COSEWIC
Assessment and Status Report

on the

Eastern False Rue-anemone
Enemion biternatum

in Canada

SPECIAL CONCERN
2022

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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Previous report(s):

COSEWIC 2005. COSEWIC assessment and update status report on the false rue-anemone *Enemion biternatum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 19 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

Austen, M.J.W. 1990. COSEWIC status report on the false rue-anemone *Isopyrum biternatum* in Canada.Committee on the Status of Endangered Wildlife in Canada. Ottawa. 32 pp.

Production note:
COSEWIC would like to acknowledge Audrey Heagy for writing the status report on Eastern False Rue-anemone (*Enemion biternatum*), in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Bruce Bennett, Co-chair of the COSEWIC Vascular Plant Specialist Subcommittee.

For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment and Climate Change Canada
Ottawa, ON
K1A 0H3

Tel.: 819-938-4125
Fax: 819-938-3984
E-mail: ec.cosepac-cosewic.ec@canada.ca
www.cosewic.ca

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Eastern False Rue-anemone — Photograph by William van Hemessen.

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COSEWIC
Assessment Summary

Assessment Summary – May 2022

Common name
Eastern False Rue-anemone

Scientific name
Enemion biternatum

Status
Special Concern

Reason for designation
This perennial forest herb is at the northern edge of its range and in Canada is restricted to a few fragmented riverside sites in southwestern Ontario. It occurs in six subpopulations that are at risk of decline in area and quality of habitat resulting from various activities, including recreational trail use and expansion of exotic invasive plants.

Since the previous assessment, COSEWIC has changed its interpretation and application of the terms ‘severe fragmentation’ and ‘area of occupancy’ to better align with IUCN assessment criteria and the species exceeds criteria thresholds as now applied.

Occurrence
Ontario

Status history
Designated Special Concern in April 1990. Status re-examined and designated Threatened in May 2005. Status re-examined and designated Special Concern May 2022.

COSEWIC
Executive Summary

Eastern False Rue-anemone
Enemion biternatum

Wildlife Species Description and Significance

Eastern False Rue-anemone (*Enemion biternatum*) is a delicate spring-flowering perennial herb that grows to 10-40 cm in height. The flowers are 1.5-2 cm wide with five white petal-like sepals surrounding a cluster of stamens with yellow anthers.

The Canadian population of Eastern False Rue-anemone is restricted to the Carolinian Zone in southwestern Ontario, where it is part of a nationally significant suite of species of conservation concern at the northern edge of their range.

Aboriginal (Indigenous) Knowledge

All species are significant and are interconnected and interrelated. There is no species-specific ATK in the report.

Distribution

Eastern False Rue-anemone occurs in the United States and Canada. This species is considered common throughout most of its range from the Great Lakes south to Oklahoma, Arkansas, and Tennessee west of the Appalachians. It is rare on the periphery of this range and possibly extirpated from New York and South Dakota. In Canada, Eastern False Rue-anemone occurs locally in southwestern Ontario, which represents less than 1% of its global range. There are six documented extant subpopulations.

Habitat

This woodland perennial herb grows in moist deciduous woodlands and thickets, often on river floodplain terraces and valley slopes, and sometimes on tablelands. Canadian subpopulations are generally found in hardwood Carolinian forests, often dominated by Sugar Maple in combination with various other species.

Biology

In Canada, Eastern False Rue-anemone flowers from April to May and bears fruit in May to June. Insects are the main pollinators. The seeds germinate in the autumn. Eastern False Rue-anemone is a perennial with considerable vegetative propagation. Specific

information on the age of first flowering, longevity or average age of mature individuals in the population is not available. First flowering of individuals developed from seed or vegetative propagules likely requires several years.

Population Sizes and Trends

The Eastern False Rue-anemone population in Canada was previously estimated at one million stems and considered stable. This population is distributed across several subpopulations and numerous sites, although the vast majority of plants are concentrated at just two sites, representing two subpopulations. The current population size is considered similar to previous estimates, due in part to increased survey effort. Declines have occurred or are inferred to have occurred at a few sites including a large decline (approximately 70%) in the estimated number of stems at the largest reported patch.

Threats and Limiting Factors

Competition from invasive non-native plants is considered the primary threat to this species in Canada. High densities of White-tailed Deer may be reducing plant vigour. Recreational trails are present close to Eastern False Rue-anemone plants at many sites and may result in localized trampling and soil compaction. Many of the subpopulations are in or near expanding urban areas and recreational pressures are expected to increase.

Important limiting factors for this species include its limited dispersal capability, low rate of visitation by pollinators, and self-compatibility which can lead to inbreeding depression or reduced reproductive success, particularly in small subpopulations in fragmented habitat.

Protection, Status and Ranks

Eastern False Rue-anemone is listed as Threatened under the *Species at Risk Act* in Canada and under the *Endangered Species Act, 2007* in Ontario. A federal Recovery Strategy that identifies Critical Habitat was prepared in 2017. Ontario has adopted the federal Recovery Strategy and prepared a response statement outlining the provincial government's intended actions and priorities. The plant and its general habitat are afforded protection under the provincial *Endangered Species Act, 2007.* Many extant subpopulations occur on private lands. Several sites with significant numbers of plants are within municipality-owned lands and conservation areas that are managed for conservation purposes. None of the known occurrences are on federal lands.

This species has a NatureServe conservation rank of Globally Secure (G5), although the status has not been reviewed since 1984. It is ranked Imperilled in Ontario (S2) and Canada (N2). The species is also of conservation concern in nine jurisdictions on the periphery of its range in the United States.

Approximately half of the known Canadian population of this species is on publicly owned lands.

TECHNICAL SUMMARY

Enemion biternatum

Eastern False Rue-anemone

Isopyre à feuilles biternées

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

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)	Unknown, estimated as 3 to 10 yrs.
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, whichever is longer up to a maximum of 100 years].	Not applicable
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. n/a b. n/a c. n/a
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	1155 km² for extant sites; 2917 km² if extant and historical sites are included
Index of area of occupancy (IAO) (Always report 2x2 grid value).	72 km² for extant sites only; 84 km² for all known extant and historical sites.

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. No Connectivity is present among sites in the larger subpopulations (SPs 1, 2, 4, 6) but species unlikely to disperse between watersheds.
Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	More than 10 locations (15-23) 23 locations (sites) have been confirmed extant within past 10 years.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No; Extent of occurrence stable.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, inferred. Inferred decline of 12 km^2 since 1981 (8 km^2 in past 30 years) related to four presumed extirpated sites.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes, inferred. Inferred decline related to one presumed extirpated subpopulation (since 1994).
Is there an [observed, inferred, or projected] decline in number of “locations”*?	Yes, inferred. Inferred decline related to four presumed extirpated sites.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred Habitat quality inferred to be declining due to proliferation of invasive non-native plants and increasing recreational pressures.
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**
1 Lower Kettle Creek	200,000-250,000 stems
2 Medway Valley London	200,000 stems
3 Parkhill (Mud) Creek	66,000 stems
4 Ausable River Valley	50,000-150,000 stems
5 Thames Riverbend London	0

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

6 Dodd Creek	5000-10,000 stems
7 Lynn Valley	Unknown
8 East of Arva	1750 stems
9 Medway North of Arva	Unknown
Total	525,000-675,000 stems (likely >100,000 ramets)

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	Unknown, Population Viability Analysis (PVA) not available.

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

Was a threats calculator completed for this species? Yes. Assigned overall threat impact Low.

i. 8.1 Invasive Non-Native Species (Low Impact)
ii. 8.2 Problematic Native Species (Low Impact)
iii. 6.1 Recreational Activities (Low Impact)

What additional limiting factors are relevant?
Low dispersal capability, low rate of visitation by pollinators, and self-compatibility which can lead to inbreeding depression.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Unknown Status of Michigan and Ohio populations not ranked. New York population is considered extirpated
Is immigration known or possible?	Unknown, considered unlikely
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Unknown, likely. Habitat modelling for this species predicted additional areas of potential habitat
Are conditions deteriorating in Canada?[+]	Unknown, but likely deteriorating
Are conditions for the source (i.e., outside) population deteriorating?[+]	Unknown
Is the Canadian population considered to be a sink?[+]	Unknown, small subpopulations may be sinks
Is rescue from outside populations likely?	No. Unlikely due to lack of specialized means of dispersal

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

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Special Concern in April 1990. Status re-examined and designated Threatened in May 2005. Status re-examined and designated Special Concern May 2022.

Status and Reasons for Designation

Status:	**Alpha-numeric codes:**
Special Concern	Not applicable

Reasons for Designation:
This perennial forest herb is at the northern edge of its range and in Canada is restricted to a few fragmented riverside sites in southwestern Ontario. It occurs in six subpopulations that are at risk of decline in area and quality of habitat resulting from various activities, including recreational trail use and expansion of exotic invasive plants.

Since the previous assessment, COSEWIC has changed its interpretation and application of the terms ‘severe fragmentation’ and ‘area of occupancy’ to better align with IUCN assessment criteria and the species exceeds criteria thresholds as now applied.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Declines have occurred or are inferred to have occurred at a few sites but are not believed to meet thresholds.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Although the EOO of 1155 km^2 and IAO of 74 km^2 are both below the thresholds for Endangered, the species is found at more than ten locations, the population is not severely fragmented, and does not undergo extreme fluctuations; however, the area of occupancy, habitat quality, and the number of subpopulations and possibly the number of mature individuals have declined.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Population estimate of mature individuals exceeds thresholds.
Criterion D (Very Small or Restricted Population): Not applicable. Population estimate of mature individuals exceeds thresholds, and the population is not considered vulnerable to rapid and substantial decline.
Criterion E (Quantitative Analysis): Not applicable. Analysis not conducted.

PREFACE

Since the last COSEWIC assessment of this species, the accepted English common name has been updated to “Eastern False Rue-anemone” to distinguish it from its congeners in western North America (Brouillet *et al*. 2022).

The status of several subpopulations has changed since the previous status reports (Austen 1990; COSEWIC 2005) as a result of a detailed review of all known Eastern False Rue-anemone occurrences by the Natural Heritage Information Centre (NHIC) (ECCC 2017) and targeted field surveys at known sites in 2021. Of the six extant subpopulations summarized in the 2005 report, four (SPs 1, 2, 3 and 4) are still extant, one (EOID#17 in COSEWIC 2005) is now considered to be part of the main Kettle Creek subpopulation (SP#1), and one (SP#5) is considered extirpated (no plants found during 2021 fieldwork). Of two subpopulations considered extirpated in the 2005 status report (COSEWIC 2005), one (SP#6) was verified as extant in 2016 and 2021, and the other (SP#7) was re-classified by NHIC as historical based on the availability of suitable habitat even though the species has not been reported from this area since 1897. The NHIC review also identified two other historical subpopulations (SP# 8 and #9), each based on a single record from 1994 general vegetation surveys, that had been overlooked in the previous report. One of these historical subpopulations (#8) was confirmed extant in 2021 while the other was not included in the 2021 surveys and is still considered historical.

COSEWIC made changes to definitions and the application of the terms ‘severe fragmentation’, ‘location’, and ‘area of occupancy’ in 2011 and 2014 to be more consistent with the application of IUCN criteria. As such, the species would have exceeded thresholds under the B and D2 criteria as they are currently applied..

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 (2022)

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
Environnement et Changement climatique Canada
Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment and Climate Change 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: *Enemion biternatum* Raf.

Synonyms: *Isopyrum biternatum* (Raf.) Torr. & Gray

Common names:

English: Eastern False Rue-anemone, False Rue-anemone, False Meadow-rue

French: Isopyre à feuilles biternées, Isopyre faux-pigamon

Family name: Ranunculaceae (Buttercup family)

Major plant group: Angiosperm (eudicot flowering plant)

No infraspecific taxa are recognized.

Description of Wildlife Species

Eastern False Rue-anemone is a delicate spring-flowering perennial herb that grows to 10-40 cm in height (cover page). Leaves typically have a biternate structure, with each leaf divided into three segments, each of which is divided into three leaflets. The smooth reddish stems originate from tough fibrous roots which are weakly rhizomatous. The shallow roots are swollen at intervals to form tiny tubers (Wherry 1948). The plant often occurs as dense colonies (Figure 1).

Eastern False Rue-anemone flowers lack true petals but have five white, obovate, petal-like sepals, surrounding a cluster of stamens with yellow anthers. Stems may divide into two or more branches, each with a single flower that is 1.5-2 cm wide. The petal-like sepals are 4-10 mm long and 3-8 mm wide. Follicles are divergent, glabrous and somewhat compressed (Mitchell and Dean 1982). Seeds are smooth (Ford 1997) with no adaptations to assist in dispersal.

Figure 1. Dense patch of flowering Eastern False Rue-anemone on field edge near Kettle Creek (site #1.4) (photo credit A. Heagy, used with permission).

The flower and leaf structure of Eastern False Rue-anemone are superficially similar to Rue-anemone (*Thalictrum thalictroides*), another spring-flowering woodland wildflower native to eastern North America. In Ontario, Rue-anemone generally occurs in drier woodlands and is more common under oaks (*Quercus* spp.) than maples (*Acer* spp.) (NHIC 2002). Features that distinguish Eastern False Rue-anemone from Rue-anemone include alternate deeply lobed leaves versus opposite or whorled crenate leaves, presence of a minute apiculum (short abrupt flexible point) at the leaf apex versus a notched apex, and few-seeded follicles versus single-seeded achenes (Austen 1991; Ford 1997). The vegetative characteristics of Eastern False Rue-anemone are similar to meadow-rues (*Thalictrum* spp.), particularly Early Meadow-rue (*Thalictrum dioicum*), which is also a spring woodland ephemeral, but Eastern False Rue-anemone has a reddish stem and more deeply lobed leaflets.

Population Spatial Structure and Variability

No genetic studies on Canadian occurrences of this species have been done.

The Canadian population includes at least 33 known sites[1] comprising nine subpopulations. For Eastern False Rue-anemone, the COSEWIC definition of subpopulation is consistent with the NatureServe habitat-based plant element occurrence (EO) delimitation guideline, where occurrences (sites) are grouped as an EO if separated by less than 1 km, or if separated by 1 to 3 km where no gaps in suitable habitat exceed 1 km, or they are connected by a riparian system and separated by no more than 10 km, provided no gaps in suitable habitat exceed 3 km (NatureServe 2020).

Five of the nine subpopulations are limited to a single site each. Each of the other four subpopulations comprises multiple sites connected by suitable habitat and waterflow along a river valley system, which function as a metapopulation (NatureServe 2020). Gene flow between subpopulations through pollen transfer by insect or wind is very unlikely given the distances involved. Water dispersal of propagules to downstream subpopulations in the same watershed is possible but considered unlikely due to the distances involved.

Known subpopulations in southwestern Ontario are separated by least 100 km (and major rivers or lakes) from the nearest extant subpopulations in the United States which are in southeastern Michigan (Bassett pers. comm. 2021) and northwestern Ohio.

Designatable Units

The Canadian population of Eastern False Rue-anemone represents a single designatable unit (DU) within the Great Lakes Plain Ecological Area (COSEWIC 2018). All subpopulations occur in southwestern Ontario. There is no genetic or morphological evidence to support further segregating subpopulations of this species in distinct DUs.

Special Significance

Eastern False Rue-anemone is the only member of the genus present in central and eastern North America. The four other species of *Enemion* are localized endemics of western North America. The only other species found in Canada is the Queen Charlotte Islands False Rue-anemone (*E. savilei*), endemic to the coast of British Columbia (Ford 1997).

