COSEWIC
Assessment and Status Report

on the

Toothcup
Rotala ramosior

Great Lakes Plains population
Southern Mountain population

in Canada

Great Lakes Plains population – THREATENED
Southern Mountain population – ENDANGERED
2014

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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Previous report(s):

COSEWIC. 2000. COSEWIC assessment and status report on the toothcup *Rotala ramosior* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 19 pp.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Rotala rameux (*Rotala ramosior*), population des plaines des Grands Lacs et la population des montagnes du Sud, au Canada.

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Toothcup — Photo credit: Sprawling Toothcup plant at Puzzle Lake, Ontario (photo by S.R. Brinker on 30 August 2011).

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COSEWIC
Assessment Summary

Assessment Summary – November 2014

Common name
Toothcup - Great Lakes Plains population

Scientific name
Rotala ramosior

Status
Threatened

Reason for designation
This annual plant is known from the shores of only two lakes at the southern edge of the Canadian Shield in southeastern Ontario. Year-to-year fluctuations in water levels along the lakeshore impact the abundance of plants. Impacts from development, recreational boating activities, and manipulation of water levels have the potential to reduce the number of individuals.

Occurrence
Ontario

Status history
The species was considered a single unit and designated Endangered in April 1999. Status re-examined and confirmed in May 2000. Split into two populations in November 2014. The Great Lakes Plains population was designated Threatened in November 2014.

Assessment Summary – November 2014

Common name
Toothcup - Southern Mountain population

Scientific name
Rotala ramosior

Status
Endangered

Reason for designation
This annual plant is known from just two local populations in the Southern Interior of British Columbia. Some locations have been lost as a result of shoreline development; at present, this species is limited by the availability of suitable seasonally wet sites, and threatened by invasive exotic plant species.

Occurrence
British Columbia

Status history
The species was considered a single unit and designated Endangered in April 1999. Status re-examined and confirmed in May 2000. Split into two populations in November 2014. The Southern Mountain population was designated Endangered in November 2014.

COSEWIC
Executive Summary

Toothcup
Rotala ramosior

Great Lakes Plains population
Southern Mountain population

Wildlife Species Description and Significance

Toothcup is a low growing annual plant in the loosestrife family (Lythraceae). Its small flowers are sessile, and usually solitary in the leaf axils. Flowers usually have 4 white or pink petals up to 1 mm long. In Canada, Toothcup is at the northern limit of its North American range. Populations at the edge of a species' range may be genetically distinct.

Distribution

Toothcup is native to North America, Central America, and South America. In North America, it ranges in the east from Massachusetts south to Florida, and west from southern Minnesota, south to Texas and into Mexico. It is found only sparingly in the Midwestern US and Intermountain region, appearing more frequently along the west coast from California, north to south-central British Columbia. It has a disjunct distribution in Canada, known from Ontario and British Columbia.

Habitat

Toothcup is a species of open, seasonally wet areas with natural or artificial water level fluctuation. Its habitat includes riverbanks, ditches, pond margins, sandy to muddy shores, interdunal swales, and occasionally, moist edges of cultivated fields. In south-central Ontario, it grows in moist, shallow bedrock crevices filled with small accumulations of sand, gravel and peat along lake and river shorelines. In southwestern Ontario, it formerly grew in remnant sand prairie within moist old field habitat. In the South Okanagan Valley of British Columbia, Toothcup inhabits moist to wet, sometimes saline, muddy to sandy shorelines of lagoons or ponds, inshore swales, and shallow depressions. In the Kamloops area, it inhabits sandy or silty, shallow depressions and interdunal swales, or muddy silty-sands of exposed channel banks.

Biology

Toothcup is an annual plant associated with periodically flooded areas, and populations may undergo large fluctuations from year to year. It reproduces sexually, producing copious amounts of seed. The large majority of Toothcup seeds are dormant when they mature in autumn, but tend to break dormancy while flooded in late fall or winter.

Population Sizes and Trends

The total Canadian population of Toothcup was estimated to include at least 6,859 individuals in 2011, when it was known from four subpopulations, including two in Ontario (Great Lakes Plains DU) and two in British Columbia (Southern Mountain DU).

In Ontario, counts from 2011 were low relative to counts from previous years. A total of 1,444 mature individuals was recorded (305 mature individuals from Sheffield - Long Lake / Clare River and 1,139 from Puzzle Lake). The highest count was made in 2004, when 4,325-6,325 mature individuals were counted (2,615-4,615 from Sheffield - Long Lake / Clare River and 1610-1710 from Puzzle Lake).

In British Columbia, between 5,410 and 5,570 individuals were observed in 2011 at two sites in the Kamloops subpopulation. No individuals were observed from the other previously reported Kamloops site at McArthur Island. No individuals were observed at the South Okanagan Valley subpopulation in 2011, but not all sites were visited, including one which held an estimated 12,000 individuals in 2004. The highest single year estimate here was 12,180 individuals in 2004.

Since the previous assessment, no losses of Toothcup subpopulations have been documented in Ontario. Infrequent counts at both subpopulations suggest fluctuations among years, though census data are insufficient for assessment of trends. In British Columbia, although the Kamloops subpopulation is extant, the South Okanagan Valley subpopulation is believed to be declining and several sites are known to have been extirpated historically. The likelihood of natural immigration of Toothcup from outside Canada is extremely low.

Threats and Limiting Factors

The Canadian range of Toothcup is limited by its restricted occurrence to seasonally flooded habitats. In Ontario, shoreline development and recreational activities are the main threats. In British Columbia, invasive plant species pose the greatest threat to extant populations of Toothcup. Habitat loss through development, habitat degradation and livestock, as well as the modification of natural Osoyoos Lake levels, are also threats in British Columbia.

Protection, Status, and Ranks

Toothcup was originally designated by COSEWIC as Endangered in Canada in 1999 and is listed on Schedule 1 of the federal *Species at Risk Act*. A federal Recovery Strategy has not yet been finalized for Toothcup. COSEWIC assessed the Great Lakes Plains population of Toothcup as Threatened and the Southern Mountain population as Endangered in November 2014. Toothcup is listed as an Endangered Species under the Ontario *Endangered Species Act, 2007*, receiving species and habitat-level protection. It also receives protection in Puzzle Lake Provincial Park and Mellon Lake Conservation Reserve. There is no specific legal protection for Toothcup in British Columbia. The General Status rank for Toothcup is “At Risk” for Ontario, British Columbia, and Canada.

TECHNICAL SUMMARY - Great Lakes Plains Population

Rotala ramosior

Toothcup (Great Lakes Plains population) Rotala rameux (Population des plaines des Grandes Lacs)

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 (2008) is being used)	<1 yr
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? Consistent monitoring at subpopulations over years is lacking. Possible loss of one site at the Sheffield – Long Lake / Clare River subpopulation (this would represent a loss of 2,615-4,615 mature individuals).	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	N/A
Are there extreme fluctuations in number of mature individuals? A fluctuation in the order of magnitude of 10 or greater has been observed at the Sheffield – Long Lake / Clare River subpopulation (from a low of 0 to a high of 2,615-4,615).	Possibly

Extent and Occupancy Information

Estimated extent of occurrence EO was estimated as 3.4 km^2, but in accordance with COSEWIC guidelines, is set equal to the IAO.	20 km^2
Index of area of occupancy (IAO) (Always report 2x2 grid value).	20 km^2
Is the total population severely fragmented? Nearest population is in New York State, over 500 km to the south.	No
Number of locations* 1) Along Puzzle Lake, 4 locations are defined based on land ownership (3 private parcels, 1 for public land) 2) Sheffield - Long Lake / Clare River, 3 locations (2 private, 1 public).	7

*See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No
Is there an [observed, inferred, or projected] continuing decline in number of locations?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population *(in 2011)*	**N Mature Individuals**
Puzzle Lake	1,139
Sheffield Long Lake – Clare River	305
Total	1,444

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	N/A

Threats (actual or imminent, to populations or habitats)

1) Shoreline development
2) Shoreline impacts of recreational activities.
3) Water level manipulation

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? U.S.A.: not currently of conservation concern throughout its core range; of conservation concern in adjacent/nearby northeastern states: New Hampshire (SH), Minnesota (S2), New York (S2), and Michigan (S3).	
Is immigration known or possible? Toothcup is present in adjacent states in New York and Michigan.	Possible
Would immigrants be adapted to survive in Canada?	Unknown but likely
Is there sufficient habitat for immigrants in Canada? Unoccupied habitat exists in central Ontario on undeveloped shorelines with fluctuating water levels.	Yes.

