lake population and 215 km away from the closest part of Nova Scotia at Brier Island, Digby County. Almost all that distance is across the open water of the Gulf of Maine and Maleberry has no obvious means of frequent long-distance dispersal (see **Dispersal and Migration**).

THREATS AND LIMITING FACTORS

Threats

Threats to Maleberry in Nova Scotia are limited because the only known occurrence is within an area owned by the Nova Scotia Nature Trust. Unauthorized use of off-road vehicles and potential associated brush clearing could affect a few individuals along the population margin but are unlikely to affect a large proportion of the whole Canadian population. The only potential significant threat is competitive exclusion from the invasive shrub Glossy Buckthorn which is known 45 km away and probably occurs closer than that. Expansion of Glossy Buckthorn into the Maleberry occurrence is likely over one to several generations but could be readily managed at the small known Maleberry occurrence. Climate change is not considered in this assessment as a threat because there is no obvious mechanism under which anticipated future climate would make conditions less

suitable for Maleberry in southern Nova Scotia. Effects of an altered future climate are, however, uncertain and not necessarily predictable based solely on anticipated rising temperatures.

Threats to Maleberry assessed in this report are organized and evaluated based on the International Union for Conservation of Nature - Conservation Measures Partnership (IUCN-CMP) unified threats classification system (IUCN 2017). Threats are defined as the proximate activities or processes that directly and negatively affect the Maleberry population and are outlined below in general order of highest to lowest impact. Results on the impact, scope, severity, and timing of threats are presented in tabular form in Appendix 1. The overall calculated and assigned threat impact is Low for Maleberry.

Unauthorized Off-road Vehicle Use and Trail Expansion (IUCN Threat 6.1 Recreational Activities) (Low impact)

One Maleberry clump has established at the edge of an old roadbed used occasionally by off-road vehicles and is at high risk of being affected by illegal brush clearing on the existing trail or being directly driven over. Other Maleberry plants are at low risk from off-road vehicles.

Figure 6. Off-road vehicle trail showing evidence of moderate use in 2011, at the edge of the Maleberry population at the Jack and Darlene Stone Conservation Lands, Long Lake, Nova Scotia. Occasional unauthorized use continues to the present. The small shrub in the foreground on the right is the Maleberry individual most likely to be affected by off-road vehicle damage or unauthorized trail maintenance.

Off-road vehicles are not permitted within the Jack and Darlene Stone Conservation Lands. The main access point into the property's old logging and off-road vehicle trail network is posted against vehicle use and roped off but off-road vehicles regularly go under the rope onto the western branch of the trail, causing extensive rutting and puddling (Belliveau pers. obs. 2011-2019). The eastern branch of this trail extends along the upland margin of the Long Lake Maleberry population (Figure 6) and seems to end 1.2 km northward at the rapids on the Tusket River between Wilsons Lake and Bennetts Lake (Google Earth 2019; 2018 imagery). As of April 2019, use has become infrequent and a large fallen tree, likely in place for about a year, blocks further progress about 100 m beyond the Maleberry (Belliveau pers. obs. 2011-2019). At the Maleberry site, this trail was well-constructed by heavy equipment, having been slightly ditched and raised 20-30 cm above the level of the adjacent swamp. It could easily be re-opened by a determined rider with a chainsaw. Because the roadbed has been raised above the swamp, it is unlikely that the trail locality would be changed so that it went further into the occupied area and affected more individuals. New trails through the Maleberry to access the lakeshore are unlikely as there is already trail access to the lake elsewhere.

Glossy Buckthorn (IUCN Threat 8.1 Invasive Non-native Species) (Low impact)

The exotic shrub Glossy Buckthorn is one of the most problematic invasive plant species in Canada and the northeast U.S. (Catling and Porebski 1994; Frappier *et al.* 2003a,b; Catling and Mitrow 2012; IPANE 2019). Peaty open wetlands and swamps, especially riparian swamps, have a well documented susceptibility to Glossy Buckthorn invasions that create a dense canopy or subcanopy layer (Reinartz and Kline 1998; Catling and Mitrow 2012; Fiedler and Landis 2012), which has been shown to significantly inhibit woody seedling growth (Hamelin *et al*. 2016).