[1] The use of the term “site” in this report differs from the previous status reports. A site refers to a discrete area of potential habitat supporting one to many known patches. Sites are generally separated by more than 1 km. Where habitat is continuous along river systems, sites were sometimes delineated based on road crossings, with all occurrences on a given bank of the stream between those road crossings being considered a single “site”. In previous reports (Austen 1990; COSEWIC 2005) some patches separated by as little as 300 m were considered separate sites. This resulted in some ambiguity due to the spatial uncertainty of the previous records. Some sites in this report encompass as many as four sites as previously defined. The term subsite is used to refer to these former sites and other occurrences within a site that are separated by at least 100 m. While most sites do not extend into more than one land tenure parcel, a few span into several adjacent properties. Some large land tenure parcels (e.g., Medway Valley Heritage Forest) encompass multiple sites.

The Canadian population of Eastern False Rue-anemone is entirely restricted to the Carolinian Zone, where it is part of a nationally significant suite of species of conservation concern at the northern edge of their range (Theberge 1989; Oldham 2017). At some sites, this species co-occurs with other plant species of national and provincial conservation concern, such as American Gromwell (*Lithospermum latifolium*), Virginia Bluebells (*Mertensia virginica*), and species at risk including Green Dragon (*Arisaema dracontium*).

There is no information regarding any special economic or biological significance of this species. The species is promoted by gardeners in the United States as a suitable plant for shady woodland gardens (e.g., TNGA 2021).

ABORIGINAL (INDIGENOUS) KNOWLEDGE

Aboriginal Traditional Knowledge (ATK) is relationship-based. It involves information on ecological relationships between humans and their environment, including characteristics of species, habitats, and locations. Laws and protocols for human relationships with the environment are passed on through teachings and stories, and Indigenous languages, and can be based on long-term observations. Place names provide information about harvesting areas, ecological processes, spiritual significance or the products of harvest. ATK can identify life history characteristics of a species or distinct differences between similar species.

Cultural Significance to Indigenous Peoples

This species is culturally significant to Indigenous peoples who hold detailed knowledge on the evolving, dynamic nature of the species. There is no species-specific ATK in the report. However, Eastern False Rue-anemone is important to Indigenous peoples who recognize the interrelationships of all species within the ecosystem.

DISTRIBUTION

Global Range

Eastern False Rue-anemone occurs in Canada and the United States (Figure 2). This species is considered common throughout its main range. It is rare in several jurisdictions on the periphery of its range including the province of Ontario (Oldham 2017) and the states of Texas, Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina, Virginia, and West Virginia (Kartesz 2021; NatureServe 2021). Outlying populations of this species in New York and South Dakota are presumed and possibly extirpated (NatureServe 2021; Young pers. comm. 2021). Occurrences in Pennsylvania, Maryland, and Massachusetts are considered escapes from cultivation (Frye pers. comm. 2021; Grund pers. comm. 2021; Kartesz 2021; Wernerehl pers. comm. 2021; Woods pers. comm. 2021). Eastern False Rue-anemone is recorded infrequently east of the Appalachian Mountains (Boufford and Massey 1976).

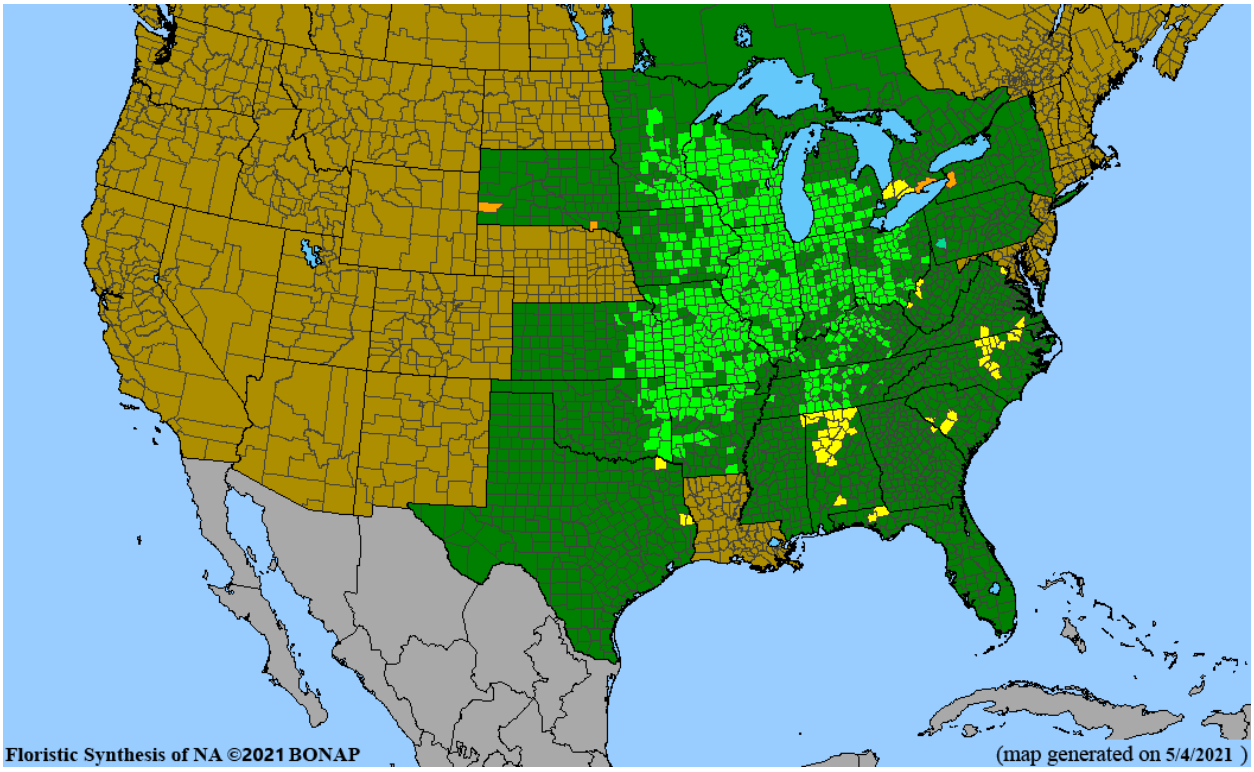

Figure 2. Global distribution of Eastern False Rue-anemone. Occupied lower-level jurisdictions (e.g., counties) where the species is not rare (light green), rare (yellow) or historic/extirpated (orange) are shown. Dark green indicates upper-level jurisdictions where the species is present. Map generated by Kartesz, J. 2021. Floristic Synthesis of North America, Version 1.0. and modified to show occupied lower-tier jurisdictions in Canada. Used with permission.

Canadian Range

In Canada, Eastern False Rue-anemone is known only from southwestern Ontario, where it occurs locally in Elgin, Middlesex, and Lambton counties, and was reported historically from Norfolk County (Macoun 1897) (Figure 2). The Canadian distribution of the species (Figure 3) is restricted to the Carolinian Zone (also known as the Deciduous Forest Region and the Lake Erie Lowland Ecoregion) and is near the northern limit of its global range. The Canadian range comprises less than 1% of the global range.

Eastern False Rue-anemone was first collected in Canada by J. Dearness in 1891 at two sites near Parkhill, Middlesex County, Ontario (NHIC 2020). Nine subpopulations have been documented of which six are extant (Figure 3, Table 1).

Table 1. Summary of known subpopulations of Eastern False Rue-anemone in Canada as of 2021 including year first observed, year last observed, year last searched, status, and additional notes.

SP#	Subpopulation (SP) Name, locale, County	EO ID[1]	First Obs	Last Obs	Last Search	Status	Notes on number of known sites, number of tetrads[2] and spatial extent
1	**Lower Kettle Creek**, between Port Stanley and St. Thomas, Elgin County	2522	1952	2021	2021	Extant	12 sites in 8 tetrads along ~10 km section of Kettle Creek valley.
2	**Medway Valley London**, within City of London, Middlesex County	2533	1958	2021	2021	Extant	8 sites in 3 tetrads along ~4 km section of lower Medway Valley plus adjacent site on Thames River.
3	**Parkhill (Mud) Creek**, near Parkhill, Middlesex County	2524	1891	2021	2021	Extant	2 sites in 2 tetrads along ~3 km section of Parkhill (Mud) Creek
4	**Ausable River Valley**, north of Arkona, Middlesex & Lambton Counties	2525	1958	2021	2021	Extant	6 sites in 6 tetrads along ~10 km stretch of the Ausable River.
5	**Thames Riverbend London**, within City of London, Middlesex County	13028	1994	1994	2021	Extirpated	1 site in 1 tetrad along Thames River.
6	**Dodd Creek**, west of St. Thomas, Elgin County	115666	1981	2021	2021	Extant	1 site in 1 tetrad along Dodd Creek (Kettle Creek tributary)
7	**Lynn Valley**, southeast of Simcoe, Norfolk County	95609	1897	1897	2021	Historical	1 general site in 1 tetrad near Lynn Creek
8	**Arva Moraine East**, east of Arva, Middlesex County	115681	1994	2021	2021	Extant	1 site in 1 tetrad, isolated forest patch not near a creek
9	**Medway Creek North**, north of Arva, Middlesex County	96274	1994	1994	1994	Historical	1 site in 1 tetrad along Medway Creek

[1] EO ID: NHIC Element Occurrence Identifier
[2] Tetrad is a 2 km x 2 km grid square, as used to calculate index of area of occupancy (IAO).

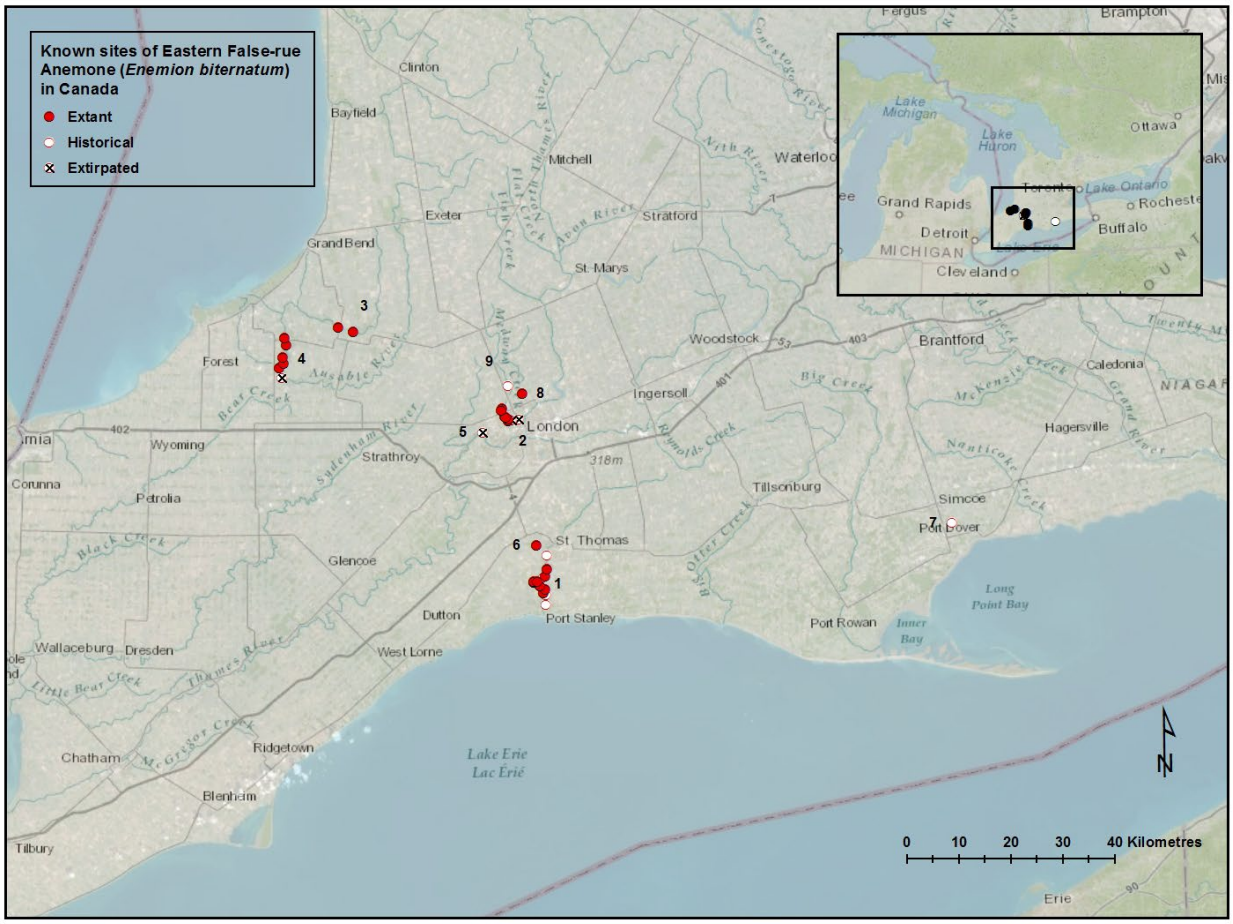

Figure 3. Distribution of Eastern False Rue-anemone in Canada. Numbers correspond to the subpopulation identifiers used in this report (see Table 1). Map produced by COSEWIC Secretariat for this report and used with permission.

Understanding of the number and status of several subpopulations has changed since the previous status reports (Austen 1990; COSEWIC 2005) as a result of a detailed review of all known Canadian occurrences conducted in 2016 by Ontario's Natural Heritage Information Centre (NHIC) (ECCC 2017) and additional fieldwork carried out since 2016. Of the six extant subpopulations summarized in the 2005 report, four (SP#s 1, 2, 3 and 4) are still extant, one (EO ID #17 in COSEWIC 2005) is now included within the Lower Kettle Creek subpopulation (SP#1), and one (SP#5) is presumed extirpated (not found at only reported site during recent targeted search). Of two subpopulations considered extirpated in the 2005 report, one (SP#6) was redetermined as extant in 2016. The other (SP#7) was re-classified by the NHIC as historical (equivalent to possibly extirpated) based on the availability of suitable habitat even though the species has not been reported from this area since 1897 and was not found during recent targeted searches (habitat only partially surveyed). Two subpopulations (SPs # 8 and #9) found in 1994 were overlooked in the previous report. SP#8 was confirmed extant in 2021 fieldwork. SP#9 has not been searched for since 1994 and is considered historical.

As of 2021, six subpopulations (SPs 1, 2, 3, 4, 6, and 8) are considered extant, two (SPs 7 and 9) are considered historical, and one (SP#5) is presumed extirpated. Although SP#7 (Lynn Valley) is considered historical based on the NHIC assessment, it could instead be considered as "unconfirmed", as the specimen collected in 1897 cannot be located and the collector had suggested that this was an introduced occurrence (NHIC 2020). This uncertainty does not affect the overall status assessment.

Four subpopulations (SPs 1, 2, 3, and 4) include multiple sites (Table 1, Appendix 1). Since 2005, several new occurrences within these subpopulations have been discovered including three sites along Lower Kettle Creek (SP#1) (McCune pers. comm. 2020), one site in the Medway Valley London (SP#2) (NHIC 2020), a second site along Parkhill (Mud) Creek, and three sites along the Ausable River Valley (SP#4) (Jean pers. comm. 2020; NHIC 2020).

Of the 33 known sites (Appendices 1, 2), four sites are considered extirpated, including the only known site in the Thames Riverbend London subpopulation (SP#5), two sites (#2.1 and #2.2) in the Medway Valley London (SP#2), and one site (#4.1) in the Ausable River Valley (SP#4). Three of these local extirpations occurred in the last 30 years (site #5.1 sometime between 1994 and 2021, sites #2.1 and #2.2 between 1989 and 2003). The fourth site (#4.1) was last reported in 1981 and not found during fieldwork in 1989 (Austen 1990). Six sites are considered historical.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) for all nine documented subpopulations (extant, historical and possibly extirpated) of Eastern False Rue-anemone in Canada is 2,917 km^2, calculated using a minimum convex polygon enclosing all known sites. The EOO of the 23 extant sites is 1,155 km^2. This difference in EOO is mostly related to the outlying Lynn Valley (SP#7) subpopulation which is possibly extirpated (considered historical by the NHIC but not observed since 1897).