Is rescue from outside populations likely? Toothcup is rare and declining in the northeastern US / adjacent states.	Unlikely

Status History

COSEWIC Status History: The species was considered a single unit and designated Endangered in April 1999. Status re-examined and confirmed in May 2000. Split into two populations in November 2014. The Great Lakes Plains population was designated Threatened in November 2014.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Threatened	B1ab(iii)+2ab(iii)

Reasons for designation:
This annual plant is known from the shores of only two lakes at the southern edge of the Canadian Shield in southeastern Ontario. Year-to-year fluctuations in water levels along the lakeshore impact the abundance of plants. Impacts from development, recreational boating activities, and manipulation of water levels have the potential to reduce the number of individuals.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not met. Trend data are insufficient for quantifying declines.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Threatened B1ab(iii)+2ab(iii) because EO and IAO are below thresholds, there are 7 inferred locations, and habitat quality is declining.
Criterion C (Small and Declining Number of Mature Individuals): Not met. No documented declines.
Criterion D (Very Small or Restricted Total Population): Not met. Although the IAO is below the threshold, threats from habitat modification are not expected to act over very short timeframes.
Criterion E (Quantitative Analysis): Not done. Not met. No quantitative analysis.

TECHNICAL SUMMARY - Southern Mountain Population

Rotala ramosior

Toothcup (Southern Mountain population) Rotala rameux (Population des montagnes du Sud)

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

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 (2008) is being used)	<1 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? Although consistent monitoring at subpopulations over years is lacking, two of the South Okanagan Valley sites may be lost or will be lost because of rapid invasion by introduced grasses.	Yes
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals? A fluctuation in the order of magnitude of 10 or greater has been observed at two of the South Okanagan Valley sites (from a low of 4 to a high of 2250 and from ~600 to ~12,000), but fluctuations do not appear to be synchronous across sites.	Yes

Extent and Occupancy Information

Estimated extent of occurrence	630 - 1080 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	20 – 28 km²

Is the total population severely fragmented?	No
Number of locations* 1. South Okanagan Valley includes 2-4 locations: one at Mica Spit, another on private property. Both threatened by invasive exotic species. A site on the Osoyoos Oxbows though not seen since 1995 may still be extant and a collection labelled “mouth of Inkaneep Creek” has not been relocated. 2. Kamloops subpopulation considered 3 locations based on land management and ownership. Location defined based on common threat of invasive exotic species.	5-7
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Possibly
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy? Loss of the South Okanagan Valley subpopulation is projected.	Possibly
Is there an [observed, inferred, or projected] continuing decline in number of populations? Loss of the South Okanagan Valley subpopulation is projected	Possibly
Is there an [observed, inferred, or projected] continuing decline in number of locations*? Loss of the South Okanagan Valley subpopulation is projected	Possibly
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population *(in 2011)*	**N Mature Individuals**
South Okanagan Valley (*excluding Veronica Lake, Osoyoos Oxbows, and Inkaneep Creek, which were not revisited*)	0
Kamloops	5,415 – 5,575
Total	5,415 – 5,575

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	N/A

*See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this

Threats (actual or imminent, to populations or habitats)

1) Invasive Species
2) Habitat loss and development
3) Altered flood dynamics

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? U.S.A.: not currently of conservation concern throughout its core range; of conservation concern in its northwestern range limits in Montana, Oregon and Washington	
Is immigration known or possible? Toothcup is present in adjacent Washington State.	Possible
Would immigrants be adapted to survive in Canada?	Unknown but likely
Is there sufficient habitat for immigrants in Canada? Suitable unoccupied habitat also exists in the Kamloops and Thompson River areas of British Columbia.	Possibly
Is rescue from outside populations likely? Toothcup is rare or absent in adjacent or nearby U.S. states.	Unlikely

Status History

COSEWIC: The species was considered a single unit and designated Endangered in April 1999. Status re-examined and confirmed in May 2000. Split into two populations in November 2014. The Southern Mountain population was designated Endangered in November 2014.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	B1ab(iii)+2ab(iii)

Reasons for designation:
This annual plant is known from just two local subpopulations in the Southern Interior of British Columbia. Some locations have been lost as a result of shoreline development; at present, this species is limited by the availability of suitable seasonally wet sites, and threatened by invasive exotic plant species.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals):
Not met. Trend data are insufficient to quantify declines.

Criterion B (Small Distribution Range and Decline or Fluctuation):
Meets Endangered B1ab(iii)+2ab (iii) because EO and IAO are below thresholds, and there are 5-7 locations, and declines in habitat quality are observed (iii).

Criterion C (Small and Declining Number of Mature Individuals):
Not met. Close to meeting Threatened, but no documented declines (because of inconsistent surveys and fluctuations).

Criterion D (Very Small or Restricted Total Population): Not met. Although the IAO is below the threshold, the key threat (invasive exotic species) is not thought to have the potential to act over a very short timeframe.
Criterion E (Quantitative Analysis): Not met. No quantitative analysis.

PREFACE

Since the 2002 assessment of the Toothcup, declines at one British Columbia subpopulation have been documented, and habitat quality continues to deteriorate due to shoreline disturbance, change in flood dynamics, and loss of habitat from invasive species.

This report reflects field survey work conducted in 2011 in Ontario and British Columbia, and ongoing monitoring by Ontario Ministry of Natural Resources staff since 2000. Two designatable units (DUs) are described: the Great Lakes Plains DU (Ontario) and the Southern Mountain DU (British Columbia). The division is based on the discreteness of the eastern and western populations and their lack of biotic or abiotic interactions.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2014)

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

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

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

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

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

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Rotala ramosior

Great Lakes Plains population
Southern Mountain population

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2014

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Rotala ramosior* (L.) Koehne in Martius, [Fl. brasiliensis 13(2): 194. 1877]

Synonyms:
Ammannia ramosior L.
Ammannia humilis Michaux
Ammannia catholica Cham. & Schlecht
Ammannia monoflora Blanco, Fl. Filip
Ammannia occidentalis DC
Ammannia dentifera A. Gray
Ammannia ramosa Hill
Boykinia humilis (Michx.) Raf.
Peplis occidentalis Sprengel
Rotala catholica (Cham. & Schltdl.) Leeuwen
Rotala dentifera (A. Gray) Koehne
Rotala ramosior var. *dentifera* (A. Gray) Lundell
Rotala ramosior var. *interior* Fernald & Griscom

Common Name: English: Toothcup, Toothcup Meadow-foam, Branched Toothcup, Lowland Toothcup, Lowland Rotala, Toothcap, Wheelwort
French: Rotala rameux

Family: Lythraceae (Loosestrife family)

Major Plant Group: Eudicot flowering plant

Type Specimen: North America, Virginia, *Clayton (Gronovius) No. 774* (holotype: BM, see Fernald & Griscom, Rhodora 37: 169. 1935).

Toothcup (*Rotala ramosior*) is a member of the Lythraceae, which includes terrestrial and aquatic shrubs and trees as well as annual and perennial herbs. *Rotala* consists of small-flowered annual or perennial herbs of terrestrial, aquatic, or periodically flooded environments. The 49 species of *Rotala* occur mainly in the subtropics and tropics, with a few temperate members (Graham *et al*. 2011). Toothcup is the only native representative of the genus in North America.

Morphological Description

Toothcup is a low, sprawling to erect, simple or branched, terrestrial or semi-aquatic annual, usually 10-25 cm tall with weakly 4-angled stems (Figures 1 & 2). Leaves are in opposite pairs that alternate at right angles along the stem, and flowers are typically solitary with 4 white or pink petals up to 1 mm long. Fruits are globose, up to 4.5 mm in diameter, opening by valves to release numerous dark red to brown seeds, roughly 0.5 mm long (Cook 1979).