Glossy Buckthorn is unusual among invasive species in Nova Scotia because although it thrives in disturbed sites, it also readily colonizes completely undisturbed sites well away from human settlement (AC CDC 2019) via bird dispersal. In the acidic wetlands in which it occurs in southern Nova Scotia, it is generally the only non-native species present (Hill and Blaney 2009; Blaney pers. obs. 1999-2019). In southern Nova Scotia along the Medway, Mersey, and Pleasant rivers in Queens and Lunenburg counties (75 km northeast of Long Lake), riparian floodplain habitats dominated by Red Maple are especially susceptible to Glossy Buckthorn invasion (Blaney pers. obs. 1999-2019; Hill and Blaney 2009; AC CDC 2019).

In southern Nova Scotia there are major epicentres of Glossy Buckthorn invasion around the towns of Digby (70 km north of Long Lake) and Caledonia (75 km northeast) and a newer, smaller invasion at Barrington (45 km southeast). There are likely other undetected occurrences closer to Long Lake. The similarity of the Long Lake Maleberry site to invaded sites elsewhere in southern Nova Scotia strongly suggests it would be susceptible to Glossy Buckthorn invasion. Rate of spread from earliest detection over about 40 years in Ontario was roughly 1 km per year, but rate of spread was suggested to have accelerated significantly 50 years later as populations increased (Catling and Porebski 1994). It thus seems likely that Glossy Buckthorn will reach Nova Scotia's Maleberry within

one to three generations (roughly 20 to 60 years) and could start having impacts within one to four generations (20 to 80 years). It is unlikely to quickly eliminate Maleberry but could reduce seedling establishment and growth and health of individuals, increase mortality and ultimately reduce population. The maximum height of Glossy Buckthorn (6-8 m; Gucker 2008 and references therein) exceeds that of Maleberry (4 m), so over time all Maleberry individuals could be susceptible to increased shading if no management action took place. It is important to note, however, that the very small size of the known Maleberry occurrence in Nova Scotia would make management of Glossy Buckthorn by manual removal quite feasible with less than one person-day of labour per year. Glossy Buckthorn is a greater threat to theoretical undocumented occurrences elsewhere in southern Nova Scotia.

Limiting Factors

Invertebrate herbivores are likely limiting for Maleberry to some degree but are not documented in Canada and are not discussed here.

Limited Dispersal

Apparently suitable but unoccupied wetland habitats are widespread in southern Nova Scotia and more broadly in the Maritimes, southern Ontario and southern Quebec. These habitats fall within climate zones that are occupied by Maleberry in the United States. The general absence of Maleberry in Canada must be a consequence of: a) a rate of dispersal inadequate to have reached all suitable Canadian habitat following the last glacial maximum, b) a cryptic abiotic or biotic limitation, or c) some combination thereof.

Aside from its position in southernmost Nova Scotia in an especially mild climate zone (Climate Zone 6b; McKenney *et al*. 2014), there is nothing obviously unusual about the Long Lake location occupied by Maleberry, and there is extensive unoccupied and apparently similar habitat within the same climate zone in Nova Scotia. A dispersal limitation would thus seem to be the simplest explanation for its widespread absence in Canada.

If, however, a climate-related factor was limiting Maleberry to its especially warm region in southernmost Nova Scotia, reaching that area could present an especially significant barrier because it is separated from continuously occupied areas of Maine by at least 200 km across the open waters of the Gulf of Maine, or by an overland migration route of about 800 km around the Bay of Fundy through colder climate zones and back south to southern Nova Scotia.

Native Pathogens

Maleberry leaves in Nova Scotia are often extensively spotted with a tar spot fungus (Figure 5), probably *Rhytisma decolorans*, a native species that occurs only on Maleberry and close relatives (Farr and Rossman 2019), This tar spot has been observed in all years in which the Long Lake site was visited (Blaney pers. obs. 2011; Belliveau pers. obs. 2011-2019). Studies on other tar spot fungi have demonstrated significant effects on the host

species. Maple Tar Spot fungus (*Rhytisma acerinum*) significantly decreased mature Norway Maple (*Acer platanoides*) trees' growth rate and increased the mortality of seedlings following its arrival in Quebec (Lapointe and Brisson 2010). *Rhytisma polare* reduced carbon in infected leaves by 118% versus healthy leaves in Polar Willow (*Salix polaris*), primarily due to pathogen carbon consumption (Masumoto *et al*. 2018). The tar spot of Maleberry could thus reduce productivity and health in the Nova Scotia population but there is no evidence to suggest its rate of occurrence in Nova Scotia is affected by anthropogenic factors. It may, however, occur at a higher rate in Canada than is typical in the United States. Examination of 120+ online photographs of *in situ* plants or herbarium specimens of American populations showed only five clearly having the tar spot fungus, whereas it seems to be on most or all Maleberry individuals in the Canadian population.