The index of area of occupancy (IAO) is 72 km^2 based on the 23 extant sites (Appendix 1), 84 km^2 if the six historical sites are included, and 96 km^2 if all 33 known sites are included. The IAO of the subpopulations ranges from 4 km^2 (single tetrad) to 32 km^2 (Table 1). Different methods were used to calculate the area of occupancy in the 2005 status report.

Loss of the four extirpated sites does not affect the EOO but reduces the IAO by a total of 12 km^2 since 1981, including a decline of 8 km^2 in the past 30 years.

The Eastern False Rue-anemone population is not severely fragmented, as the majority of the area of occupancy is situated in relatively well-connected habitat along Lower Kettle Creek (SP#1), Medway Valley London (SP#2), and Ausable River Valley (SP#4) riparian corridors.

Search Effort

The Carolinian Zone in southwestern Ontario has been recognized as an area of exceptional floristic diversity, including many rare plant species, for more than a century (Oldham 2017). Due to the efforts of professional and amateur botanists and naturalists, the flora of this region is relatively well known.

Based on an evaluation of Ontario False Rue-anemone occurrences managed by the NHIC (2020), most records were made by local naturalists and biologists during general fieldwork or plant surveys during the spring flowering period (mid-April to mid-June). The ephemeral nature of the species' above-ground parts means that detection probability decreases rapidly in June. There are no records of observations after late June (NHIC 2020).

Prior to 1950, the species was collected at five "sites" (general locales with low spatial accuracy) across the current Canadian range, including two sites near Parkhill in 1891, near Lynn Valley southeast of Simcoe in 1897 (specimen missing), St. Thomas in 1907, and London in 1908 (NHIC 2020). One or more extant subpopulations are present in the vicinity of these historical general locales except for the Lynn Valley occurrence. The status of the Parkhill (Mud) Creek subpopulation (SP#3) was uncertain for more than century, until it was "re-discovered" at one site in 2002 (Bradley 2002) and at a second site in 2021 (McFarlane pers. comm. 2021).

For the currently known sites (Appendix 1), the first year of observation ranges from 1952 to 2021. Due to the spatial uncertainty of the pre-1950 records, they cannot be definitively matched with known sites. Appendices 1 and 2 include information on search effort for each site.

Extensive targeted searches have been carried out to inform the three COSEWIC status reports on Eastern False Rue-anemone in Canada (Austen 1990; COSEWIC 2005, this report), as summarized in Table 2. The 1989 search effort focused on searching suitable habitat in the vicinity of historical herbarium collections (Austen 1990). Fieldwork in 2003-2004 focused on 18 of 19 occurrences (subsites) documented in the 1990 status report, plus two additional sites found in 1992 and 1993. The 2021 search effort focused on known sites, prioritizing historical sites in subpopulations with limited information (e.g., SP#5, SP#8), sites with previous abundance estimates (i.e., occurrences included in the previous reports), and some recent sites lacking abundance information.

Table 2. Summary of targeted search effort at known Eastern False Rue-anemone sites (and subsites[2]) in Canada.

Year	Search effort	Surveyor	Subpopulations N=9	Number of known sites (subsites) searched N=33 (45)	Number of known sites (subsites) confirmed
1989	n/a	M.J.W. Austen	SPs #1, 2, 3, 4	Unknown	9 (15)
2003-2004	6 days	M.J. Thompson	SPs #1, 2, 4	14 (20)	8 (9)
2021	11 days (66 h)	A. Heagy	SPs #1, 2, 3, 4, 5, 6, 7, 8	22 (32)	18 (23)

The number of sites where the species was confirmed during the targeted search is also indicated in Table 2. During the 2003-2004 surveys, the species was confirmed at only 8 of 14 sites checked (9 of 20 subsites). In 2021, the species was confirmed at two of four sites (4 of 9 subsites) where it was not found in 2003-2004. The status of some sites where the species was not found is uncertain as small patches are difficult to relocate if accurate spatial information is not available.

The only known sites in SP#5, SP#8, and SP#9 were discovered during general botanical surveys conducted at 85 forest patches in the vicinity of the City of London in 1994 (Bowles *et al*. 1994).

Since 2005, localized targeted surveys for Eastern False Rue-anemone and other species at risk plants have been carried out in potential habitat and near known sites in the Medway Valley London (SP#2) (Dillon Consulting Limited 2021), Parkhill (Mud) Creek (SP#3) (Jean pers. comm. 2020), and Ausable River (SP#4) (Jean pers. comm. 2020; Koscinski pers. comm. 2020). Two subpopulations (SPs #6 and #7) that were presumed extirpated (COSEWIC 2005) were visited in 2016 by Oldham (five hours search effort), resulting in the re-discovery of one site (6.1) (NHIC 2020). Targeted searches of potential habitat for this species were conducted as part of a research project focused on developing and testing Species Distribution Models (SDMs) for rare woodland plants in southern Ontario (McCune 2016, pers. comm. 2020; McCune *et al*. 2020). An SDM was developed for this species using georeferenced data on known occurrences with high spatial accuracy (100 m or better) provided by the NHIC. The model was tested using independent presence/absence occurrence data collected during detailed surveys conducted in a total of 117 1-ha survey plots (McCune pers. comm. 2020). These surveys were completed between 2014 and 2018 during the time of year when Eastern False Rue-anemone would be identifiable (June 22 was used as the cut-off date for this species). Survey effort was 5 to 10 person-hours per plot.

Of the 54 plots predicted by the SDM to have suitable habitat, two (3.7%) had Eastern False Rue-anemone present and 52 (96.3%) did not. At a third site the species was found adjacent to the survey plot. The species was not found in any of the 63 survey plots where the SDM predicted that habitat was unsuitable for this species. The plots where the species was present were situated between 500 and 1000 m from the nearest known occurrence.

[2] Subsites refer to occurrences within a site that were previously treated as separate sites and/or more than 100 m apart.

Many areas of potential habitat have never been searched, including apparently suitable areas on privately owned lands in the vicinity of the known sites.

HABITAT

Habitat Requirements

Throughout its range, Eastern False Rue-anemone occurs in moist deciduous woods and thickets, often on rich wooded slopes in or adjacent to floodplains or along streams. Boufford and Massey (1976) reported Eastern False Rue-anemone growing in flat bottoms of alluvial woods behind natural levees in Virginia. A field study in Illinois found 50% and 74% of 147 clumps were located within 10 and 25 m of a stream, respectively (Melampy and Heyworth 1980). It is not usually found in open, highly disturbed sites, although it has been reported in open pastures in the United States (Ford 1997).

In Ontario, this species is closely associated with river valleys, often occurring locally on floodplain terraces (not subject to frequent flooding) or near the base of valley slopes. A notable exception is the Arva Moraine East subpopulation (SP#8), where the only known occurrence is on the edge of a small (10 ha) forest patch adjacent to agricultural fields in a tableland situation on a glacial moraine.

Across its range, this species is often associated with limey soils (Ford 1997). In Ontario, the species occurs in areas dominated by grey brown luvisolic soils rich in calcareous till derived from limestone and dolostone and lacustrine deposits (Hoffman 1989).

In Ontario this species typically is found in forested habitats, but some atypical occurrences are situated in hedgerows or open habitats along the disturbed margins of active agricultural fields (Figure 1) or in early successional shrub thicket or woodland habitats on river bottomlands that were formerly used to pasture livestock.

Subpopulations in Ontario are generally associated with mixed hardwood Carolinian forests (Figure 4), often dominated by Sugar Maple (*Acer saccharum*) in combination with other species including Black Maple (*Acer nigrum*), Eastern Hop-hornbeam (*Ostrya virginiana*), American Beech (*Fagus grandifolia*), Bitternut Hickory (*Carya cordiformis*), American Basswood (*Tilia americana*), Black Walnut (*Juglans nigra*), Butternut (*Juglans cinerea*), and ashes (*Fraxinus* spp.). Eastern False Rue-anemone occurs with other spring perennial herbs including Bloodroot (*Sanguinaria canadensis*), trilliums (*Trillium* spp.), toothworts (*Cardamine* spp.), anemones (*Anemone* spp.), violets (*Viola* spp.), and trout lilies (*Erythronium* spp.) (Austen 1990).

Figure 4. Deciduous forest habitat at large Eastern False Rue-anemone patch (site #2.5) in Medway Valley Heritage Forest (photo credit A. Heagy, used with permission).

Habitat modelling work for this species in southwestern Ontario (McCune *et al*. 2020) found that of 14 environmental variables included in the SDM, the most important predictors were: soil texture, soil drainage, precipitation seasonality, slope, annual mean temperature, and total growing season precipitation. The model suggested that the more suitable habitat for Eastern False Rue-anemone was characterized by loam, clay or variable soil textures (variable textures are common in floodplains), lower precipitation seasonality, steeper slopes, higher annual mean temperature, and higher amounts of precipitation in the growing season. The SDM output indicated areas of predicted habitat, with similar environmental features to documented sites. The predicted habitat (Figure 5) is largely limited to riparian areas along rivers in the central Carolinian Zone within or near the known EOO.

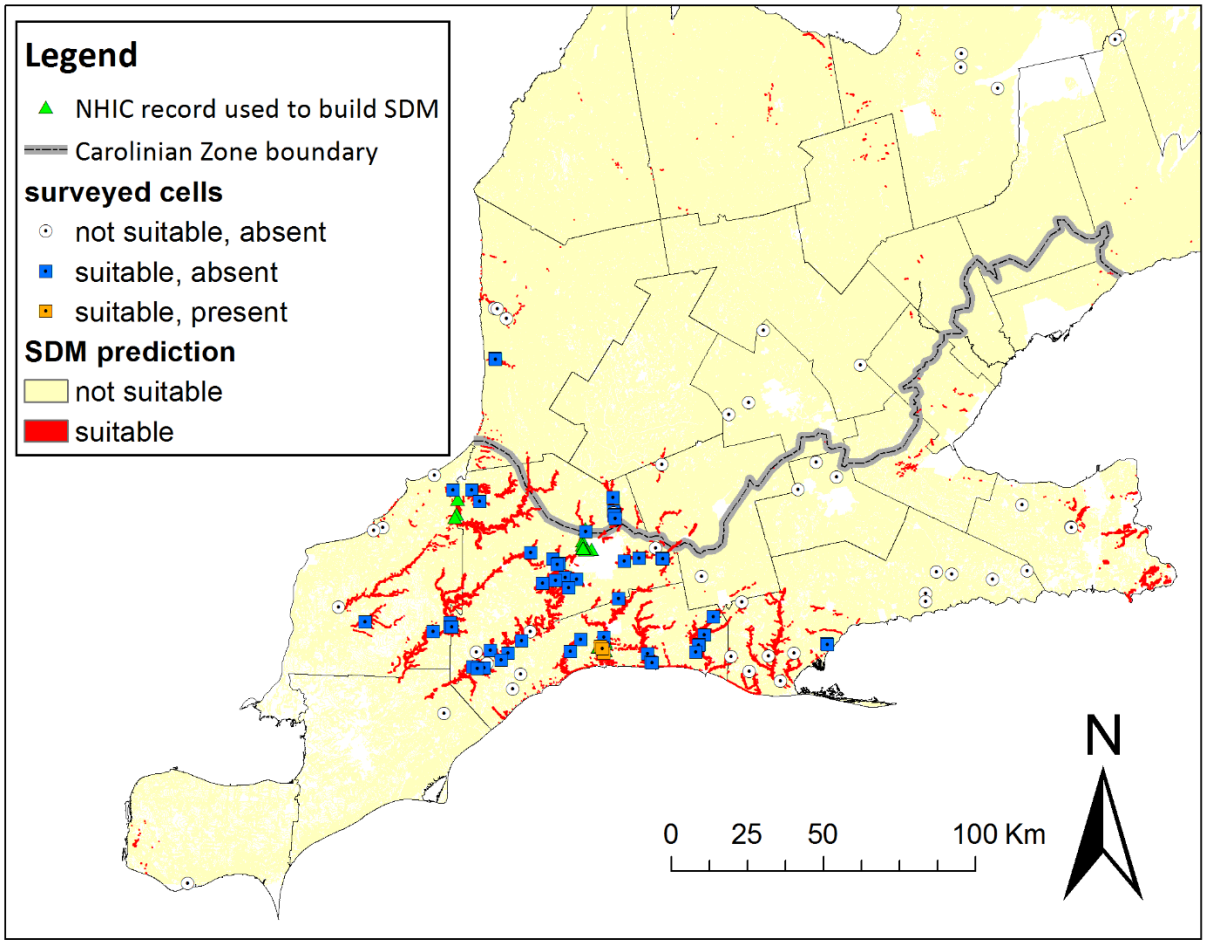

Figure 5. Predicted suitable habitat for Eastern False Rue-anemone in southwestern Ontario and associated occurrence data, search effort, and search results. Map produced by J. L. McCune for this report and used with permission.

The known subpopulations are distributed across five watersheds draining into southern Lake Huron (Mud Creek/Parkhill Creek, Ausable River), Lake St. Clair (Thames River, including Medway Creek tributary), and Lake Erie (Dodd Creek/Kettle Creek, and Lynn Creek). The SDM mapping (Figure 5), suggests that suitable habitat conditions may exist in these and other nearby watersheds (Sydenham River, Talbot Creek, Catfish Creek, Big Otter Creek, Big Creek), although the species was not detected in any of the plots sampled in these other watersheds during associated fieldwork (McCune *et al*. 2020).

Out of 115 plots in southwestern Ontario that were surveyed during the SDM fieldwork where the species was not found (see **Search Effort**), 52 (45.2%) were predicted to have suitable habitat. This finding suggests that additional factors not used as predictors in the SDM analysis, especially dispersal limitation and competition, may play key roles in determining the species' distribution in the landscape (McCune 2016; McCune *et al*. 2020).

Habitat Trends

The Carolinian Zone in southwestern Ontario (equivalent to the Lake Erie Lowland ecoregion, Statistics Canada 2017) is one of the most threatened ecoregions in Canada (Kraus and Hebb 2020). Historical rates of habitat loss to agriculture and urbanization are among the highest in Canada and only 14% of this ecoregion remains in natural cover (Krause and Hebb 2020). Remaining habitat patches are generally small, highly fragmented and degraded (Jalava *et al*. 2015; Kraus and Hebb 2020). The extent of natural cover in the Carolinian Zone is continuing to decline despite localized habitat restoration efforts on conservation lands and elsewhere (Jalava *et al*. 2015).

Forest cover for the watersheds encompassing the extant Eastern False Rue-anemone subpopulations ranges from 9.4 to 20.5% (Table 3). Forest cover in the more urbanized watersheds (Kettle Creek and Medway Creek) is continuing to decline despite ongoing tree planting efforts (UTRCA 2017; KCCA 2018).

Table 3. Forest condition indicators and trends for watersheds with Eastern False Rue-anemone subpopulations.