In Canada, Toothcup may be mistaken for Scarlet Ammannia (*Ammannia robusta*) and Marsh Seedbox (*Ludwigia palustris*). Scarlet Ammannia only grows with Toothcup in British Columbia, while Marsh Seedbox is a common associate in Ontario.

Figure 1. Sprawling Toothcup plant at Puzzle Lake, Ontario (photo by S.R. Brinker on 30 August 2011).

Figure 2. Patch of Toothcup plants from Mica Spit area (C. Björk 2005).

Population Spatial Structure and Variability

Fernald and Griscom (1935) described two varieties of *Rotala ramosior* based on geographic distribution and morphological variation. Current treatments of *Rotala* do not recognize infraspecific taxa (e.g., Godfrey and Wooten 1981; Voss 1985; Gleason and Cronquist 1991; Kartesz 1994; Crow and Hellquist 2000; Michigan Flora Online 2011).

The genetic structure and morphological variability of the Canadian Toothcup population have not been studied. Subpopulations are widely disjunct, occurring in Ontario and British Columbia, and occupy different ecozones. There are no known morphological or genetic differences that distinguish the populations in Ontario and British Columbia.

Designatable Units

Two designatable units (DUs) for Toothcup are described in this report: the Great Lakes Plains designatable unit (Ontario) and the Southern Mountain designatable unit (British Columbia). The Great Lakes Plains DU captures the extirpated Rotala Field subpopulation in Norfolk County as well as the Puzzle Lake and Sheffield – Long Lake / Clare River subpopulations even though they technically lie in the Boreal Ecozone. Because of their proximity to the Great Lakes Plains Ecozone and because Toothcup is not a boreal species, this subpopulation has been included in the Great Lakes Plains DU. The two proposed DUs (Figure 3) are discrete based on the large, natural disjunction that separates populations in Ontario and British Columbia such that movement of individuals between regions is not likely. This disjunction could drive the formation of genetically distinct populations, and the loss of either unit would significantly alter the Canadian range and extent of occurrence. The ecological settings of subpopulations in the two DUs are notably distinct.

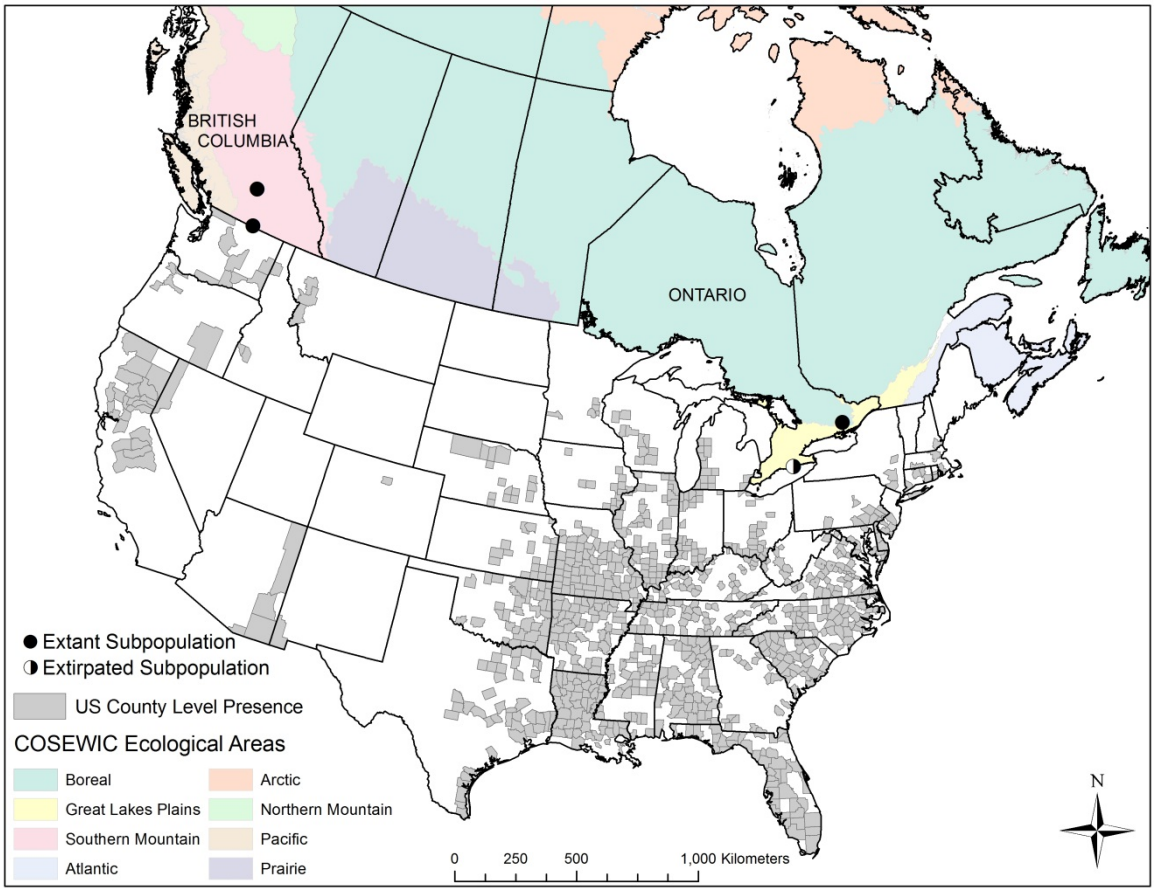

Figure 3. North American distribution of Toothcup with COSEWIC National Ecological Areas. County-level US distribution based on BONAP (2011).

Special Significance

Toothcup subpopulations in Canada are at the northern limit of the species' North American range. A number of other plant species of conservation concern found in southern Ontario and British Columbia share similar patterns of distribution and may represent relictual, more southerly populations of a once more continuous distribution (Argus and White 1977; Straley *et al*. 1985; Argus 1992; Brownell *et al.* 1996). Populations at the edge of a species range may be genetically distinct and, thus, may be especially important for the future adaptive potential of the species (Lesica and Allendorf 1995).

The genus *Rotala* is popular among pond and aquarium enthusiasts. Most commercially available and commonly grown species are from tropical Asia and India, but Toothcup is occasionally sought after and propagated.

No Aboriginal traditional knowledge sources for Toothcup have been found.

DISTRIBUTION

Global Range

Toothcup ranges widely in North America (Figure 3), from Massachusetts west through southern Ontario and Minnesota, south to Florida, Arkansas, Texas, and Mexico. It is rare in the Intermountain and Rocky Mountain regions, increasing in frequency along the west coast from central California north to southern British Columbia. Toothcup also occurs in portions of Central and South America, although its full range in these regions is poorly known.

Canadian Range

Toothcup has a restricted and disjunct distribution in Canada, representing less than one percent of the species' global range. It is presently known from south-central Ontario and south-central British Columbia.

In Ontario (Figure 4), Toothcup is restricted to shoreline habitat on Puzzle Lake and Sheffield – Long Lake (an enlargement of the Salmon River) and adjoining Clare River. These water bodies are situated along the southern edge of the Canadian Shield in the county of Lennox and Addington. Plants in Ontario are disjunct from the nearest population in New York State by almost 500 km (Brownell *et al.* 1996). Toothcup was formerly present in two sandy fields near Walsh Station in Norfolk County (Sutherland 1987), roughly 350 km southwest of the southern Shield subpopulations. Both Norfolk County sites were ploughed to make way for cropland by 1987.