Climate

As noted under **Search Effort**, climate does not appear to be directly limiting for Maleberry in Canada because much of the Maritimes and parts of southern Ontario and Quebec fall into the plant hardiness zones (defined primarily by minimum annual temperatures) that are occupied by Maleberry in the northern United States (McKenney *et al*. 2014; USDA-ARS 2012). Maleberry's restriction to the warmest part of the Maritimes in southern Nova Scotia could be a consequence of some climate-related limitation aside from minimum winter temperatures, but it could also be explained by a chance dispersal event to the region nearest to the United States Maleberry population, and inadequate time or dispersal ability to colonize other parts of Nova Scotia.

Seedling Establishment

Aside from some isolated clumps likely to have been derived from seed, most stems in the Nova Scotia population appear to have arisen via rhizomes. Maleberry's limitation to a single known site in Nova Scotia would be consistent with a difficulty in establishing from seed, but it is unclear how rare and limiting seedling establishment might be. Given that distance between shoots along a rhizome can be as much as 4 m (Laycock 1967 in Carey 1994), the observed area of occupancy at Long Lake could be derived from only one or a few seedling establishment events.

Browsing by Mammals

White-tailed Deer and Snowshoe Hare browsing of Maleberry were both observed in 2019 and deer and hare scat piles were relatively abundant (Belliveau pers. obs. 2011-2019). They may limit the population somewhat but do not appear to be a threat.

Maleberry is noted as being a less-preferred browse species, especially for deer (see **Interspecific Interactions**). White-tailed Deer are common in southwestern Nova Scotia but are not at the hyper-abundant levels shown to have major impacts on forest understory biodiversity in parts of the northeastern United States (Carson *et al*. 2014; Habeck and Schultz 2015), Alternate browse is common to abundant within 1 km of the Maleberry occurrence, and deer browse intensity appeared higher on other species at Long Lake than

on Maleberry (Belliveau pers. obs. 2011-2019). Snowshoe Hare browsing impacts were noted as the cause of a high proportion of the observed stem deaths at Long Lake (estimated 40 dead stems out of 820 total; Belliveau pers. obs. 2011-2019). This level of browsing seems unlikely to be problematic for a long-lived and highly rhizomatous shrub.

Number of Locations

The known Canadian population of Maleberry could represent a single location because it occupies a very small area under a single owner (Nova Scotia Nature Trust) and that area has relatively uniform habitat conditions and potential threats. It is also possible that threats are too insignificant in scope or immediacy for the concept of “locations” to be applied.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Maleberry currently has no legal status in any jurisdiction of occurrence. Ohio (SH) and Vermont (S3S4) are the only jurisdictions aside from Nova Scotia in which ranks indicate some level of concern, but plant species are not listed under Ohio endangered species legislation (Ohio Revised Code 1531.25, Ohio Department of Natural Resources 2018), and Maleberry is not listed under Vermont’s Endangered Species Law (10 V.S.A. Chap. 123; Vermont Natural Heritage Inventory 2015).

Non-Legal Status and Ranks

Maleberry has a global status of Secure (G5) and is Secure (S5) in New York, Virginia, Kentucky, and North Carolina, Apparently Secure (S4) in West Virginia and Delaware, Vulnerable to Apparently Secure (S3S4) in Vermont and Possibly Extirpated (SH) in Ohio (NatureServe 2019; equating to “Presumed Extirpated” – not seen in last 20 years on Ohio’s official list of rare plants, Gardner pers. comm. 2020). In all other United States jurisdictions in which it occurs it is Not Ranked (SNR). Based on the number of counties in which it is present in each state (Kartesz 2015), this likely means it is considered secure in those states.

Habitat Protection and Ownership

The only Canadian occurrence of Maleberry is on the Jack and Darlene Stone Conservation Lands owned by the Nova Scotia Nature Trust and managed to maintain its status as an IUCN Class 1b Wilderness Area, a category defined as “unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition” (Dudley 2008). The land has no regulatory protection under provincial law.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

This report was greatly enhanced by the individuals documented below who shared their knowledge and information. The report writers sincerely thank all contributors. Production of the report was funded by the Nova Scotia Species at Risk Conservation Program.