	Medway Creek	Kettle Creek	Parkhill Creek	Lower Ausable River
Subpopulations	SPs 2, 8, 9	SPs1, 6	SP#3	SP#4
Forest cover	9.4%	14.1%	14.5%	20.5%
Trend in Forest Cover[1]	Slight Decline	Slight Decline	Steady	Steady
Riparian Forest Cover[2]	28.7%	48.5% Lower Kettle Creek (2013) 22.3% Dodd Creek (2013)	29.9%	46.9%
Trend	n/a	n/a	No change	Decline
Source	UTRCA 2017	KCCA 2013, 2018	ABCA 2018b, c	ABCA 2018a

[1] Trend information is short-term, 5 to 10 year period depending on available data sources.
[2] Riparian forest cover is measured for areas within 30 m of watercourse.

In all of these watersheds, forest cover is concentrated in the riparian corridors. Riparian forest cover within 30 m of watercourses is highest in the Lower Kettle Creek (48.5%) and Ausable River (46.9%) watersheds and much lower in the Medway Creek (28.7%), Dodd Creek (22.3%), and Parkhill Creek (29.9%) watersheds (Table 3). The majority of the documented Eastern False Rue-anemone population is associated with forested stream valleys with relatively high habitat connectivity compared to the surrounding landscape.

Habitat quality in riparian and woodland habitats in southern Ontario is generally considered to be in decline due to the cumulative (and in some cases compounding) impacts of agricultural and urban run-off, competition from exotic invasive plants, deforestation, increased tree mortality due to exotic insect and disease infestations, changing hydrological dynamics (e.g., stream flow variability increased due to increasing

agricultural drainage, stream channelization and extreme precipitation events), and increased recreational pressures due to human population growth.

Habitat trends for this species are difficult to assess as there is limited site-specific habitat information. The 2005 assessment report (COSEWIC 2005) suggested habitat quality had declined since the initial 1990 status assessment due to apparent increases in the abundance of exotic invasive plant species, the number of recreational trails, and increased trail usage. During fieldwork in 2021, the ongoing presence of exotic invasive plant species and actively used recreational trails were noted at most sites (Heagy pers. obs. 2021). Since 2002, extensive ash mortality has occurred at many sites due to the spread of the Emerald Ash Borer (*Agrilus planipennis*) infestation across southern Ontario (Invasive Species Centre 2021). However, people familiar with multiple sites across the extant subpopulations did not see evidence that these ongoing issues were leading to changes in Eastern False Rue-anemone abundance or rapid habitat degradation (Jean pers. comm. 2020; van Hemessen pers. comm. 2020; Heagy pers. obs. 2021).

Habitat conditions are improving at key sites in the Medway Valley London (SP#2) as a result of active management by the City of London including targeted invasive plant control efforts (Dillon Consulting Limited 2020a,b), the ongoing development of a conservation plan to reduce recreational impacts in sensitive habitats (Dillon Consulting Limited 2021), and the implementation and enforcement of trail closures and restrictions (McDougall pers. comm. 2020; Williamson pers. comm. 2021). Intensive annual monitoring of the invasive treatment areas since 2013 demonstrated that the invasive plant control work was effective at reducing the density of invasive plants and that Eastern False Rue-anemone abundance had increased in monitored plots (Dillon Consulting Limited 2020a,b).

BIOLOGY

The demography, phenology, and reproductive ecology of Eastern False Rue-anemone in Ontario have not been studied. Information on several aspects of its biology is available from field and laboratory studies in parts of the species' main range in the United States. No additional studies on the population biology and ecology of this species have been published since a literature summary was prepared by Austen (1990) for the original status report. That literature summary is supplemented with available observations from Ontario.

Life Cycle and Reproduction

Information on the flowering ecology of Eastern False Rue-anemone is available from work by Schemske *et al*. (1978) in Illinois. Flowering begins when temperatures are suitable for plant growth and pollinator activity and ends before closure of the canopy. Flowering times of Eastern False Rue-anemone are earlier in warmer weather and can be delayed by colder temperatures. Flowering lasts 7-10 days, the first 3-4 days of which are a female phase (flower stigmas are receptive before the anthers open). Delayed flowering peaks can be detrimental to seed set (Schemske *et al*. 1978).

In Ontario, the Eastern False Rue-anemone flowering period can extend from mid-April through to June. Seeds mature by late May to early June (Austen 1991). Seeds are dispersed immediately (Baskin and Baskin 1986).

Leaves begin to turn yellow or brown as seeds ripen. In central Kentucky, all leaves senesce by early to mid-June according to Baskin and Baskin (1986). Timing of senescence is slightly later in Ontario but by late June the above-ground parts have died back, and the species is no longer detectable.

In central Kentucky, new leaves emerge in mid-September, remaining green all winter and a few plants may flower in the autumn (Baskin and Baskin 1986). The emergence of new leaves in fall has also been observed in Michigan (Reznicek *et al*. 2011). By early March, winter leaves have turned red and new spring leaves emerge (Baskin and Baskin 1986).

Eastern False Rue-anemone is bisexual (both male and female organs within the same flower) and grows in dense colonies (Figure 1) that probably often represent clones (Melampy and Heyworth 1980). The species is self-compatible but not autogamous (self-pollination within a single flower); autogamy appears to be prevented by protogyny with stigmas becoming non-receptive by the time the anthers dehisce (Melampy and Hayworth 1980).

Potential seed production for this species is approximately 27 seeds per stem on average (mean of 3.1 flowers/stem, range 1-15, and 8.7 ovules per flower, range 1-15), although many ovules are not fertilized (18-36% fertilization rate observed during a three-year study) (Schemske *et al*. 1978).

Melampy and Hayworth (1980) found that Eastern False Rue-anemone plants were geitonogamous (with transfer of pollen between flowers on the same genetic individual) 26% of the time, outcrossed within a patch 16% of the time, and outcrossed between patches 28% of the time. In the absence of outcrossing, geitonogamous pollination may potentially lead to inbreeding depression.

Eastern False Rue-anemone is entomophilous (pollinated by insects). A variety of insects have been observed visiting flowers, including Western Honey Bee (*Apis mellifera*), andrenid bees, halictid bees, syrphid flies, other flies, and beetles (Schemske *et al*. 1978; Melampy and Hayworth 1980). However, the rate of visitation of these pollinators is low even when Eastern False Rue-anemone is in peak bloom. No nocturnal pollinators were seen on this species by Melampy and Hayworth (1980).

Eastern False Rue-anemone is a nectar-less plant and is not a preferred resource for insect pollinators when the nectar-bearing flowers of plants such as Narrow-leaved Eastern Spring Beauty (*Claytonia virginica*) and Cut-leaved Toothwort (*Cardamine concatenata*) are nearby (Melampy and Hayworth 1980). Nectar-less plants may receive insect visits by extending their flowering season to include intervals when few nectar-producing plants are

flowering. Strategies employed by Eastern False Rue-anemone to maximize seed set may include maintaining low flower availability per unit time and extending the flowering season to include gaps between or after flowering periods of other sympatric species preferred by pollinators such as Narrow-leaved Spring Beauty (Melampy and Hayworth 1980).

The low flower visitation rate of pollinators suggests that Eastern False Rue-anemone may rely on mistakes by foraging insects that visit its flowers while searching for those of other species. Mistakes may increase, or insects may be forced to visit Eastern False Rue-anemone occasionally, as preferred species decline in abundance. Declines in pollinator availability could limit seed production in Eastern False Rue-anemone (Melampy and Hayworth 1980). There is some evidence that wind plays a role in the species' pollination. For example, three of 37 flowers covered with nylon screen produced seed in a field study conducted by Melampy and Hayworth (1980).

Germination of Eastern False Rue-anemone was investigated by Baskin and Baskin (1986) using seeds collected from central Kentucky that were sown in soil and placed in a non-heated greenhouse. They found that the mature seeds are non-dormant and have under-developed embryos that grow slowly over the summer, when temperatures are high, and elongate rapidly in early autumn. Seeds germinate in late September to early October, soon after the embryos fully elongate. In the Baskin and Baskin (1986) study, 70% of seeds germinated.

Developing seed capsules were frequently observed during fieldwork in Ontario in May 2021. Abundant seeds were produced in plants observed in Elgin County during early June (Austen 1990). It is not known when germination occurs in the field in Ontario.

Vegetative reproduction is presumably important in this clonal species but has not been studied (Schemske *et al*. 1978). In wildflower gardens, the species is propagated by root division (LBJWC 2020).

Eastern False Rue-anemone is a perennial species, but specific information on the age of first flowering, longevity and average age of mature individuals in the population is not available. First flowering of individuals (ramets) developed from seed or vegetative propagules likely requires several years. The large size of some patches suggests that clonal colonies (genets) can persist for many years (possibly decades). The generation time is unknown, but potentially in the range of 3 to 10 years.

Physiology and Adaptability

Unlike other mesic deciduous woodland herbs of forests in the eastern North America, whose seeds require a period of cold stratification and germinate in the spring, Eastern False Rue-anemone seed is non-dormant and completes germination in autumn (Baskin and Baskin 1986). By germinating and emerging in autumn, Eastern False Rue-anemone seedlings have a much longer period for establishment and growth before the onset of dormancy the following June than if germination was delayed until spring. This species may require less time to reach reproductive maturity than many other similar woodland plants.

There may, however, be a disadvantage to passing the winter as a seedling versus a seed (Baskin and Baskin 1986). For example, such a strategy could make the species more susceptible to extreme winter conditions.

Eastern False Rue-anemone is a perennial with considerable vegetative propagation (Schemske *et al*. 1978), which may diminish to some extent the importance of high seed production in any one year. This species often occurs in floodplains and is presumably adapted to periodic flooding and scour events. In Ontario, it was commonly observed on floodplain terraces subject to infrequent flooding but rare on active floodplain areas that experience annual flooding (Heagy pers. obs. 2021).

Annual monitoring of ten small patches (approximately 20 to 400 stems per patch) at Site #2.5 over a seven-year period (Dillon Consulting Limited 2020a,b) suggests that some plants may remain dormant in some years. The number of stems observed during this monitoring effort was stable or increased at most patches but marked fluctuations were observed at three patches (e.g., 0, 1, 6 plants in lowest year versus 21, 21, and 70-85 stems in the highest year). The lowest counts occurred in the same year (2017) but were variously attributed to spring flooding at a low-lying patch, drought in the previous year at an upland patch, and competition from other native plants at the third patch (Dillon Consulting Limited 2020a). Colony expansion and the establishment of "new" proximal sub-colonies with up to 20 plants were also observed during this study, suggesting occurrences can be dynamic.

Dispersal

Seeds have no known special means of dispersal (Schemske *et al*. 1978). Seeds of some Ranunculaceae species found in periodically flooded wetlands are buoyant for extended periods (e.g., 50% of *Thalictrum flavum* seeds were buoyant for at least 42 days in moving water) (van den Broek *et al*. 2005). Eastern False Rue-anemone propagule dispersal distances are unknown but water-dispersal of seeds or root masses over significant distances is plausible for colonies occurring in floodplain or valley slope situations.

Interspecific Interactions

No information was found regarding competitive or interspecific interactions that affect Eastern False Rue-anemone other than the pollinator information discussed in the **Life Cycle and Reproduction** section.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Observation data compiled by NHIC (2020) for this species includes information from herbarium specimens (including specimens examined for the Atlas of the Rare Plants of

Ontario Project, Argus *et al*. 1982-87), many casual or incidental observations by field naturalists and biologists (including iNaturalist records), and the results of targeted field visits to known sites (see **Search Effort**). In preparation for this report, additional recent observations were obtained from several sources (see **Acknowledgements** and **Authorities Contacted**). Some of these observations include information on the number of patches or colonies, patch size (e.g., large, small, approximate dimensions) and estimates of the number of "plants" observed. Observations reported since 2005 often also include high accuracy geographic coordinates and details on the spatial configuration of patches at a site.

Abundance information was collected during targeted surveys in 1989, 2003-2004, and 2021 (see **Search Effort**). In the 1989 and 2021 surveys, information on the number of patches (colonies), approximate patch sizes (length x width), and estimated number of stems per patch was collected (Austen 1990). In the 2003-2004 surveys, only the estimated number of stems per site was reported (COSEWIC 2005). In 2021, accurate locational information was collected for each occurrence and the extent of the largest patches was mapped using a GPS unit.

Obtaining accurate abundance counts or estimates of the number of mature individuals for this delicate clonal species is difficult and has not been attempted. The number of stems is used as an index of abundance, although it over-estimates the number of mature individuals, as both flowering and vegetative (non-flowering) stems are included (COSEWIC 2005) and individual plants are often multi-stemmed. Precise information on the number of stems per individual plant (or root crown) is not available but was visually estimated as approximately five (Heagy pers. obs. 2021). As stem counts are feasible only for very small patches, almost all abundance estimates are based on visual estimates of the number of stems. For very large patches (>1000 m^2), abundance estimates are generally extrapolated from patch size and stem density estimates.

The number of mature individuals (ramets) in the population is less than the number of stems, potentially by a factor of five when multi-stemmed individuals and potentially immature stems are taken into consideration. Nothing is known about the relationship between the number of stems and the number of genetic individuals (genets) (ECCC 2017). The number of genetic individuals is unknown and is presumably much less than the number of stems but greater than the number of patches.

Abundance

Occurrences in Ontario vary from small isolated patches less than 1 m^2 (e.g., site #2.8) to relatively large areas covered with thousands of stems. Several sites contain one or a few patches that occupy only a small area of habitat (easily missed if accurate spatial coordinates are not available). The largest patches observed in the 2021 survey (edges mapped with GPS unit) covered 6,000 m^2 (Site# 1.1), and 1750 m^2 (Site# 2.5). The bulk of the Canadian population is concentrated in those patches. During the 1989 fieldwork, Austen (1990) estimated there may be 500,000 to 700,000 stems present in a single 25 m x 25 m (625 m^2) patch (site # 2.5).

Abundance estimates were recorded for each known site and subpopulation in 1990, 2005, and 2021 (Table 4; Appendices 1, 2). Current abundance estimates are presented for all 23 extant sites, including estimates from the 2021 targeted surveys for 18 sites and provisional estimates (lower and upper order of magnitude range extrapolated from patch size information) from other surveys completed in 2018 (4 sites) or 2009 (1 site).

Table 4. Abundance estimates for Eastern False Rue-anemone subpopulations and sites in Canada as of 1990, 2005, and 2021. Estimates reported as number of stems.