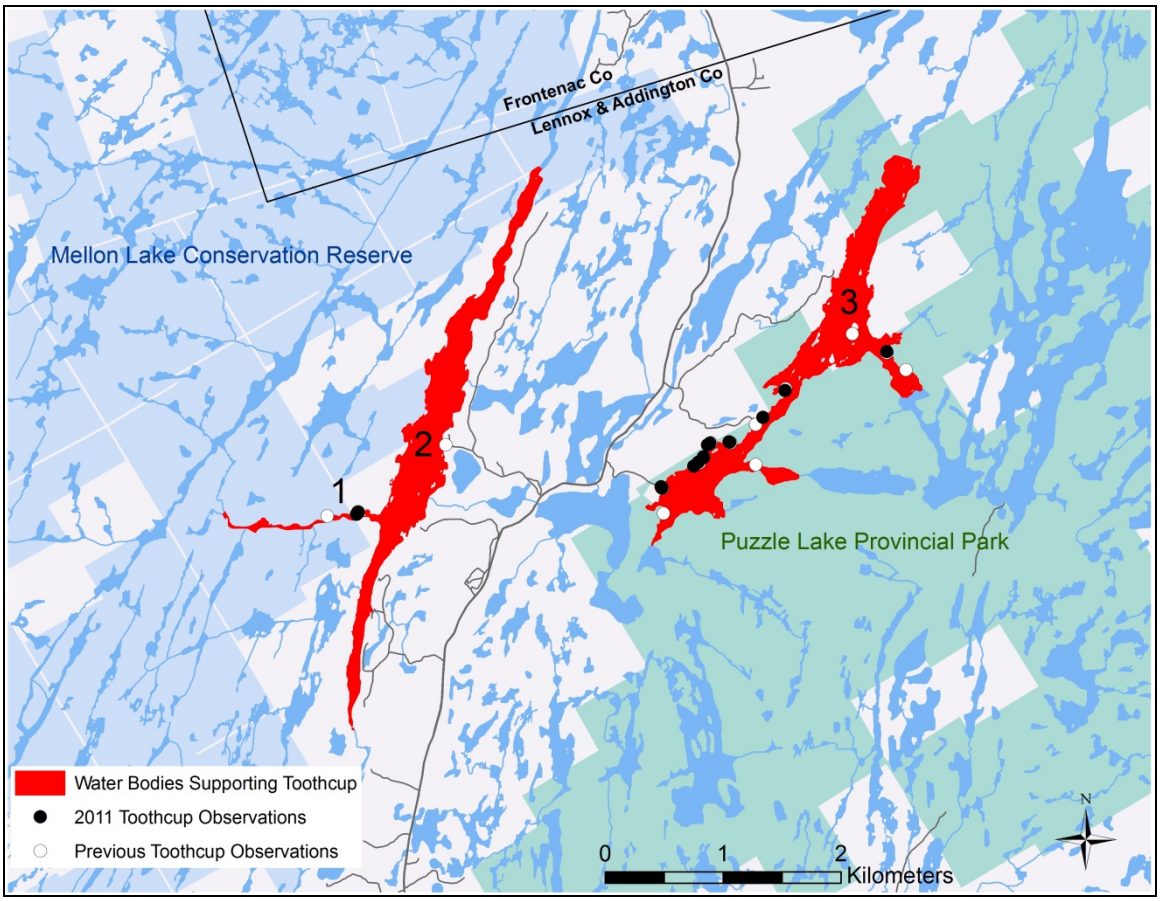

Figure 4. Extant locations of Toothcup in Ontario. Numbered water bodies referred to in the text are: 1. Clare River; 2. Sheffield - Long Lake; 3. Puzzle Lake. Solid circles represent subpopulations documented in 2011; white circles represent previously documented subpopulations not observed in 2011.

In British Columbia (Figure 5), Toothcup is known from sites along and north of Osoyoos Lake in the extreme southern part of the Okanagan Valley, and along the eastern end of Kamloops Lake in the Thompson River valley. These two subpopulations are about 180 km apart. Plants at Osoyoos Lake are disjunct from the nearest U.S. population in central Washington State by about 200 km.

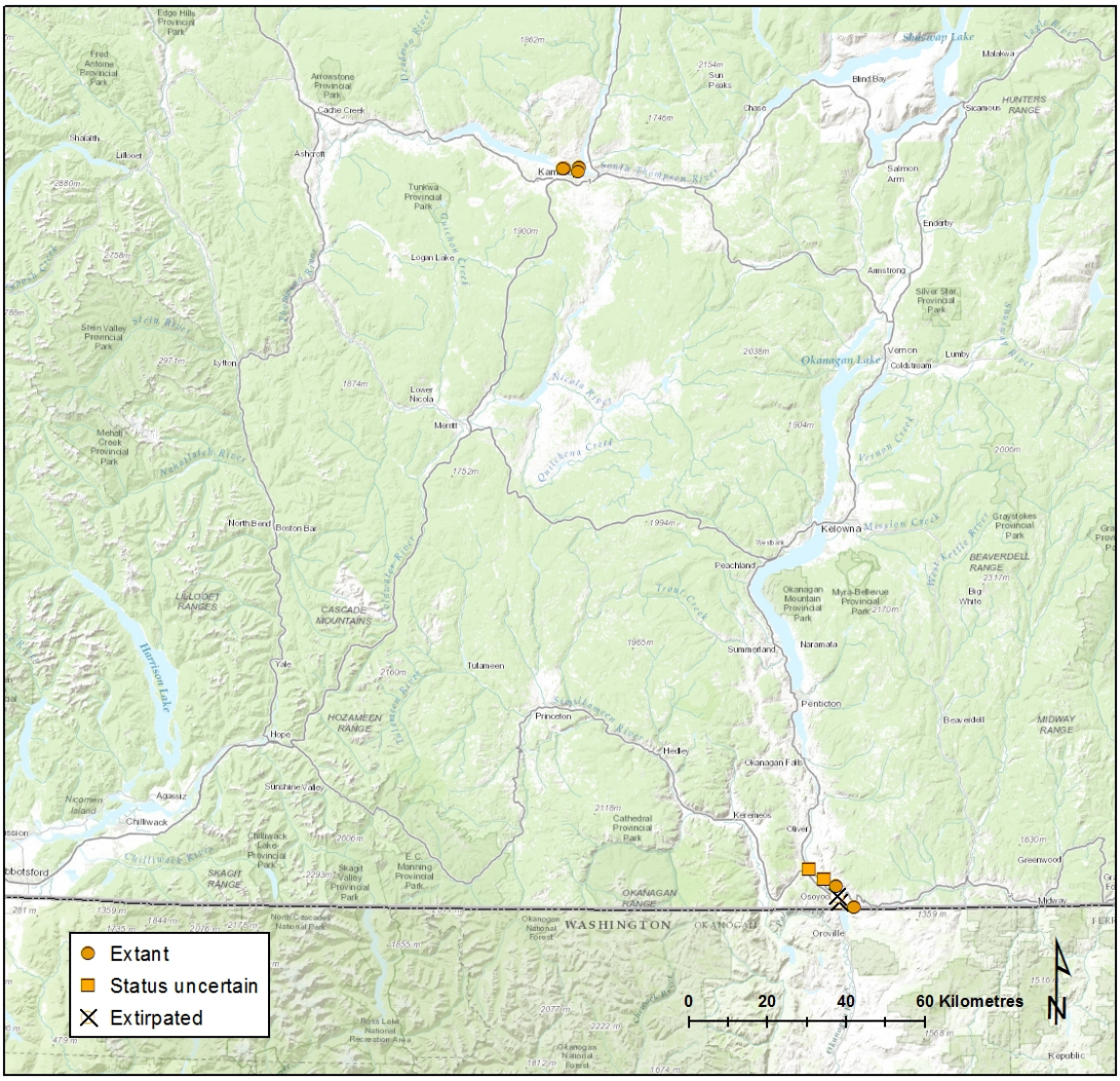

Figure 5. Locations of Toothcup in British Columbia.

Extent of Occurrence and Area of Occupancy

The total extent of occurrence (EO) of Toothcup in Canada is approximately 285,884 km². If calculated for each designatable unit (DU), the EO for the Great Lakes Plains DU (Ontario) is 3.4 km² and 630 - 1080 km² for the Southern Mountain DU (British Columbia). The index of area of occupancy, as determined by a 2x2 km grid overlay, is equivalent to 40 km² in Canada (20 km² in Ontario and 20 - 28 km² in British Columbia).