Authorities Consulted

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Alain Belliveau is the Irving Biodiversity Collections Manager at the E.C. Smith Herbarium, K.C. Irving Environmental Science Centre for Biodiversity at Acadia University in Wolfville, NS. He manages the E.C. Smith Herbarium, the largest collection of vascular plant specimens in Atlantic Canada. He has collected and contributed records for tens of thousands of vascular plant and lichen occurrences in Atlantic Canada. He's a member of several species' recovery teams, including the Black Ash Recovery Team and the Atlantic Coastal Plain Flora Recovery Team for Nova Scotia. He has or is currently in the process of writing or co-writing several COSEWIC and provincial status reports. Prior to employment at Acadia University, Alain received a Master of Resource and Environmental Management, and worked for several years as a botanist for both the Atlantic Canada Conservation Data Centre and the Mersey Tobeatic Research Institute.

COLLECTIONS EXAMINED

All Canadian specimens of Maleberry were already documented in AC CDC (2019), so no further examination of specimens was undertaken for this report.

Appendix 1. IUCN Threats assessment on Maleberry.

Species or Ecosystem Scientific Name	Maleberry (*Lyonia ligustrina*)			
Element ID	127927		**Elcode**	PDERI0R030
Date:	11/09/2019			
Assessor(s):	Blaney, C.S.			
References:	COSEWIC. 2019 (in review). COSEWIC assessment and status report on the Maleberry Lyonia ligustrina in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.			
	Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	0	0
	C	Medium	0	0
	D	Low	2	2
	Calculated Overall Threat Impact:		Low	Low
	Assigned Overall Threat Impact:		**D = Low**	
	Impact Adjustment Reasons:			
	Overall Threat Comments			

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development						No threat to single known population because it is within a Nova Scotia Nature Trust protected area. Could be a threat to other undiscovered sites.
1.1	Housing & urban areas						
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas						
2	Agriculture & aquaculture						No threat to single known population because it is within a Nova Scotia Nature Trust protected area. Could be a threat to other undiscovered sites.
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3	Energy production & mining						No threat to single known population because it is within a Nova Scotia Nature Trust protected area. Could be a threat to other undiscovered sites.
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						
4	Transportation & service corridors						No threat to single known population because it is within a Nova Scotia Nature Trust protected area. Could be a threat to other undiscovered sites.
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance	D	Low	Small (1-10%)	Extreme - Moderate (11-100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
6.1	Recreational activities	D	Low	Small (1-10%)	Extreme - Moderate (11-100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	One isolated clump is immediately adjacent to old logging road used in the recent past by unauthorized off-road vehicles. This clump potentially represents as much as 3% of the Canadian population of 33 clumps / patches; but note that there is uncertainty around how mature individuals should be counted and this could represent less than 1% of the Canadian population. Recent ATV use appears limited due to downed trees. Future unauthorized trail clearing could affect this individual but is unlikely to affect others. The individual could be killed but is more likely to be cut off at the base and then resprout. This makes "Severity" hard to classify - could be limited, could be 100%.
6.2	War, civil unrest & military exercises						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.3	Work & other activities						
7	Natural system modifications						
7.1	Fire & fire suppression						
7.2	Dams & water management/use						
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes	D	Low	Small (1-10%)	Moderate – Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
8.1	Invasive non-native/alien species/diseases	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, <10 yrs/3 gen)	Invasive Glossy Buckthorn (*Frangula alnus*) is likely to arrive in the occupied area within the next 3 generations and could ultimately have negative effects through competition because its maximum height is taller than that of Maleberry and it can produce dense seedlings. This will be a slow acting threat and could be readily managed within the single small area of occurrence by manual removal.
8.2	Problematic native species/diseases		Unknown	Pervasive - Large (31-100%)	Unknown	High (Continuing)	A tar spot fungus (likely *Rhytisma decolorans*, a species specific to Maleberry and its relatives) is widely present on leaves, but is presumed to be native and is not known to be significantly affecting Maleberry. This is classified in the status report as a limiting factor rather than a threat.
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution						
9.1	Domestic & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather						
11.1	Habitat shifting & alteration						
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						
11.5	Other impacts						
Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).							