Sub-population	Site ID (# subsites)	1990 (Austen 1990)	2005 (COSEWIC 2005)	2021
SP#1 Lower Kettle Creek	1.1	Unknown	Unknown	Unknown
	1.2	Unknown	Unknown	Unknown
	1.3			2000-10,000[1]
	1.4	3500-5000	3000	10,000
	1.5			100-1000[1]
	1.6	12,000	10,000	10,000
	1.7	3500	3000	20,000
	1.8			1000-10,000[1]
	1.9		Unknown	Unknown
	1.10 (4)	23,300+ at 4 subsites	20,000 at 2 of 4 subsites	15,000-25,000 at 2-3 subsites[2]
	1.11 (2)	>100,000	100,000	150,000 at 2 subsites
	1.12	Unknown	Unknown	Unknown
	12 sites 16 subsites	**150,000+ stems at 5 sites, 2 other extant sites**	**136,000 stems at 5 sites**	**208,000 to 236,000 stems at 8 sites**
SP#2 Medway Valley London	2.1	200	Not found	not searched
	2.2 (2)	2500 at 1 subsite	Not found/not searched	not found/not searched
	2.3	Unknown		10
	2.4	Unknown	Not found	800
	2.5 (2)	500,050-700,075 at 2 subsites	500,000-700,000 at 1 of 2 subsites	150,000 at 1 of 2 subsites
	2.6 (3)	29,250-34,250 at 3 subsites	35,000 at 1 of 2 subsites	50,000 at 3 subsites
	2.7 (1 to 3)	<500, 2 subsites	Not found at 2 subsites	350 at 1 of 3 subsites
	2.8			150
	8 sites 14 subsites	**532,500 to 737,525 stems at 7 sites**	**535,000 to 735,000 stems at 2 sites**	**200,670 stems at 6 sites**
SP#3 Parkhill (Mud) Creek	3.1	Historical (1891), 2 general sites	400 “plants”	50,000
	3.2			16,000
	2 sites	**Historical (1891)**	**400 “plants” at 1 site**	**66,000 stems at 2 sites**
SP#4 Ausable River Valley	4.1	Not found		Not found
	4.2	2500-3000	Not found	7000

Sub-population	Site ID (# subsites)	1990 (Austen 1990)	2005 (COSEWIC 2005)	2021
	4.3 (2)		1000	30,000 at 2 subsites
	4.4			10,000-100,000[3]
	4.5			1000-10,000[4]
	4.6			2500
	6 sites (7 subsites)	**3500 to 6000 stems at 2 sites**	**1000 stems at 1 of 2 sites**	**50,000 to 150,000 stems at 5 sites**
SP#5 Thames Riverbend London	5.1		Unknown	Not found
	1 site		**Unknown**	**Extirpated (1994)**
SP#6 Dodd Creek	6.1 (1 or 2)	Not searched?	Not searched	5000-10,000 at 1 subsite
	1 site (1 or 2 subsites)	**Unknown**	**Presumed extirpated**	**5000-10,000 stems at 1 site**
SP#7 Lynn Valley	7.0	Not searched	Not searched	Not found (limited search)
	1 locale	**Historical (1897)**	**Presumed extirpated**	**Historical (1897)**
SP#8 Arva Moraine East	8.1		Unknown	1750
	1 site		**Unknown**	**1750 stems at 1 site**
SP#9 Medway Creek North	9.1		Unknown	Not searched
	1 site		**Unknown**	**Historical (1994)**

[1] Extrapolated from information collected by McCune in 2018. [2] 15,000 stems at 2 subsites in 2021, 3rd subsite not visited but presumed to have 10,000 stems. [3] Extrapolated from information collected by ABCA staff in 2018. [4] Extrapolated from information collected by ABCA staff in 2009

Although all of the targeted surveys used a similar approach to developing abundance estimates, caution is needed in comparing estimates across years due to observer bias and potential differences in the spatial extent of the search effort (patches found in the 2021 survey were often more than 100 m from coordinates in NHIC database).

The Lower Kettle Creek (SP#1) and Medway Valley London (SP#2) subpopulations are the largest documented in Canada, with over 200,000 stems found at fourteen separate extant sites (eight for SP#1 and six for SP#2; Table 4). In both these subpopulations, most stems are located at a single site (150,000 stems each at sites #1.11 and #2.5) where they are concentrated in a single patch. In SP#1, at least three other sites have in excess of 10,000 stems and most sites contain multiple patches. In SP#2, one other site has roughly 50,000 stems in multiple patches but the other four extant sites each comprise a single small patch with less than 1,000 (10 to 800) stems.

The Ausable River Valley subpopulation (SP#4) is estimated to have between 50,000 and 150,000 stems at five sites. The abundance estimate for this subpopulation is less precise, as only three of five extant sites were visited in 2021, with some 39,500 stems observed. Abundance estimates for the other two sites are extrapolated from mapping by Ausable Bayfield Conservation Authority (ABCA) staff in 2018 and 2009, which documented multiple patches at these sites, including a very large patch (at site #4) which could potentially have similar numbers to the very large patches in SP#1 and SP#2.

In 2021, an estimated 66,000 stems were observed in multiple patches at two sites in the Parkhill (Mud) Creek subpopulation (SP#3).

The Dodd Creek subpopulation (SP#6) is known from a single site, where 5,000 to 10,000 stems were observed in 2021, although the survey may not have covered the full extent of the occurrence.

Two of three occurrences previously known only from collections in 1994 were checked in 2021. The Arva Moraine East subpopulation (SP#8) was confirmed extant, with approximately 1,750 stems at one site. No plants were found at the Thames Riverbend London (SP#5) site. The Medway Creek North (SP#9) site was not checked in 2021. No plants were found during limited searches in 2021 and 2016 in the vicinity of the Lynn Valley (SP#7) general locale.

Habitat availability and survey effort vary across the known subpopulations. The Medway Valley London subpopulation has been intensively surveyed relative to the other subpopulations. New sites with significant numbers of stems have recently been found in the Lower Kettle Creek, Ausable River Valley, and Parkhill (Mud) Creek subpopulations and many nearby areas with potentially suitable habitat for this species have never been searched. Potential habitat in the vicinity of the single known sites for each of the other five subpopulations is relatively limited. Other subpopulations may be found, particularly in the areas of potential habitat identified in the SDM mapping (Figure 5).

In 2005, the size of the Canadian Eastern False Rue-anemone population was estimated at approximately one million flowering stems in several subpopulations, with the vast majority concentrated at just two sites (#2.5 and #1.11) (COSEWIC 2005). Based on recent fieldwork, the current population size estimate is similar in magnitude but distributed across a greater number of sites representing six subpopulations. The number of mature individuals (ramets) in the Canadian population is fewer than 1,000,000 but more than 100,000.

Fluctuations and Trends

Available information indicates the population of this perennial plant is not subject to extreme fluctuations. Seven years of annual monitoring at one site (#2.5) and the results of three targeted surveys over a 32-year period indicate abundance is generally stable at the site level. Some occurrences not found in 2003-2004 (e.g., #2.4. #4.2) were observed in 2021 but this is likely due to differences in the extent of the search effort. Flooding or drought events may result in some year-to-year variability in the number of stems present at a local scale (Dillon Consulting 2020a). However, given the variation in topographic position, not all patches in the population would be impacted.

Quantitative population trend information is not available for this species. Of the 18 extant sites with 2021 abundance estimates (Table 4), estimates from 1990 are available for nine sites and estimates from 2005 are available for eight sites. As noted previously, abundance estimates from different years may not be directly comparable.

For the five sites in SP#1 that were covered by all three targeted surveys (#'s 1.4, 1.6, 1.7, 1.10, 1.11), the stem count estimates were generally very similar. Higher numbers for sites #1.4 and #1.7 in 2021 may be the result of more extensive search effort.

In SP#2, the two largest sites (#'s 2.5 and 2.6) were covered by targeted surveys in 1989, 2003, and 2021. Abundance estimates for site #2.6 were similar or increasing over this period whereas the 2021 estimate of 150,000 stems at site #2.5 is much lower (approximately 70% decline) than the earlier estimates of 500,000-700,000 stems at this site. The accuracy and comparability of these estimates by different observers is unknown but the survey data suggest that stem density in the main patch at site #2.5 was much higher in 1989 and 2003 than in 2021. Reasons for this apparent change in density are not known as the habitat conditions and land use do not appear to have changed drastically since 1989 (Figure 4). Since 2013, Eastern False Rue-anemone stem density in the main patch at site #2.5 has been stable and Goutweed (*Aegopodium podagraria*) density has remained low (Dillon Consulting 2020a,b; Williamson pers. comm. 2021).

In SP#4, site #4.2 had similar abundance in 1989 and 2021 (it was not found in 2004) and site #4.3 had higher abundance in 2021 than in 2004 (although only part of the site was surveyed that year).

Over the past 30 years, the known population size has increased due to greater survey effort, although some local declines have occurred, including the presumed extirpation of three small occurrences (sites #2.1, #2.2, and #5.1) and an apparent decrease in abundance at site #2.5, which prior to 2005 contained a very large portion of the population. Previous status reports predicted that occurrences situated in field edges or other disturbed areas (e.g., sites 1.4, 1.10) would decline but this has not been observed.

Rescue Effect

The probability of Canadian habitat being recolonized from populations in the United States is low. The closest populations in the United States are over 100 km away and likely beyond the dispersal range of seeds or root masses, particularly given that the propagules would need to cross Lake Huron, Lake Erie or the connecting river systems and then move upstream.

THREATS AND LIMITING FACTORS

Threats to existing subpopulations were assessed using the International Union for Conservation of Nature - Conservation Measures Partnership (IUCN-CMP) standardized threat classification system (Salafsky *et al*. 2008; Master *et al*. 2012). Threats are defined as activities or processes that have a direct negative impact on the Canadian population. An assessment of the impact, scope, severity and timing of known threats is presented in tabular format in Appendix 3.

Threats to Eastern False Rue-anemone subpopulations in Canada include invasive species, high densities of White-tailed Deer (*Odocoileus virginianus*), and recreational activities. A number of threats with unknown impact have also been identified (Appendix 3). Threats are discussed below in approximate order of perceived importance using IUCN threat classification categories as headings. The overall threat impact for this species is Low (Appendix 3).

Threats

Invasive Non-native Species and Diseases (8.1, Low Impact)

Direct competition from invasive non-native plants and the indirect impacts of accelerated tree mortality due to non-native insects and diseases are pervasive and ongoing threats to Eastern False Rue-anemone and its habitat. However, it appears that the impact of this threat is less than previously assumed. Despite the widespread occurrence of invasive plant species and pest-related tree mortality at Eastern False Rue-anemone sites, there are no indications of severe declines at most sites (Jean pers. comm. 2020; van Hemessen pers. comm. 2020; Heagy pers. obs. 2021). The severity of this threat on the population over the next 10 to 30 years (estimated time range for three generations) is considered slight.

One invasive non-native species does appear to pose a serious threat at some sites. Goutweed is a shade-tolerant horticultural groundcover plant that is highly invasive and displaces native plants in the ground layer. Encroachment by Goutweed may have contributed to the extirpation of two Eastern False Rue-anemone sites (#2.1 and #5.1) along the Thames River in London. Site #2.1 consisted of a single small patch last observed in 1989 (COSEWIC 2005). In 2021, a dense patch of Goutweed was observed at the only known site in the extirpated Thames Riverbend London subpopulation (SP#5). As the habitat at this site is generally intact, direct competition from Goutweed is the most plausible explanation for the loss of this subpopulation (Heagy pers. obs. 2021). These extirpated sites supported a negligible portion (<1%) of the Canadian population.

Goutweed was previously identified as a serious threat to important occurrences in the Medway Valley Heritage Forest Environmentally Significant Area (MVHF ESA) within SP#2 (COSEWIC 2005). Since 2014, the City of London has undertaken an invasive species management program in the MVHF ESA targeting severe Goutweed infestations in close proximity to significant Eastern False Rue-anemone patches (Dillon Consulting Limited 2020a). This intensive program has been effective in controlling Goutweed abundance while maintaining the integrity of proximal Eastern False Rue-anemone colonies. The City of London plans to continue to monitor and mitigate the impact of invasive species on significant plant occurrences at the MVHF ESA (McDougall pers. comm. 2020).

Garlic Mustard (*Alliaria petiolata*), an invasive Eurasian herb that is widely established in natural areas across southern Ontario (Catling *et al*. 2015), is present at most sites (Jean pers. comm. 2020; Heagy pers. obs. 2021). During the 2021 fieldwork, dense Garlic Mustard infestations were observed in anthropogenically and naturally disturbed habitats

(e.g., field edges and active floodplain) at several sites (e.g., #2.4, #3.2), but in general only scattered plants were observed in or near Eastern False Rue-anemone patches (Heagy pers. obs. 2021). Eastern False Rue-anemone and Garlic Mustard have co-occurred at several sites for at least 30 years, suggesting that this invasive plant species is presently a minor threat (ECCC 2017). Garlic Mustard control is ongoing at a few sites including site #2.5 (Dillon Consulting Limited 2020a) and site #4.6 (Koscinski pers. comm. 2020).

Invasive exotic shrubs such as buckthorns (*Rhamnus* spp.) and honeysuckles (*Lonicera* spp.) are also present at most sites but at densities that do not appear to pose a threat to Eastern False Rue-anemone (Heagy pers. obs. 2021).

Dog-strangling Vine (*Vincetoxicum rossicum*) is a highly invasive plant in both open and woodland situations that is considered a potential threat as it is established and spreading in many parts of southern Ontario, including along floodplains and valley bottoms in the City of London. It has not yet been reported at any of the known Eastern False Rue-anemone sites but could conceivably spread to some subpopulations within the next 10-30 years, where it would likely have a severe impact (Jean pers. comm. 2020).

Several exotic forest pest species are causing or expected to cause elevated mortality of common tree species, potentially altering light and/or moisture levels in Eastern False Rue-anemone habitat (ECCC 2017). In the past 20 years, Emerald Ash Borer, a non-native beetle, has rapidly spread across southern Ontario and virtually eliminated ash as a canopy tree species in much of this region (Invasive Species Centre 2021). However, the impact of ash mortality on Eastern False Rue-anemone (other than increased tree fall) is not presently apparent, even at sites where ash was formerly a common canopy species (Jean pers. comm. 2020; van Hemessen pers. comm. 2020; Heagy pers. obs. 2021). The composition of the tree canopy at the site and population level is sufficiently diverse that the impact of the rapid decline of one tree species or genus is limited.

Problematic Native Species (8.2, Low Impact)

White-tailed Deer is a problematic native species that at high densities can have very significant ecological impacts that threaten many native woodland plant species in eastern North America (Gorchov *et al*. 2021). The density of White-tailed Deer in southern Ontario is high relative to historical levels and is altering forest plant communities (ESTR Secretariat 2016). Heagy (pers. obs. 2021) attributed the observed herbivory and localized trampling at most sites to White-tailed Deer. Damage to Eastern False Rue-anemone was not severe but plants often had reduced vigour, except where they were protected from deer by fallen branches, wire fences, or other barriers (Heagy pers. obs. 2021). Eastern False Rue-anemone contains the alkaloid isopyroine (Glasby 2012) and its foliage is likely not as palatable to herbivores as other spring wildflowers, which can be severely impacted by deer herbivory (ESTR Secretariat 2016). For this species, the ongoing threat from high deer densities is likely to result in only a slight reduction in productivity and the overall impact is low.

Recreational Activities (6.1, Low Impact)

Formal and informal recreational trails are present at many sites in most subpopulations. Plants near trails may be adversely affected by trampling and soil compaction due to foot, bicycle, and/or motorized off-road vehicle use. Trails also function as pathways for the spread of invasive species (threat 8.1) (Ballantyne and Pickering 2015).

Trails within the MVHF ESA, which encompass most of SP#2, are actively managed to minimize and mitigate the impact on sensitive plant occurrences, including installation of improved signage (McDougall pers. comm. 2020; Dillon Consulting Limited 2021). One trail passing near a large patch is closed seasonally to prevent damage (Williamson pers. comm. 2021). Only minor trampling of plants situated on trail edges in the MVHF ESA was observed in 2021 even though trail use was exceptionally high (Heagy pers. obs. 2021). Trampling due to off-leash dogs (a prohibited activity) has also been reported in the MVHF ESA (Williamson pers. comm. 2021). Efforts to control unauthorized motorized vehicle use on conservation lands in the Ausable River Valley are ongoing as past measures (e.g., signage, education, and enforcement) have not been effective (Jean pers. comm. 2020).

Informal camping may occur occasionally at a few sites. During 2004 targeted surveys, for example, a small group of people were observed camping near the large Eastern False Rue-anemone patch located at site #1.11.

Despite the large number of sites with active trails, few plants are directly affected, so the impact of recreational activities is considered low. Trail density at the known sites does not appear to be increasing over time (Heagy pers. obs. 2021). Recreational usage is likely increasing at sites near growing urban centres (SPs #1, 2, 5, 6, and 8). Small occurrences near residential developments are particularly vulnerable to recreational activities (e.g., sites #5.1 and #8.1).