Delimitation of Subpopulations

COSEWIC separates subpopulations as geographically or otherwise distinct groups between which there is little demographic or genetic exchange (COSEWIC 2012). Because rates of genetic exchange are unknown for Toothcup, subpopulations are defined in this report using NatureServe (2004) Guidelines, under which occurrences meeting one of the following conditions are grouped into a single subpopulation: 1) occurrences separated by less than 1 km, 2) occurrences separated by 1 to 3 km with no break in suitable habitat between them exceeding 1 km, 3) occurrences separated by 3 to 10 km but connected by linear water flow with no break in suitable habitat between them exceeding 3 km. Thus there are four extant subpopulations known to occur in Canada: 1) Puzzle Lake, 2) Sheffield - Long Lake / Clare River, 3) South Okanagan Valley, and 4) Kamloops. The historical Rotala Field subpopulation from Norfolk County is believed extirpated through conversion of habitat to row crops. The historical subpopulations of Hayes Point and Osoyoos townsite are considered extirpated and the status of subpopulations at North Osoyoos Oxbows and the mouth of the Inkaneep River remain undetermined.

Search Effort

Ontario

Toothcup was first discovered in Ontario in 1984 by D. A. Sutherland and M.J. Oldham during a natural areas inventory of the Regional Municipality of Haldimand and Norfolk Counties (Gartshore *et al.* 1987). Two sites were found adjacent to one another, with plants present two years apart, though both sites were subsequently destroyed through conversion of the land to row crops. These sites have not been observed since 1987 despite occasional visits by Ministry of Natural Resources (MNR) staff and local naturalists. A scan of the fields and roadside ditches in 2011 did not produce any observations and the fields were still under cultivation.

Two additional Ontario subpopulations were found in 1994 along adjacent lakes in the County of Lennox and Addington during a detailed life science inventory of the Puzzle Lake Area of Natural and Scientific Interest (ANSI) (Brownell 1997). Casual monitoring at both lakes since then involving shoreline surveys from a canoe by C. Bonta, L. Viet, and T. Norris have led to the discovery of additional sites associated with these subpopulations. One was found on Puzzle Lake in 2000 (Veit 2000), five in 2004 (Bonta 2004), four in 2008 (Bonta 2008), and three in 2011 as part of fieldwork associated with the update status report. An additional site was found at Sheffield - Long Lake / Clare River in 2004. Elsewhere in the area, portions of Lost Lake, Gull Lake, and Fifth Depot Lake were searched in 2004 but Toothcup was not observed. Additional habitat was searched on Norway and Bear Lake by Ontario Parks staff and little suitable shoreline was identified (Brdar pers. comm. 2011).

Efforts to find Toothcup in Ontario in 2011 are summarized in Table 1. A total of approximately 47 km of shoreline was searched over 9 days incorporating roughly 115 person-hours. Surveys for Toothcup involved scanning shorelines of water bodies for exposed sand and mud from a boat, as well as helicopter-based surveys conducted as part of other fieldwork. This included landing at remote sites, and scanning moist ditches and depressions along roadsides. When suitable habitat was identified, an intuitive meandering search pattern was used to cover appropriate habitat to locate and count all mature individuals.

Table 1. Summary of 2011 Toothcup search effort in Ontario.

Survey Date	Site	Surveyors	Person-Hours	Approximate Area Surveyed
Successful				
30/08/2011	Puzzle Lake	S. Brinker, C. Jones	15	9 km of shore
01/09/2011	Sheffield Long Lake / Clare River	S. Brinker, C. Jones	12	5 km of shore
29/09/2011	Sheffield Long Lake, Salmon River	S. Brinker, M. Oldham, C. Jones	15	8 km of shore
06/10/2011	Puzzle Lake	S. Brinker	2	100 m of shore
Unsuccessful				
23/08/2011	Mellon Lake	S. Brinker, T. Norris	15	10 km of shore
30/08/2011	Gull Lake	S. Brinker, C. Jones	0.5	100 m of shore
07/09/2011	Rotala Field	S. Brinker, C. Jones	0.5	50 m of ditch
12/09/2011	Puzzle Lake Provincial Park wetlands	S. Brinker, W. Bakowsky, M. Oldham, C. Jones, R. Craig	20	1 km of shore
13/09/2011	Kaladar area Crown Land blocks	S. Brinker, M. Oldham, M. McMurtry, T. Taylor, C. Bonta	20	1 km of shore
05/10/2011	Kennebec Lake	S. Brinker, M. Oldham	7.5	7 km of shore
05/10/2011	5th Depot Lake	S. Brinker, M. Oldham	7.5	6 km of shore
Totals			~ 115 hrs	~ 47 km

While no other specific efforts have been made to search for Toothcup in Ontario, there has been a fairly substantial body of fieldwork conducted over the last 40 years by competent field biologists and botanists within its range. Caution is necessary when interpreting negative survey results, however. Even with targeted surveys, Toothcup can be easily overlooked, especially in areas with small populations or during high water years. Also, timing is critical, as surveys outside the normal period of detection (late summer/early fall) could lead to false absences.

In the Puzzle Lake area, most large and accessible lakes have been surveyed, though not over multiple years. However, the region still supports areas of suitable habitat that have not been searched by botanists, largely due to inaccessibility and private property limitations. Priorities for additional targeted searches include areas of low nutrient, gently sloping shoreline and naturally fluctuating water levels along the southern edge of the Canadian Shield in eastern Ontario, especially those east of Puzzle Lake to Kingston. In contrast, few moist, open, acidic sandy areas remain in Norfolk County or elsewhere in southern Ontario off the Canadian Shield, and the best remaining examples of these have been well botanized. The likelihood of rediscovering Toothcup in Norfolk County is low, though plausible with the continued existence of a few remnant moist, sandy meadows in the St. Williams – Turkey Point – Walsh area. Most of these occur on private land and are not accessible, however.

British Columbia

South Okanagan Valley: previous searches—The first documented Canadian record of Toothcup was J.W. Eastham's 1939 collection from an unspecified locality alongside Osoyoos Lake in British Columbia (UBC V25712). J.A. Calder and D.B. Savile made another early collection (UBC V84759) at Hayne's Point (just south of Osoyoos) in 1953. In 1977, O. Ceska and P.D. Warrington found a third occurrence for Toothcup in the South Okanagan Valley on the shore of a ponded area along Osoyoos Lake in the town of Osoyoos.

The Mica Spit occurrence, on Osoyoos Indian Band property, was discovered by A. Ceska in 1980. G.W. Douglas and numerous co-workers investigated this occurrence starting in 1994 (Douglas 1994) and continuing to 2004 with the assistance of Osoyoos Indian Band members. These searches resulted in the discovery of at least four sites for Toothcup on sandy or muddy soils most often along the edges of inshore lagoons. Two of the original sites for Toothcup were destroyed during this time, one by ATV use and the other by wave action (Douglas and Oldham 2002). Further investigations by McIntosh and Björk between 2005 and 2007 confirmed at least four sites of Toothcup in the Mica Spit area. One site was located in 2005 and three more sites in 2007 (Björk pers. comm. 2012). One of the 2007 sites was adjacent to the larger lagoon at Mica Spit and two were found in swales on private property north of Mica Spit. The landowners have requested that locality and population data not be made available for this report (McIntosh pers. comm. 2012).

A collection of Toothcup was made by Lomer in 1995 just north of Osoyoos Lake in the Osoyoos oxbow area (BCCDC 2012). This site was not reported in Douglas and Oldham (2002) nor by the National Toothcup Recovery Team (2008).

The historical sites for Toothcup at Haynes Point (Calder's collection) and in the Town of Osoyoos (O. Ceska and Warrington's collection) were surveyed for Toothcup and other rare plants by boat and walking surveys in 2009 (McIntosh 2010). All potential habitats for at-risk shoreline plants along the Canadian Osoyoos Lake shorelines, excluding Osoyoos Indian Band property, were surveyed that year. Toothcup was not observed along the lake during the survey. Extensive searches for rare plants were also completed by various botanists at Hayne's Point in 1991, 1994, 1995, 1997, 1999, and 2002 and Toothcup was not observed (BCCDC 2012). Toothcup is considered extirpated at both the Hayne's Point and Osoyoos localities (BCCDC 2012). Heavy modifications of the shoreline probably destroyed the Hayne's Point site. Extensive shoreline development destroyed the pond edges and all potential Toothcup habitat at the Town of Osoyoos site (A. and O. Ceska pers. comm. 2012).