Logging and Wood Harvesting (5.3, Unknown Impact)

Some of the known sites (e.g., site #'s 1.10, 4.1, 6.1) are on private lands where selective logging and wood harvesting activities occur from time to time. There are no plans to harvest timber near occurrences on lands owned by the ABCA (site #'s 3.1, 3.2, 4.2, 4.3, 4.4, and 4.5) (Jean pers. comm. 2020). Logging activities at all sites are subject to municipal tree-cutting bylaws which provide for forest conservation by requiring minimum residual basal areas. Collectively, the potentially affected sites support only a small (1-10%) proportion of the population.

The impact of wood harvesting on Eastern False Rue-anemone would vary depending on the extent of ground disturbance and canopy openings created during logging operations. The impact of selective logging conducted on frozen ground is likely minimal or potentially beneficial, as the discarded tree tops could protect plants from deer and increased light availability could promote plant vigour. Overall, the impact of logging is unknown. Logging operations may result in the inadvertent introduction or proliferation of

non-native invasive plants (Halloran *et al*. 2013). The impact of invasive plants is covered above under threat 8.1.

Other Ecosystem Modifications (7.3, Unknown Impact)

Human activities and ecosystem modifications leading to a general decline in North American pollinator populations was identified as a threat to this insect-pollinated species (ECCC 2017). Reduced cross-pollination leading to reduced reproductive output would be particularly detrimental for small isolated subpopulations and patches (e.g., SPs #3 and #8). There is insufficient information to assess the severity of this threat.

Agricultural Effluents (9.3) and Urban Waste Water (9.1) (Unknown Impact)

Surface water quality in watersheds supporting Eastern False Rue-anemone subpopulations is rated as poor to fair due to pollution from agricultural and urban runoff (UTRCA 2017; ABCA 2018 a,b,c; KCCA 2018), but the level of impact on the species is unknown. Increased nutrients (e.g., high phosphorus) can increase interspecific competition from both native and exotic invasive species. However, the habitats in which Eastern False Rue-anemone occurs are relatively nutrient-rich and may be more resilient to additional nutrient input. At several sites (#1.4, #1.10, #8.1), patches situated along the margins of agricultural crop fields have persisted despite exposure to pesticide drift and fertilizers.

Climate Change (11.1, 11.2, 11.4) (Unknown Impact)

This species is likely susceptible to climate change related habitat alteration (threat 11.1), droughts (threat 11.2), and flooding events (threat 11.4), but the level of impact from these potential threats is poorly understood. An increase in short-lived flooding events could increase long-distance dispersal but prolonged flooding events in early spring could reduce flowering or even destroy plants. Warming temperatures could expand the extent of suitable habitat for this species within southern Ontario but it is unlikely to colonize new sites.

Brinker *et al*. (2018) found Eastern False Rue-anemone to be Moderately Vulnerable using the climate change vulnerability of the Canadian population using the NatureServe Climate Change Vulnerability Index (CCVI) (Young and Hammerson 2015). Several trait-based factors, including its narrow historical thermal niche (proxy for temperature shift tolerance), presence of anthropogenic barriers that restrict movement (the Canadian population of this species is situated in a predominately agricultural landscape), limited dispersal capability, and potential dependence on animals for propagule dispersal (Brinker *et al*. 2018) were identified.

Other Threats

Additional threats mentioned in previous status reports (Austen 1990; COSEWIC 2005) or observed during the 2021 fieldwork (Heagy pers. obs. 2021) at one or more sites

include damage from farm equipment at a patch adjacent to an agricultural field (#1.4), potential collection of wildflowers by recreational users, and potential harm from road maintenance activities (small roadside patch at #1.11). These threats affect a negligible portion of the Canadian population.

Many subpopulations are situated in or near expanding urban areas. However, housing and other developments at the known sites are very unlikely, even on private lands, as almost all patches are situated on hazard lands (floodplains and valley slopes) where development is prohibited or restricted. An exception is site #8.1; comprising all of the Arva Moraine East subpopulation (SP#8), it is not on hazard lands and could potentially be impacted by development in the future. However, this site is located just outside the City of London urban boundary and development is not expected within the next 30 years. The indirect impacts of intensive residential development on adjacent lands (e.g., increased recreational use, increasing diversity and abundance of non-native invasive plants) are considered under the relevant category above.

Limiting Factors

Important limiting factors for this species include its limited dispersal capability, low rate of visitation by pollinators, and self-compatibility which can lead to inbreeding depression.

Several of the known subpopulations (SPs 3, 5, 7, 8, and 9) are situated in small (i.e. less than 5 ha) isolated woodlots found within a highly disturbed landscape matrix. These subpopulations are vulnerable to genetic isolation and reduced reproductive success, as well as continued habitat degradation that could ultimately lead to population declines and local extirpations, as observed in the closely related Rue-leaved Isopyrum (*Isopyrum thalictroides*) in Europe (Skrajna *et al*. 2015). The status of small isolated occurrences consisting of very few plants can be highly precarious.

Number of Locations

The term “location”, as used by COSEWIC, defines a geographically or ecologically distinct area in which a single event can rapidly affect all individuals of the taxon present. There is no single dominant threat to this species. Competition from non-native invasive species, such as Goutweed, appears to be the most serious known threat. Goutweed can readily spread at the site level but is unlikely to spread rapidly to all sites in a large subpopulation. Management of invasive species is generally up to individual property owners or land managers and implemented at a site level or smaller area.

If the number of sites is used as an approximation for the number of locations, there are 23 locations, corresponding to the 23 extant sites. If the number of independent land managers is used as an approximation for the number of locations, then there are an estimated 15 locations.

The latter estimate is based on considering the five extant sites managed by ABCA (#'s 3.1, 3.2, 4.3, 4.4, and 4.5) as a single location, and the five extant sites managed in whole or part[3] by the City of London (#'s 2.3, 2.4, 2.5, 2,6, and 2.7) as a single location. There is not a one-to-one correspondence between the 13 other sites and number of private landowners as some sites extend across multiple land parcels and some individuals may manage multiple land parcels, but the estimate assumes that these two scenarios are equally likely.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Eastern False Rue-anemone is listed as Threatened in Canada on Schedule 1 of the federal *Species at Risk Act* (SARA). A federal recovery strategy that identifies Critical Habitat has been prepared (ECCC 2017). None of the known occurrences are on federal lands.

In Ontario, the species is listed as Threatened on the Species at Risk in Ontario (SARO) list and the plant and its general habitat[4] are protected under the provincial *Endangered Species Act, 2007*. The province has adopted the federal Recovery Strategy and prepared a Government Response Statement outlining the government's intended actions and priorities (MECP 2018, 2019).

Non-Legal Status and Ranks

Eastern False Rue-anemone is considered Globally Secure (G5), although this status has not been reviewed since 1984 (NatureServe 2021). This species is ranked as Imperilled in Ontario (S2) and Canada (N2), with the latest subnational rank (S-Rank) review completed in 2015 (NHIC 2020; NatureServe 2021). The species is considered Secure (N5?) in the United States and is not of conservation concern in the core of its range but is ranked as Extirpated (SX) in New York (Young pers. comm. 2021), Possibly Extirpated[5] (SH) in South Dakota, and Critically Imperilled (S1) or Imperilled (S2) in eight jurisdictions on the periphery of its range. The species has not been given a subnational rank in Michigan, where it is reportedly fairly secure but limited to the southern half of the lower peninsula in moderately disturbed (logging and/or light grazing) to undisturbed rich forests (Bassett pers. comm. 2021). Wild occurrences in Maryland (Frye pers. comm. 2021) and Pennsylvania are considered exotic. Arkansas, Indiana, Kansas, Michigan, Minnesota, Missouri, Ohio, Oklahoma, Tennessee, and Wisconsin have not yet been ranked for Eastern False Rue-anemone (Table 5).

Eastern False Rue-anemone has not been assessed by IUCN.

[3] There are some private in-holdings within the MVHF ESA.
[4] Under *ESA 2007*, general habitat is an area on which a species depends, directly or indirectly, to carry out its life processes. It is not spatially defined or delineated.

[5] Equivalent to Historical.

Table 5. Eastern False Rue-anemone (*Enemion biternatum*) conservation status ranks (NatureServe 2021).

Jurisdiction	Status Rank
Global	**G5 (Secure)** last assessed April 1984
Canada	**N2 (Imperilled)**
Ontario	S2 (Imperilled)
United States	**N5? (Secure)**
New York	SX (Presumed Extirpated)
South Dakota	SH (Possibly Extirpated)
Florida, Georgia, Mississippi, South Carolina, Virginia, West Virginia	S1 (Critically Imperilled)
Alabama, North Carolina	S2 (Imperilled)
Iowa	S4 (Apparently Secure)
Illinois, Kentucky	S5 (Secure)
Arkansas, Indiana, Kansas, Michigan, Minnesota, Missouri, Ohio, Oklahoma, Tennessee, Wisconsin	SNR (Unranked)
Pennsylvania	SNA (Exotic)

Habitat Protection and Ownership

The provincial designation recognizing the Ausable River Valley as an Area of Natural and Scientific Interest (ANSI) confers some protection through the *Provincial Policy Statement* (PPS) and the official plans of regional and lower tier municipalities in that no development is permitted in ANSIs unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions.

Similar protection is afforded under the PPS to areas identified in municipal official plans as significant forests or significant valleylands. Natural heritage feature mapping is not yet incorporated into the official plans of all municipalities within the Canadian range of Eastern False Rue-anemone but most of the known sites would likely qualify as significant valleylands and/or significant forests.

Approximately half of the known Canadian population of this species is on publicly owned lands. Almost all of the large Medway Valley London subpopulation (SP#2) is located within the MVHF ESA, which is owned and managed by the City of London in cooperation with the Upper Thames River Conservation Authority and is formally designated as a protected area (McDougall pers. comm. 2020). Both sites in the Parkhill (Mud) Creek subpopulation (SP#3) and three important sites (#4.3, #4.4, and #4.5) in the Ausable River Valley subpopulation (SP#4) are on land owned and managed by the ABCA. The ABCA lands are not designated as protected areas but known species at risk

populations and habitat are conserved through management plans (Jean pers. comm. 2020). Parts of the Parkhill sites (3.1 and 3.2) are managed for recreation, flood protection, and forestry purposes but these activities do not directly impact the Eastern False Rue-anemone patches. The ABCA-owned sites in the Ausable River Valley subpopulation are managed in compliance with a forest management plan and good forestry practices (Jean pers. comm. 2020). One private site (#4.6) in the Ausable River Valley is managed for the conservation and protection of biodiversity (Koscinski pers. comm. 2020). Most other extant sites are on private land other than some patches that may be on municipal road allowances (sites #1.4, #1.11).

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AUTHORITIES CONTACTED

Bassett, Tyler. Botanist, Michigan Natural Features Inventory Office, Michigan State University, Michigan.

Deacon, Pat. Biologist, Natural Resources Solutions Inc, Waterloo, Ontario.

Firestone, Chris. Botanist, Wild Plant Management Program, Department of Conservation and Natural Resources, Bureau of Forestry, Tioga State Forest, Wellsboro, Pennsylvania.

Frye, Christopher. State Botanist, Wildlife and Heritage Service, Department of Natural Resources, Wye Mills, Maryland.

Gardner, Rick. Chief Botanist, Ohio Department of Natural Resources, Division of Natural Areas and Preserves, Columbus, Ohio.

Grund, Steven P. Botanist, Western Pennsylvania Conservancy/Pennsylvania Natural Heritage Program, Pittsburgh, Pennsylvania.

Jean, Ian. Forestry and Land Stewardship Specialist, Ausable Bayfield, Ontario. Conservation Authority, Exeter, Ontario.

Jones, Colin. Natural Heritage Information Centre, Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario.

Koscinski, Daria. Conservation Property Manager, Thames Talbot Land Trust, London, Ontario.

Kruse, Lisa. Senior Botanist, Wildlife Conservation Wildlife Resources Division, Georgia Department of Natural Resources, Social Circle, Georgia, USA

McCune, Jenny L. Assistant Professor, Department of Biological Sciences, University of Lethbridge, Lethbridge, Alberta.

McDougall, Linda. Ecologist, City of London, London, Ontario.

Monck-Whipp, Liv. Conservation Biology Coordinator, Southwestern Ontario (East), Nature Conservancy of Canada, Norfolk Office, Ontario.

Nishino, Misako. Data Manager, Biota of North America Program, Chapel Hill, North Carolina.

Petruniak, Jennifer. Partner, Dillon Consulting Limited, Toronto, Ontario.

Quinlan, Cathy. Biologist, Upper Thames River Conservation Authority, London, Ontario.

Shifflett, Mark. Senior Water Resources Engineer, Upper Thames River Conservation Authority, London, Ontario.

Singhurst, Jason. Botanist/Plant Ecologist, Texas Parks and Wildlife Department, Austin, Texas, USA.

Snyder, Eric. Plant Species at Risk Specialist, Ontario Ministry of Environment, Conservation and Parks, Peterborough, Ontario.

Thompson, Melinda. Management Biologist, Ministry of Natural Resources and Forestry, Guelph, Ontario.

Thorn, Greg Curator, Laurie L. Consaul Herbarium (UWO), Western University, London, Ontario.

van Hemessen, Will. Ecologist, Cambridge, Ontario.

Weerasuriya, Nimalka. Assistant to the Curator, Laurie L. Consaul Herbarium (UWO), Western University, London, Ontario.

Wernerehl, Robert. State Botanist of Massachusetts Natural Heritage & Endangered Species Program, Division of Fisheries & Wildlife, Westborough, Maine.

Williamson, Emily. Ecologist and Planner, City of London, London, Ontario.

Wilson, Ross. Water and Soils Resource Coordinator, Ausable Bayfield, Ontario. Conservation Authority, Exeter, Ontario.

Woods, Peter. Inventory Ecologist, Pennsylvania Natural Heritage Program, Pittsburgh, Pennsylvania.

Young, Steve. Chief Botanist, New York Natural Heritage Program, Albany, New York.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Audrey Heagy is a field biologist, technical writer and conservation practitioner with over 30 years' experience working for non-profit conservation organizations and as an independent consultant, primarily in southern Ontario. She was the lead writer for six other COSEWIC status reports (four bird species, one report on three plant species, and one insect species), the Ontario Barn Swallow Recovery Strategy, and many other technical reports and documents. She has extensive experience in planning, implementing and reporting on species at risk surveys and habitat management.

COLLECTIONS EXAMINED

No collections were examined additional to those consulted by Austen (1990) other than scanned digital images of specimens from the Dr. Laurie D. Consaul Herbarium (UWO) at Western University, London, ON.

Appendix 1. Summary of abundance information (number of patches[6], patch size, and number of stems[7]) for Eastern False Rue-anemone subpopulations (SP) and sites in Canada as of 1990, 2005, and 2020.

Site#	1980-1989 period	1990-2004 period	2005-2020 period
SP#1	**~150,000+ stems (~1990)**	**~136,000 stems (~2005)**	**n/a, surveys required (~2020)**
1.1	1989: no information, last observed 1969 when "sparse".	No information	No information
1.2	1989: no information, last observed 1960 when several large patches in one small area	No information	No information
1.3			2018: thousands of stems.
1.4	1987: Several thousand stems. 1989: 2 patches totaling 44 m^2 (15 to 29 m^2) with ~3,500-5000 stems	2004: ~3000 stems	No new information.
1.5			2018: large patch reported (only 1 plant observed in June)
1.6	1989: 1 very large patch with and 8 small patches (<1m^2) with ~750 stems. Estimated 12,000 stems.	2003: ~3000 stems.	No new information
1.7	1989: 6 patches, estimated 3,500 stems.	2003: ~3000 stems	No new information
1.8			2018: Small patch.
1.9	1989: ~30 patches, estimated 12,500 stems.	2003: ~10,000 stems	No new information
1.10		1993: scattered patches. 2004: not relocated	No new information
1.11	1989: 10 small patches (up to 2.2 m^2), estimated 800 stems.	Not found	2020: Patch with <100 stems found between sites 1.11 and 1.12
1.12	1989: 8 patches totaling 80 m^2 (range 0.4 to 57.8 m^2), no estimate of stem numbers.	Not found	
1.13	1989: 25 patches extending over 275 m^2, patch size 0.1 to 31.5 m^2 (mostly small), estimated 10,000 stems.	Estimated at least 10,000 stems, patchy distribution.	No new information
1.14	1989: large site with many patches and >100,000 stems, largest patch 5625 m^2.	100,000 stems	No new information? (spatial uncertainty)
1.15			2018: ~ 1000 stems 2020: present
1.16	1989: no information, last observed 1975 when large colony present.	No information	No new information

[6] The terms patch and colony are used interchangeably.

[7] The number of stems was often reported as the number of "plants", but all counts (and estimates) are based on stem counts (flowering and non-flowering).

Site#	1980-1989 period	1990-2004 period	2005-2020 period
SP#2	**530,000-735,000 stems (~1990)**	**535,000-735,000 stems (~2005)**	**n/a, surveys required (~2020)**
2.1	1989: 1 patch, 3 m^2, ~200 stems	Not found	No new information
2.2	1988: scattered clumps	Not found	Possible overlap with new site 2.11
2.3	1988: 2 clump, 1+ m across. Estimated as <500 stems.	Not found	Possible overlap with new site 2.11
2.4	1988: large clumps. No estimate of stem numbers.	Not found	Not found? (or possible overlap with site 2.9?)
2.5	1989: 1 large patch, several m in diameter.	Not found (additional habitat)	No search effort
2.6	1989: 3 small patches, estimated 12,500 stems	No search effort	2013: present, extends over ~ 50 x ~100 m area.
2.7	1989: 4 patches totaling 22 m^2 (patch size 3.5 to 11.3 m^2), estimated 1,750 stems.	Not found	2013: present at both 2.7 and 2.8 localities, combined extent of both sites mapped as ~75 x ~200 m. 2020: present
2.8	1989: large area with scattered patches with estimated 15,000-20,000 stems	~35,000 stems	
2.9	1986: present 1989: 25 m x 25 m area (625 m^2) with 500,000-700,000 stems.	Estimated 500,000-700,000 stems.	2013: 1 large colony (50+ m x 100 m) and 10 sub-colonies located up to 200 m north of main colony (total extent of site 150 m x 400 m). Possible overlap with other sites (2.4, 2.10)? No estimates of stems numbers in main colony, patch. 2004: <500 stems in 10 sub-colonies 2019: <1000 stems total in the 10 sub-colonies. 2020: present
2.10	1989: 1 patch, 0.5 m^2, with 50-75 stems	Not found	Not found? (or possible overlap with site 2.9?)
2.11	Possible overlap with sites 2.2 or 2.3		2013: 2 colonies with 5-10 stems each.
2.12			2013: 1 colony with 5-10 stems.
2.13			2013: present, extends over ~ 50 x ~100 m area.
SP#3	**n/a (~1990)**	**~500 stems (~2005)**	**~500 stems (~2020)**
3.0	No information; last observed in 1892.	No search effort?	No search effort? Potential habitat present.
3.1	1989: Not found (last observed 1891) but habitat present.	2002: 11 clusters along 110 m linear extent, with ~400 stems. Also, many isolated clumps of 15-25 stems.	2010: 8 patches (size range very small with 10 stems to 6 m^2) over a ~200 m linear extent including 6 patches totaling 10.5 m^2 plus 2 small patches with 60-70 stems. 2017: Several intermittent patches over 125 m linear extent plus some outliers.

Site#	1980-1989 period	1990-2004 period	2005-2020 period
SP#4	**3,500-6,000 stems (~1990)**	**1000 stems (~2005)**	**n/a, surveys required (~2020)**
4.1	1989: 14 patches, covering 25 m^2 (patch size 0.4 to 6.1 m^2) with estimated 2500-3000 stems.	Not found	No new information, habitat present.
4.2	1992: 20 to 30 patches with 50-100 stems each [1000-3000 stems]	Approx. 1000 stems	No new information, habitat present.
4.3			2008: 2 to 3 robust patches. 2016: 1 colony, 25 m^2 area with ~100-200 stems. Extensive additional habitat. 2017: ~500 stems in area 10 m^2 2020 – three adjacent patches (or 1 linear patch) with total area of 3.8 m^2 (1 to 1.5 m^2)
4.4			2009: 1 large patch plus scattered patches 2018: 1 very large linear patch +225 m long, 1 large linear patch 75 m long, 4 small patches
4.5			2009: at least 4 patches totaling 10 m^2 (patch size 2 to 4 m^2)
4.6			2010: 17+ patches, totaling ~86.5m^2 (patch size 0.25 to 48 m^2). 2018: 11+ patches, including 6 patches not found in 2010
SP#5	**n/a (~1990)**	**n/a, presumed extant (~2005)**	**historical, surveys needed (~2020**
5.1		1994 – present, no details	No new information, habitat present.
SP#6	**n/a, presumed extant (~1990)**	**n/a, presumed extirpated (~2005)**	**133-153 stems, additional surveys required (~2020)**
6.1	1981: sparse, no additional details.	Presumed extirpated	2016: 3 colonies totaling 475 m^2 (patch size 50 to 400 m^2) with 133-153 stems (13 to 70 stems per patch). Additional habitat present.
SP#7	**n/a, presumed extirpated (~1990)**	**n/a, presumed extirpated (~2005)**	**historical, additional surveys needed (~2020)**
7.1	No information; last observed in 1897.	No information; last observed in 1897.	2016: not found during limited search; additional habitat present so status changed to historical.
SP#8	**n/a (~1990)**	**n/a, record overlooked (~2005)**	**historical, surveys needed (~2020**
8.1		1994: present, no details	No new information, habitat present.
SP#9	**n/a (~1990)**	**n/a, record overlooked (~2005)**	**historical, surveys needed (~2020)**
9.1		1994: present, no details	No new information, habitat present.

Appendix 2. Summary of occurrence information for Eastern False Rue-anemone sites in Canada including year first observed, year last observed, year last searched, current abundance estimate, current status and approximate percent of population.

Site#	Previous records	Sources	2021 targeted survey[1]	First Obs	Last Obs	Last Search	Land Tenure	Abundance Estimate (stems)[2]	Current Status	Approx. % of population
SP#1 LOWER KETTLE CREEK (EO 2522, KETTLE CREEK NORTH OF PORT STANLEY) EXTANT (approximately 20-35% of population)										
1.1	**1989:** confirmed within past 5 years (ca.1985) **1969:** sparse	Austen 1990; NHIC 2020	Not searched	1969	~1985	~1985	Private?	Unknown	Historical (~1985)	Unknown
1.2	**1989:** confirmed within past 5 years (ca. 1985). **1960:** several large patches in one small area **1952:** sparse	Austen 1990; NHIC 2020	Not searched	1952	~1985	~1985	Private?	Unknown	Historical (~1985)	Unknown
1.3	**2018:** thousands of plants	McCune pers. comm. 2020.	Not searched	2018	2018	2018	Private	2000-10,000	Extant (2018)	<5
1.4	**2004 (Site 1h):** ~3000 stems **1989 (Site 18):** 2 patches (15 and 29 m^2) with ~3,500-5000 stems **1987:** Several thousand plants	Austen 1990; COSEWIC 2005; NHIC 2020	Two clusters (180 m apart) with total of 2240 plants (1390 and 850).	1987	2021	2021	Private	10,000	Extant	<5
1.5	**2018:** Small patch	McCune pers. comm. 2020.	Not searched	2018	2018	2018	Private	100-1000	Extant	<1
1.6	**2003 (Site 1f):** ~10,000 stems. **1989 (Site 16):** 1 very large patch with and 8 small patches (<1m^2) with 12,000 stems.	Austen 1990; COSEWIC 2005; NHIC 2020	2021: Very large patch, at least 2000 plants.	1989	2021	2021	Private	10,000+	Extant	<5
1.7	**2003(Site 1g):** ~3000 stems **1989 (Site 17):** 6 patches, estimated 3,500 stems.	Austen 1990; COSEWIC 2005; NHIC 2020	2021: Large cluster and very small outlier with total of 4215 plants	1989	2021	2021	Private	20,000	Extant	<10
1.8	**2018:** 1 plant observed in June but large patch reported by landowner	McCune pers. comm. 2020.	Not searched	2018	2018	2018	Private	1000-10,000	Extant	<5
1.9	**2004 (Site 17):** not re-located **1993:** scattered patches.	Austen 1990; COSEWIC 2005; NHIC 2020	Not searched	1993	1993	1993	Private	Unknown	Historical (1993)	Unknown
1.10 (four subsites)	**2003 (Site 1a):** ~10,000 stems **1989 (Site 11):** ~30 patches, estimated 12,500 stems	Austen 1990; COSEWIC 2005; NHIC 2020	Not searched but presumed extant	1989	2021	2021	Private	15,000 - 25,000	Extant	<10

Site#	Previous records	Sources	2021 targeted survey[1]	First Obs	Last Obs	Last Search	Land Tenure	Abundance Estimate (stems)[2]	Current Status	Approx. % of population
	2003 (Site 1d): Not found **1989 (Site 14)**:10 small patches (up to 2.2 m^2), estimated 800 stems.	Austen 1990; COSEWIC 2005; NHIC 2020	Not found, limited search							
	2020: Patch with <100 plants **2003 (Site 1c)**: Not found **1989 (Site 13):** 8 patches totaling 80 m^2 (range 0.4 to 57.8 m^2), no estimate of plant numbers.	Austen 1990; COSEWIC 2005; NHIC 2020	Two areas with total of 925 plants							
	2003 (Site 1b): Estimated at least 10,000 stems, patchy distribution. **1989 (Site 12):** 25 patches extending over 275 m^2, patch size 0.1 to 31.5 m^2, estimated 10,000 stems.	Austen 1990; COSEWIC 2005; NHIC 2020	Many small patches along 180 m section with 2025 plants							
1.11 (2 subsites)	**2020:** present **2018:** ~ 1000 plants **2003 (Site 1e):**100,000 stems **1989 (Site 15):** large site with many patches and >100,000 stems, largest patch 5625 m^2.	Austen 1990; COSEWIC 2005; NHIC 2020	Small patch with ~ 80 plants (800 m from main patch)	1989	2021	2021	Private	150,000	Extant	~15
			31500 plants in 6000 m2 area.							
1.12	**1975:** large colony present.	NHIC 2020	Not searched (potential habitat in vicinity)	1975	1975	1975	Unknown	Unknown	Historical (1975)	Unknown
SP#2 MEDWAY VALLEY LONDON (EO 2533 MEDWAY CREEK, LONDON), EXTANT (approximately 20-30% of population)										
2.1	**2003-2004 (Site 2a):** Not found **1989 (Site 1):** 1 patch, 3 m^2, ~200 stems **1958-1974:** multiple collections, presumed to be same sites as in 1989	Austen 1990; COSEWIC 2005; NHIC 2020	Not searched	1958	1989	2003	Institution	0	Extirpated	0
2.2 (2 subsites)	**2003-2004 (Site 2e):** Not found **1989 (Site 5):** 1 medium patch, 2500 stems	Austen 1990; COSEWIC 2005; NHIC 2020	Not found	1971	1989	2021	Institution	0	Extirpated	0
	1989: not mapped by Bowles **1971:** collected	NHIC 2020	Not searched							
2.3	**2013:** present **1989**: inferred present based on Bowles (1989) report	Bowles 1989; NHIC 2020	3 plants	1989	2021	2021	Municipal	10	Extant	<1

Site#	Previous records	Sources	2021 targeted survey[1]	First Obs	Last Obs	Last Search	Land Tenure	Abundance Estimate (stems)[2]	Current Status	Approx. % of population
2.4	**2003-2004 (Site 2d):** Not found **1988 (Site 4):** "large clumps or mats". No estimate of plant numbers.	Austen 1990; COSEWIC 2005; NHIC 2020	Small patch with 160 plants	1988	2021	2021	Municipal	800	Extant	~15
2.5 (2 subsites)	**2013-2020:** 1 main patch plus 10 small colonies up to 150 m upstream (northwest) of main patch. Size of main patch not estimated but density similar 2013-2020. Annual stem estimates for 10 small colonies (where Goutweed was controlled), increased from 367-437 stems in 2014 to 1235-1515 in 2020. **2003-2004 (Site 2i):** one colony, 500,000-700,000 stems. **1989 (Site 9):** approx. 25 m x 25 m area (~625 m^2) may contain 500,000-700,000 stems. **1986:** present	Austen 1990; COSEWIC 2005; Dillon 2020a; NHIC 2020	40 m x 50 m area (1750 m^2 polygon) with sparse density of 10 to 30 plants per square metre (average 15p/m^2) and several small outliers. Total of 30000 plants (26250 plants in main patch and 3115 plants in outliers)	1986	2021	2021	Municipal	150,000	Extant	~15
	2013-14: No plants mapped downstream of main patch **2003-2004 (Site 2j):** Downstream patch not found **1989 (Site 10):** 1 patch, 0.5 m^2, with 50-75 plants approximately 300 m south (downstream) of main patch	Austen 1990; COSEWIC 2005; NHIC 2020	No plants found in area downstream of main patch							
2.6 (3 subsites)	**2013:** present **2003-2004 (Site 2f):** Not checked **1989 (Site 6):** 3 small patches, estimated 12,500 stems	Austen 1990; COSEWIC 2005; NHIC 2020	3 patches with 1610 plants	1987	2021	2021	Municipal	50,000	Extant	~5
	2020: present **2013:** present **2003-2004 (Site 2g):** Not found **1989 (Site 7):** 4 patches totaling 22 m^2 (patch size 3.5 to 11.3 m^2), estimated 1,750 stems	Austen 1990; COSEWIC 2005; NHIC 2020	2 patches with 800 plants							

Site#	Previous records	Sources	2021 targeted survey[1]	First Obs	Last Obs	Last Search	Land Tenure	Abundance Estimate (stems)[2]	Current Status	Approx. % of population
	2003-2004 (Site 2h): ~35,000 plants **1989 (Site 8):** large area with scattered patches with estimated 15,000-20,000 plants	Austen 1990; COSEWIC 2005; NHIC 2020	2 clusters with 7730 plants.							
2.7 (3 subsites)	**2003-2004 (Site 2b):** Not found **1988 (Site 2):** scattered clumps	Austen 1990; COSEWIC 2005; NHIC 2020	Not found at mapped location.	1988	2021	2021	Municipal?	350	Extant	<1
	2003-2004 (Site 2c): Not found **1988 (Site 3):** 2 clumps, 1+ m across. Estimated as <500 plants.	Austen 1990; COSEWIC 2005; NHIC 2020	Not found at mapped location.							
	2013: 2 colonies with 5-10 plants each.	NHIC 2020	Two patches with total of 70 plants							
2.8	2013: 1 colony with 5-10 plants.	NHIC 2020	One patch with 30 plants	2013	2021	2021	Private?	150	Extant	<1
SP#3 PARKHILL (MUD) CREEK (EO 2524 PARKHILL CONSERVATION AREA, MUD CREEK) EXTANT (approximately 5- 10% of population)										
3.1	**2017:** Several intermittent patches over 125 m linear extent plus some outliers. **2010:** 8 patches (size range very small with 10 plants to 6 m^2) over a ~200 m linear extent including 6 patches totaling 10.5 m^2 plus 2 small patches with 60-70 plants. **2002:** 11 clusters along 110 m linear extent, with ~400 plants. Also, many isolated clumps of 15-25 plants. **1989:** Not found during limited search of general locale but habitat present. **1891-1892:** collected in general vicinity	Austen 1990; COSEWIC 2005; Jean, pers. comm. 2020; NHIC 2020	Observed 8900 plants total in ~40 patches (very small to large). Some known patches not checked in 2021. Estimated total of 10,000 plants.	2002	2021	2021	ABCA	50,000	Extant	~5
3.2	**2021:** two patches found **1989:** Not found during limited search of general locale but habitat present. **1891-1892:** collected in general vicinity	Austen 1990; NHIC 2020; McFarlane pers. comm. 2021	2 linear clusters, 12 m long and 60 m long, with 3260 plants	2021	2021	2021	ABCA	16,000	Extant	<5