Kamloops area: previous searches—The first collection of Toothcup from the Kamloops area was made by A.C. Budd in 1948. The precise locality for this collection is unknown as collection data are vague. It was collected west of one of the two Agriculture Canada stations that were operating at the time, but at which station is not clear. One station was located on each side of Kamloops Lake (BCCDC 2012). Therefore, the collection was made either in the Mission Flats area on the south side of the river or on the north side towards Tranquille. When Toothcup was observed in Mission Flats in 2011, it had not been observed in either of these areas since 1948. In 1980, O. Ceska and A. Ceska discovered a new subpopulation of Toothcup for the Kamloops area on the east side of McArthur Island on the north side of Kamloops Lake (BCCDC 2012).

2011 Searches—Efforts to locate Toothcup in British Columbia in 2011 are summarized in Table 2. Almost 14 km of shoreline and ponded inland sites were searched over 13 days incorporating approximately 88 person-hours. Most surveys were completed on foot, focusing on open soil along shorelines or inshore depressions, pond edges, and swales. An intuitive meandering search pattern was used to investigate appropriate habitats. A canoe was used to access Rabbit Island in Kamloops. Two of the known sites (McArthur Island near Kamloops and in the oxbows north of Osoyoos Lake) were visited twice because water drawdown was late at both sites.

Table 2. Summary of 2011 Toothcup search effort in British Columbia.

Survey Date	Site	Surveyors	Person-Hours	Approximate Area Surveyed
Successful				
17/09/2011	McArthur and Rabbit Islands	T. McIntosh, Jamie Fenneman, Justine McCulloch, Mandy Ross	32	3 km of shore and inland ponded sites
27/09/2011	Mission Flats	T. McIntosh, S. Joya	8	2 km of shore and inland ponded sites
30/09/2011	McArthur Island and Mission Flats	T. McIntosh, S. Joya	6	800 m of shore and inland ponded sites

Survey Date	Site	Surveyors	Person-Hours	Approximate Area Surveyed
Unsuccessful				
17/08/2011	Sun Oka Beach Provincial Park	T. McIntosh	1.5	~120 m of shoreline and inshore habitats
31/08/2011	McArthur Island and the Tranquille Wildlife Management Area	T. McIntosh, J. McCulloch	12	2 km of shore and inland ponded sites
02/09/2011	Osoyoos Oxbows	T. McIntosh	4	800 m of shore and inland ponded sites
08/09/2011	Osoyoos Oxbows	T. McIntosh	2.5	800 m of shore and inland ponded sites
09/09/2011	Osoyoos Oxbows	T. McIntosh	5.5	800 m of shore and inland ponded sites
09/09/2011	Pyramid Provincial Park	T. McIntosh	1	~100 m of shoreline habitats
09/09/2011	SW Okanagan Falls	T. McIntosh	1	~80 m of shoreline habitats
10/09/2011	Osoyoos Oxbows	T. McIntosh	2.5	250 m of shore and inland ponded sites
14/09/2011	Osoyoos Oxbows	T. McIntosh	4	300 m of shore and inland ponded sites
22/09/2011	Mica Spit	T. McIntosh, A. Baptiste	2	800 m of inland ponded sites
22/10/2011	Osoyoos Oxbows	T. McIntosh	1.5	600 m of inland ponded sites
23/09/2011	Osoyoos Oxbows	T. McIntosh	1.5	600 m of shore and inland ponded sites
29/09/2011	N shore of Thompson River and Tk'emlups Marsh	T. McIntosh, S. Joya	3	900 m of shore
Total			~ 88 hrs	~ 13.9 km

South Okanagan Valley 2011: Toothcup was not observed at any of the previously reported sites and no new subpopulations were discovered.

Kamloops area 2011: Although Toothcup was not observed at the McArthur Island site, six new sites were discovered, five along Mission Flats and a sixth on Rabbit Island.

Little suitable habitat for Toothcup remains in the South Okanagan Valley as a result development and invasion by aggressive exotic plants, mainly Reed Canary Grass (*Phalaris arundinacea*). The likelihood of rediscovering Toothcup in this area is low. In contrast, the Kamloops Lake and Thompson River areas north and east of Kamloops still support large areas of suitable habitat that have not been evaluated by botanists in part due to inaccessibility, but also due to lack of both broad inventory and targeted search efforts. However, some suitable habitat in these areas has received coverage (especially in 2011), but not over multiple years. There is potential for additional sites and subpopulations to be discovered in the Kamloops area.

HABITAT

Habitat Requirements

There are no detailed studies of Toothcup habitat, though many descriptive references are available and they consistently indicate Toothcup requires open, seasonally wet areas with natural or artificial water level fluctuation. Over its range, Toothcup habitat is described as riverbanks, ditches, pond margins, sandy to mucky shores, interdunal swales, and occasionally in moist edges of cultivated fields. It is also a relatively widespread weed in rice fields in the United States and elsewhere (Cook 1979). Toothcup is intolerant of shade, and plants tend to be reduced both in vigor and density when light levels are reduced by competing vegetation (Mattrick 2001; Brinker pers. obs.).

In New York, Toothcup is associated mainly with coastal plain pond shores (New York Natural Heritage Program 2012). In Michigan, Toothcup has a high fidelity to coastal plain marsh and lake plain wet-mesic prairie (Michigan Natural Features Inventory 2012). In New England, Toothcup is limited to pond, lake, and reservoir shorelines following natural or anthropogenic water drawdowns, although it is apparently absent from coastal plain ponds there (Mattrick 2001). Typical habitat in Minnesota is sandy shores of small shallow lakes in a savannah landscape (Minnesota Department of Natural Resources 2012). In Washington State, Toothcup is limited to riparian wetlands where it grows below the high water level in a community of small emergent annual plants (Washington Department of Natural Resources 2012).

Ontario

The central Ontario subpopulations occur in the Georgian Bay Fringe, a broad Precambrian bedrock-controlled belt covering about 2,000 km² bordering Georgian Bay, running east through the Kawartha Lakes region as far as Frontenac County. Soils are typically thin, stony, sandy and generally acidic (Chapman and Putnam 1984). Toothcup is limited to rocky shorelines with naturally fluctuating water levels (Figures 6 and 7). Annual water drawdowns are common most summers as precipitation deficit values are high, being just beyond the immediate Great Lakes-effect precipitation zone, and coupled with high summer temperatures and low water-retaining capacities of the shallow substrates (Baldwin *et al*. 2000). Shorelines where Toothcup is found here consist of exposed bedrock with shallow crevices and faults containing small accumulations of sand, gravel and peat.

Figure 6. Oblique view of exposed rocky shoreline habitat with shallow linear crevices where Toothcup grows at Puzzle Lake, Ontario (at site P10), Aug. 30, 2011 (S. Brinker).

Figure 7. Exposed rocky shoreline habitat with shallow crevices at Sheffield Long Lake / Clare River, Ontario, Sept. 01, 2011 (S. Brinker).

The southwestern Ontario subpopulation occurred on the Norfolk Sandplain, a large wedge-shaped plain covering much of Norfolk County and portions of Brant, Haldimand, Oxford, and Elgin Counties on the north shore of Lake Erie, covering an area of over 1,900 km² (Chapman and Putnam 1984). Habitat information for the former Norfolk County subpopulation was described as remnant sand prairie within a moist old field (D. Sutherland pers. comm. 2011). Substrates were wet-mesic to mesic sands of the Normandale Series, which tend to be strongly acidic to neutral with groundwater often at or near the surface during the early part of the growing season (Presant and Acton 1984). Plants were growing in periodically inundated wet depressions (D. Sutherland pers. comm. 2011).