Site#	Previous records	Sources	2021 targeted survey[1]	First Obs	Last Obs	Last Search	Land Tenure	Abundance Estimate (stems)[2]	Current Status	Approx. % of population
SP#4 AUSABLE RIVER VALLEY (EO2525 AUSABLE RIVER) EXTANT (approximately 5-10% of population)										
4.1	**1989:** not reported **1981:** collected **1958**: collected		Not found during limited search	1958	2021	2021	ABCA	0	Extirpated	0
4.2	**2003/04 (Site 4a):** Not found **1989 (Site 19):** 14 patches, covering 25 m^2 (patch size 0.4 to 6.1 m^2) with estimated 2500-3000 stems.	Austen 1990; COSEWIC 2005; NHIC 2020	10 patches with 1435 plants	1989	2021	2021	Private	7000	Extant	<5
4.3 (1 or 2 subsites)	**2018:** 11+ patches, including 6 patches not found in 2010 (2 subsites) **2010:** 17+ patches, totaling ~86.5m^2 (patch size 0.25 to 48 m^2) (2 subsites). **2003/04 (Site 4b):** Approx. 1000 stems (downstream subsite only) **1992:** 20 to 30 patches with 50-100 plants each.	COSEWIC 2005; Jean, pers. comm. 2020; NHIC 2020	Observed 2425 plants in 8 of 20+ known patches. Estimated total of 6000 plants spread along 300 m strip south and 250 m strip north of tributary stream	1992	2021	2021	ABCA	30,000	Extant	<5
4.4	**2018:** 1 very large linear patch +225 m long, 1 large linear patch 75 m long, 4 small patches **2009:** 1 large patch plus scattered patches	Jean pers. comm. 2020; NHIC 2020	Not checked	2009	2018	2018	ABCA	10,000 to 100,000	Extant	5-10
4.5	**2009**: at least 4 patches totaling 10 m^2 (patch size 2 to 4 m^2)	Jean pers. comm. 2020; NHIC 2020	Not checked	2009	2009	2009	ABCA	1000 to 10,000	Extant	<5
4.6	**2020:** three adjacent patches (or 1 linear patch) with total area of 3.8 m^2 (1 to 1.5 m^2) **2017:** ~500 plants in area 10 m^2 **2016:** 1 colony, 25 m^2 area with ~100-200 plants. Extensive additional habitat. **2008:** 2 to 3 robust patches.	Koscinski pers. comm. 2020; NHIC 2020	Four small patches with estimated 500 plant in 5 m x 3 m area at toe of slope.	2008	2021	2021	Private	2500	Extant	<1
SP#5 THAMES RIVERBEND LONDON (EO 13026 THAMES RIVER) EXTIRPATED										
5.1	**2003/04:** not checked **1994:** present, no details	Bowles *et al*. 1994; COSEWIC 2005; NHIC 2020	Intensive search of reported habitat patch and along trails. Not found	1994	1994	2021	Municipal	0	Extirpated	

Site#	Previous records	Sources	2021 targeted survey[1]	First Obs	Last Obs	Last Search	Land Tenure	Abundance Estimate (stems)[2]	Current Status	Approx. % of population
SP#6 DODD CREEK (EO 115666 LOT 44 E of MIDDLEMARCH FOREST COMPLEX) EXTANT (<5% of population)										
6.1	**2016:** 3 colonies totaling 475 m^2 (patch size 50 to 400 m^2) with 133-153 plants (13 to 70 "plants" per patch). Additional habitat present. **1981:** sparse, no additional details.	NHIC 2020	Estimated 1147 plants in 20 small patches. along 150 m section of creek terrace, Possible that additional patches further upstream (not checked)	1981	2021	2021	Private	5,000 to 10,000 stems	Extant	<5
SP#7 LYNN VALLEY (EO 95609 NEAR LYNN VALLEY) HISTORICAL										
7.0	**2016:** not found during limited search; additional habitat present so status changed to historical. **2003/04:** not checked. **Pre-2002:** Undocumented report **1989:** Not checked. **1897:** Report of collection but no known specimen.	NHIC 2020; McKeown pers. comm. 2021	Not found during limited search. Additional potential habitat not searched.	1897	1897	2021	Unknown	Unknown	Historical	Unknown
SP#8 ARVA MORAINE EAST (EO 115681 EAST OF ARVA, CITY OF LONDON) EXTANT (<1% of population)										
8.1	**1994:** present, no details	Bowles *et al*. 1994; NHIC 2020	2021: 3 small patches, total of about 350 plants	1994	2021	2021	Private	1750	Extant	<1
SP#9 MEDWAY CREEK NORTH (EO 96274 MEDWAY CREEK, NORTH OF ARVA) HISTORICAL										
9.1	**1994:** present, no details	Bowles *et al*. 1994; NHIC 2020	Not surveyed	1994	1994	1994	Private	Unknown	Historical	Unknown

1 2021 surveys estimated number of "plants", with ~3-8 stems per plant.

2 2021 abundance estimates converted to estimated number of stems by multiplying by ~5

Appendix 3. Threat Calculator for Eastern False Rue-anemone.

THREATS ASSESSMENT WORKSHEET			
Species or Ecosystem Scientific Name	Eastern False Rue-anemone (*Enemion biternatum*)		
Element ID	1053174	**Elcode**	PDRAN0G010
Date:	22/06/2021		
Assessor(s):	Bruce Bennett (Co-chair), Audrey Heagy (writer); Burke Korol (ECCC), Colin Jones (ON); Sam Brinker (ON & SSC member); Linda McDougall (City of London); Will van Hemessen (North-South Environmental Inc., Cambridge); **SSC Members**: Del Meidinger (Co-chair), David Mazzerole, Danna Leaman, Vivian Brownell, Dan Brunton, Anna Hargreaves; Angèle Cyr (Secretariat).		
References:	COSEWIC 2005, Dillon (2020a, b), Ian Jean (pers. comm. 2020) and site visits (Heagy pers. obs. 2021)		

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		Generation time 3 - 10 years in Technical Summary; will use 6 years for threats calculator, so 3 generations is 18 years. (Audrey: just a guess; based on a 'reasonable estimate to start of flowering'; some ramets are long lived, so 10 years considered upper end for an individual). Three low threats rolled up to two low threats. Three lows still calculates to a low impact even if invasive species are moved to 7.3	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development						
1.1	Housing & urban areas						Almost all patches are situated on hazard lands or valleylands. Residential development feasible at one site (#8.1) on private lands adjacent to urban boundaries. Unlikely within 30 years. Threat not scored as no plants directly impacted by threat.
1.2	Commercial & industrial areas						not applicable
1.3	Tourism & recreation areas						Golf courses adjacent to several sites (1.7, 8.1, 2.2) but expansion and or new developments considered unlikely. Threat not scored as no plants directly impacted by threat.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	
2.1	Annual & perennial non-timber crops		Negligible	Negligible (<1%)	Serious - Slight (1-70%)	High (Continuing)	Historical threat and some ongoing impacts from farm use (access roads, brushing) but additional land clearing at known sites unlikely. Damage to part of a patch observed at one site, maybe 1000 plants affected (1% scope), impact is uncertain as patch may regrow. Other sites with patches on edge of a field. Farm clearing, i.e., cleaning up the edge of the field, happens regularly. Over the long term, may not be much of a decline as some plants move into habitat adjacent to field and then can be lost when some farm work done. The scope is negligible.
2.2	Wood & pulp plantations						not applicable
2.3	Livestock farming & ranching						Historical threat from grazing on floodplains and in woodlots (page fence present at most sites) and occurring nearby but not occurring or likely to occur at known sites
2.4	Marine & freshwater aquaculture						not applicable
3	Energy production & mining						
3.1	Oil & gas drilling						not applicable (not mentioned in previous report, no indications from available maps)
3.2	Mining & quarrying						Potentially happening near SP#9.
3.3	Renewable energy						not applicable (not mentioned in previous report, no indications from available maps)
4	Transportation & service corridors		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	One small patch (<100 plants) in SP#1 impacted by roadside drainage work. Salt from road (mentioned in previous report) also a possible threat for this patch.
4.2	Utility & service lines						not applicable
4.3	Shipping lanes						not applicable
4.4	Flight paths						not applicable
5	Biological resource use		Unknown	Small (1-10%)	Unknown	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.2	Gathering terrestrial plants		Negligible	Negligible (<1%)	Negligible (<1%)	Low (Possibly in the long term, >10 yrs/3 gen)	Wildflower picking identified as potential threat in previous reports. Does not appear to be an issue at present (timing low). Possible at trailside patches but severity and impact on population negligible.
5.3	Logging & wood harvesting		Unknown	Small (1-10%)	Unknown	High (Continuing)	Logging is occurring periodically at some privately owned sites (e.g., 1.10) in several subpopulations (SPs #1, 4, and 6). Direct impact variable depending on extent of canopy opening and ground disturbance. Logging usually in winter, but some direct impact, particularly if ground not frozen. Regulated by municipal tree-cutting bylaws. No evidence of direct loss or significant harm due to logging activities. May be somewhat beneficial in that tops left from logging provide protection from browsing. Indirect impact of logging is introduction of invasive species -- treated below (8.1).
5.4	Fishing & harvesting aquatic resources						not applicable
6	Human intrusions & disturbance	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Recreational trails present in vicinity of many patches at most subpopulations. Trampling is main threat but relatively few plants directly impacted. Indirect impact from trails providing pathway for invasive species. Use is increasing/likely to increase at sites near new residential developments (6.1, 8.1). Some public landowners (SP#2, SP#3, SP#4) are trying to manage recreational trails to minimize impact on this species.
6.2	War, civil unrest & military exercises						not applicable
6.3	Work & other activities		Not a Threat	Restricted (11-30%)	Neutral or Potential Benefit	High (Continuing)	Mitigation measures used for invasive plant control at Medway Valley Heritage Forest ESA. Overall benefit. Mowing of a berm (site 3.2) noted but impact insignificant. B. Korol: mowing sometimes done on berms to control woody vegetation (so root penetration is reduced - roots (especially when rotting) can reduce structural stability of berm).
7	Natural system modifications		Unknown	Pervasive - Restricted (11-100%)	Unknown	High (Continuing)	
7.1	Fire & fire suppression						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.2	Dams & water management/use						Historical threat (e.g., Parkhill reservoir) but no plans for additional structures
7.3	Other ecosystem modifications		Unknown	Pervasive - Restricted (11-100%)	Unknown	High (Continuing)	Pollinator decline due to cumulative impact of agricultural chemicals and other pollution scored here. Potential threat, particularly for small subpopulations due to genetic inbreeding and reduced reproductive success (ECCC 2017). Plant can self-pollinate but is not always self-pollinated. There are genetic advantages to cross-pollination.
8	Invasive & other problematic species & genes	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
8.1	Invasive non-native/alien species/diseases	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Competition from invasive non-native plants and canopy tree mortality due to non-native forest pests both scored here. Garlic Mustard present at most sites (since 1980s) but not extensive. Goutweed impacting some patches in SP#2, SP#5). Successful control efforts implemented by City of London at SP#2 site. Dog-strangling Vine is a potential/emerging threat. Emerald Ash borer has killed most ash trees but no evidence of impact other than increased windfall and sapling growth. Beech Bark Disease and Beech Leaf Disease are present in region and beech is present to common at many sites depending on logging history. As difficult in this case to separate degrading habitat quality (modification of site) from direct impact of invasive species, both aspects area dealt with here. The effect of invasive species, as noted over past 10 years, has shown impact to overall population not to be that high. As far as we know, City of London will continue their control efforts and this was considered in the severity rating. Garlic Mustard has allelopathic effect but even though the plant has been observed at some sites, direct mortality has not been observed. Allelopathic effects may not have shown yet. Dillon Consulting 2019 report, the main colony is of similar density to 2013; encroachment of Goutweed into main colony has not been observed. David: Could there be local decline but some habitat shifting going on and numbers appear relatively stable? The native Wild Ginger is main competitor at MVHF ESA, not Goutweed.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species/diseases	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	White-tailed Deer browsing and trampling observed at most sites, reduced vigour except where plants are protected (by branches, fences, etc.) but not causing severe damage. Hyperabundant here! Observed that where browsing, plants were smaller, with fewer flowers, vs. those protected by fallen branches, etc. They have reduced productivity. Ongoing threat that hasn't shown to be of high impact. Browsed plants likely to survive, although continued browsing will show decline until possibly death. Some loss due to trampling. Ranunculaceae are generally toxic. Biggest long-term impact is prevention of reproduction. Perhaps a limiting factor? The deer are also removing competition, as they go after other plants before going after this species.
8.3	Introduced genetic material						not applicable
8.4	Problematic species/diseases of unknown origin						not applicable
8.5	Viral/prion-induced diseases						not applicable
8.6	Diseases of unknown cause						not applicable
9	Pollution		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	
9.1	Domestic & urban waste water		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Many sites in SP#2 are likely sometimes impacted by urban runoff (fertilizer). Several sites in SP#1 are downstream of St. Thomas sewage outfall. SP#5 downstream from London sewage outfall. Increased nutrients promote competition, particularly non-native species (Garlic Mustard). Even on edges of fields where some nutrients and pesticides, the plants are surviving. So likely not driving much decline. Forest is not likely nutrient limiting in its natural state.
9.2	Industrial & military effluents						not applicable
9.3	Agricultural & forestry effluents		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Agricultural run-off (nutrients, sediments) and/or pesticide drift potentially impacting several sites that are adjacent to/downslope from crop fields (especially in SP#1 and #6). Main impact is competition from lush grassy vegetation along field edges and active floodplain area.
9.4	Garbage & solid waste						not applicable or negligible (waste dumping not mentioned in previous reports)

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.5	Air-borne pollutants						not applicable
9.6	Excess energy						not applicable
10	Geological events						
10.1	Volcanoes						not applicable
10.2	Earthquakes/tsunamis						not applicable
10.3	Avalanches/landslides						not applicable or negligible (soil erosion mentioned re site 2.7 in previous report)
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Climate change likely causing some changes to habitat conditions but unknown severity. Fragmented habitat creates barrier to movement.
11.2	Droughts		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Increasing drought with changing climate might have some impact.
11.3	Temperature extremes		Negligible	Pervasive (71-100%)	Negligible (<1%)	Low (Possibly in the long term, >10 yrs/3 gen)	Early spring flowering plant. Extreme temperatures could impact pollinator activity for that year
11.4	Storms & flooding		Unknown	Large (31-70%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Some plants situated on eroding shorelines and increase in storms due to climate change could impact erosion rates. Species is likely dependent on flooding events for long-distance dispersal (root masses and seeds). Subpopulations on floodplains and valley slopes could also be impacted by more frequent 100-year flood events (erosion, standing water in spring).
11.5	Other impacts						