British Columbia

In British Columbia, Toothcup subpopulations are found in the bottoms of two major valley systems within the Okanagan Highlands Ecoregion, one of the warmest and driest regions in Canada. The region lies within the rain shadow of the Cascade Mountains. The climate is characterized by very warm to hot, dry summers and moderately cool winters with relatively little snowfall. The valley bottoms are characterized by a vegetation matrix of grasslands, shrub-steppe, and riparian vegetation adjacent to the waterways.

Toothcup depends on water-level fluctuations for the creation and maintenance of suitable habitat. Normally, high water levels along the valley bottoms from spring snow melt and winter-spring rainfall submerge the habitats of Toothcup. As water levels recede into the summer, soils in these habitats are exposed and Toothcup seeds germinate. This cycle has been mostly maintained along the Thompson River near Kamloops, except at the McArthur Island site where the channels have been isolated by bridges and connected by culverts, However, the cycle has been highly modified in the south Okanagan Valley by the building of a dam at the base of Osoyoos Lake and by the construction of the Okanagan River diversion/flood control channel north of the lake (International Osoyoos Lake Board of Control 2012, Department of Ecology, State of Washington 2013).

In the South Okanagan Valley, Toothcup inhabits moist to wet, sometimes saline, muddy to sandy shorelines of lagoons or ponds (BCCDC 2012, National Toothcup Recovery Team 2008). Further details include on sand alongside river channels, often in semi-shaded sites. Invasive grasses, in particular Reed Canary Grass, have invaded some sites.

In Mission Flats and on Rabbit Island east of Kamloops, Toothcup inhabits sandy or silty, shallow depressions and interdunal swales (Figure 8). Most of the open habitats at these sites are covered with dense mats of invasive grasses, mainly Quackgrass (*Elymus repens*) and Smooth Brome (*Bromus inermis*). However, a number of lightly vegetated swales and depressions are present in areas where sustained water levels probably restrict high grass cover. Some of the habitats where Toothcup are found are kept open by human use, mainly walking or ATV trails but also small excavations and bush clearing (Figure 8).

On McArthur Island, Toothcup grows on muddy silty-sands of exposed banks along a channel (BCCDC 2012, National Toothcup Recovery Team 2008). This habitat is semi-shaded mainly by Narrow-leaf Willow (*Salix exigua* var. *exigua*).

Figure 8. Habitat for Toothcup at Mission Flats showing trail maintained by human use, British Columbia, Sept. 29, 2011 (T.M. McIntosh).

Habitat Trends

Ontario

Compared to other areas of central Ontario, the southern Shield portion of Lennox and Addington County has resisted the infiltration of intensive forestry, quarrying, and mining activities, although the majority of the area was logged by the turn of the century (Chapman and Putnam 1984). However, over the past 80 years or so, shoreline habitat on most of the larger, accessible lakes in the county has been impacted to some degree by shoreline development or impoundments, which control water level for downstream flood abatement or navigation (e.g., Trent-Severn Waterway, Rideau Canal Waterway).

Complete conversion of occupied habitat to cropland caused the extirpation of the Norfolk County subpopulation.

British Columbia

Following European settlement, there was a great deal of loss of Toothcup habitat in British Columbia. Initially, the majority of this habitat was lost through urban growth, with some sites lost to agricultural activities. More recently, large areas of suitable habitat have been lost or degraded due to invasive exotic grasses, in particular Quackgrass, Smooth Brome, and Reed Canary Grass, but also, in a few cases, Common Cattail (*Typha latifolia*) and Hard-stemmed Bulrush (*Schoenoplectus pungens*).

In the south Okanagan Valley, with the exception of some protected ponds along the east side of Osoyoos Lake on Osoyoos Indian Band property and in some portions of the oxbows north of Osoyoos Lake, inshore habitats favoured by Toothcup have been heavily altered or destroyed. Figure 9, upper panel, shows the early town of Osoyoos (from the southeast), probably from around 1925. A number of foreshore ponds can be observed. Figure 9, lower panel, shows the same area in 2002. The images show that the build-up of the City of Osoyoos has permanently altered the two large ponds. Pond B on Fig. 9 is the site where O. Ceska and P.D. Warrington discovered Toothcup in 1977 (this subpopulation has been extirpated).

Toothcup habitats have also been altered and possibly destroyed following the building of a dam in 1927, rebuilt in 1988, at the base of Osoyoos Lake in Washington State. Based on agricultural and other water needs in Washington, Osoyoos Lake water levels have been controlled by the dam since that time, leading to increased lakeside erosion and unnatural drawdown events (State of Washington Water Research Center 2011). The building of the Okanagan River diversion / flood control channel north of Osoyoos Lake in the 1960s has completely altered the hydrology and flooding regimes of the Osoyoos oxbows, which probably housed considerable habitat for Toothcup. Some oxbows are flooded annually, while others are not.

There has also been a loss of Toothcup habitat in the Kamloops area. Although many of the shoreline habitats along Kamloops Lake and the Thompson River remain, many have been altered and degraded in some places by agricultural practices, recreational activities, and invasive species. Invasive grasses are especially common and cover large areas of formerly exposed sands and silts. The sites where new subpopulations were located in 2011, and which had plants in 2014 appear to have lower densities of Quackgrass than immediately surrounding areas. In one case, the site appears to have been formed by tire tracks, which created a depressed area that remains wet over a greater portion of the growing season. These wetter sites appear to be less favourable for Quackgrass, and more favourable for Toothcup (Ryan, pers. comm. 2014).

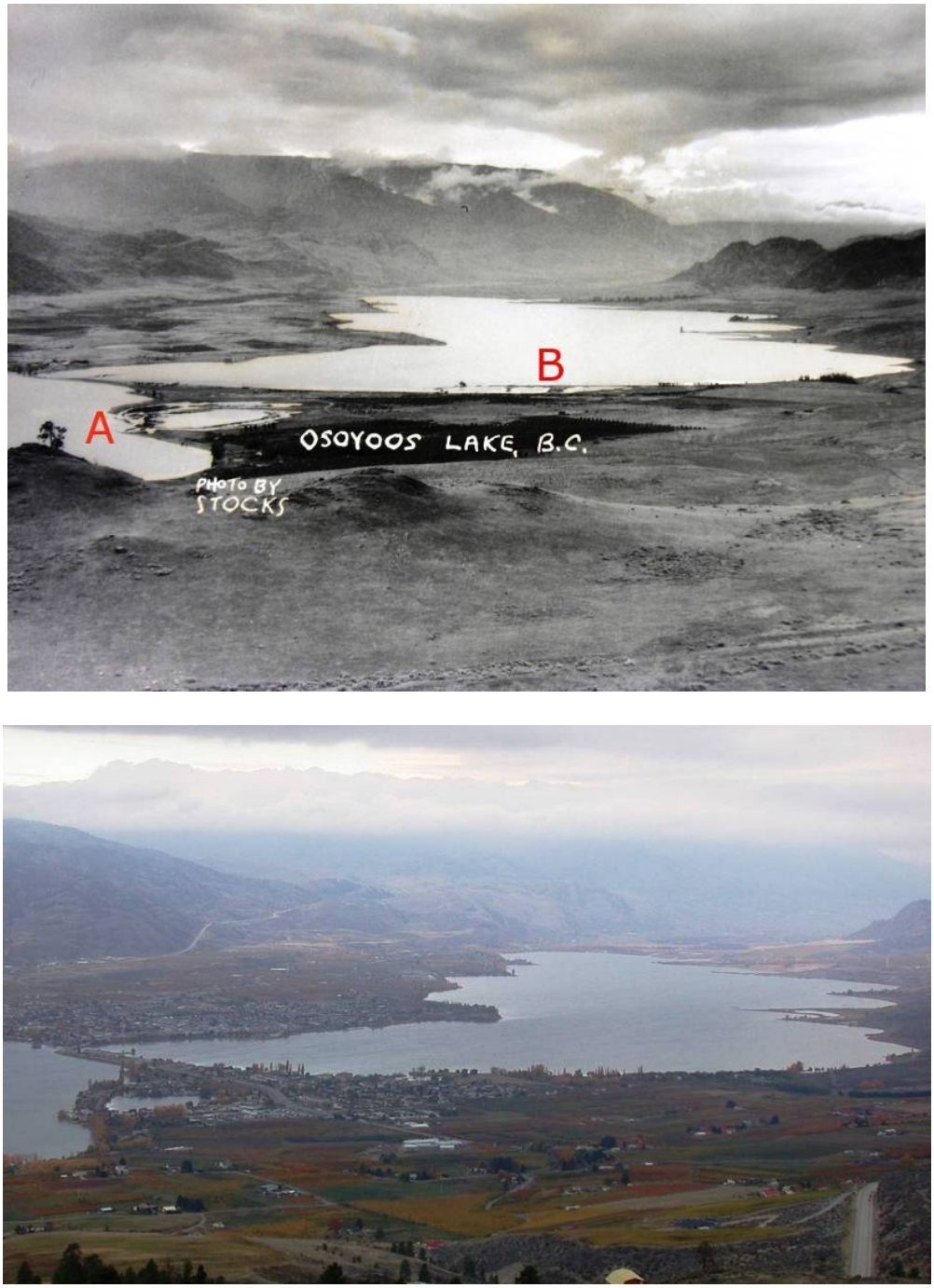

Figure 9. A view of Osoyoos and Osoyoos Lake. Upper panel, circa 1925 showing large ponded areas on both sides of the spit, marked as A and B (photographer unknown). Lower panel, 2002, showing development around the ponded areas (T. McIntosh).

BIOLOGY

Scant literature pertains to the biology of Toothcup. The information presented here is summarized largely from Mattrick (2001) and Douglas and Oldham (2002), unless otherwise cited.

Life Cycle and Reproduction

Toothcup is an annual plant associated with periodically flooded areas. Subpopulations and sites within these are dependent on a seed bank and may undergo large fluctuations in the number of mature individuals from year to year. The species has a generation time less than one year. Annual fluctuations in seed germination and growth are likely dependent on the timing and amount of seasonal rainfall and water levels at each site. Flowering times vary across the North American range, from June or July through October; in lower latitudes it likely flowers year round (Cook 1979). Canadian subpopulations usually flower in late July to late August, rarely into October. Toothcup is self-compatible and is most often self-pollinated, and produces copious amounts of seed. Like other annual species, Toothcup is not known to reproduce asexually. Cook (1979) suggests that due to the potentially large amount of selfing within subpopulations, gene flow among subpopulations is likely to be low. Insect pollination has not been reported, although Douglas (1999) suggests that plants are likely visited by skippers and small bees for nectar produced by thickened glands surrounding the base of the ovary.

Physiology and Adaptability

Baskin *et al*. (2002) studied the germination requirements of Toothcup and Valley Redstem in controlled greenhouse experiments. They found 65-100% of Toothcup seeds to be dormant at maturity in autumn. Seeds broke dormancy while flooded in late fall / winter. The optimal temperature regime for dormancy break in seeds of Toothcup was 20°C (day) and 10°C (night). A much higher percentage of seeds germinated when flooded than non-flooded. It is not clear whether seeds can remain dormant beyond their first winter.

Observations in Ontario suggest Toothcup may prefer slightly acidic soil and water conditions, although in British Columbia it is known to occupy (in some sites at least) slightly saline soil, but detailed soil and water tests have not been completed.

There is evidence that Toothcup grows well in culture. Allen (2006) reared stock from wild populations in Maryland in a controlled aquarium environment and found Toothcup easy to grow under bright lighting.

Dispersal and Migration

Dispersal in Toothcup is through passive movement of seeds, likely involving both abiotic and biotic mechanisms. The small size and weight of Toothcup seeds makes them highly vagile and suitable for water and, potentially, wind dispersal. It is not known whether seeds can float, though fluctuating water levels likely aid in short distance dispersal. The seeds have minute epidermal hairs that allow them to attach to the feet of waterfowl (Graham pers. comm. 2001) and, therefore, could be transported to new sites either on waterfowl or in mud stuck to the feet of waterfowl. The absence of this species in apparently suitable habitats near occupied sites in the Puzzle Lake area suggests that Toothcup normally only disperses over short distances, or else rarely becomes established despite dispersal.

Interspecific Interactions

No symbiotic or parasitic relationships are known. No herbivory has been reported or observed on Toothcup plants. Given its preference for open, recently exposed, moist substrates, Toothcup is likely intolerant of competition, although no studies have shown this.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Efforts to monitor subpopulations in Canada have been irregular, occurring as time and conditions have permitted, or incidentally while conducting other survey work. As well, surveys are not always thorough assessments of an entire subpopulation, owing to issues relating to, for example, access, weather, and available resources. Furthermore, previous assessments typically provided estimate ranges of the number of individuals rather than absolute counts, as plants can often be hard to detect and can occur at high densities. Sampling has normally been conducted during peak flowering / fruiting periods between August and September, as was done in some cases in 2011.

Abundance

The current Canadian population estimate of Toothcup consists of 6,859 to 7,019 individuals from four subpopulations, including two in Ontario (Great Lakes Plains DU) and two in British Columbia (Southern Mountain DU). Following the IUCN (2001) guidelines, which state to use the lower estimate for populations that fluctuate, the Canadian population currently sits at 6,859 mature individuals.

Ontario (Great Lakes Plains DU)

In 2011, 1,444 mature individuals were counted from two subpopulations, representing the lowest year count. Searches at Puzzle Lake documented 1,139 individuals from 10 sites (Table 3), and 305 individuals from Sheffield – Long Lake / Clare River from one site.

Table 3. Ontario estimates of Toothcup by survey year.

Subpopulation	Site	Ownership	Year Discovered	Survey Results				
				1994	2000	2004	2008	2011
Puzzle Lake	P01	Public	1994	50	5-10	400	400	305
Puzzle Lake	P02	Public	1994		50	150-200	150	0
Puzzle Lake	P15	Public	2011					65
Puzzle Lake	P16	Public	2011					45
Puzzle Lake	P05	Private	2000		200	0	60	454
Puzzle Lake	P06	Private	2004			700	30	12
Puzzle Lake	P17	Private	2011					3
Puzzle Lake	P07	Public	2004			40	75	83
Puzzle Lake	P08	Public	2004			~200	~200	52
Puzzle Lake	P09	Public	2004			50-70	60	40
Puzzle Lake	P10	Public	2004			70-100	0	80
Puzzle Lake	P11	Public	2008		200		140	
Puzzle Lake	P12	Public	2008				100	0
Puzzle Lake	P13	Public	2008				300-400	
Puzzle Lake	P14	Public	2008				25	0
Puzzle Lake Totals				**50**	**455-460**	**1610-1710**	**1,540-1,640**	**1,139**
Sheffield-Long Lake/Clare River	S01	Public	2004			215		0
Sheffield-Long Lake/Clare River	S03	Private	1994	33	250-270	1400		305
Sheffield-Long Lake/Clare River	S04	Private	1994			1000-3000		0
Sheffield-Long L./Clare River Totals				**33**	**250-270**	**2,615-4,615**		**305**
Ontario Totals				**83**	**705-730**	**4,225-6,325**	**1,540-1,640**	**1,444**

Note: Blank cells indicate no survey/no information at a particular site in a given year.

The highest Ontario estimate of any year was between 4,325 and 6,325 mature individuals in 2004. At this time, 1,610-1,710 individuals were counted at Puzzle Lake from 7 sites scattered across 2 km of shoreline, and 2,615 to 4,615 individuals from three sites (one on the east shore and two closely spaced ones 500 m to the west at the mouth of the Clare River). In other years, casual monitoring has resulted in additional sites at Puzzle Lake, but never have all 15 sites been present in one survey year.

British Columbia (Southern Mountain DU)

The highest estimate for the South Okanagan Valley subpopulation was more than 12,180 individuals in 2004. Ten or eleven (unsure because of lack of precise early data from the Mica Spit site) sites have been found along about 11 km of Osoyoos Lake shoreline: one in the oxbow area to the north, eight or nine along the east side of the lake to Osoyoos (mainly in the Mica Spit area), and one at Haynes Point south of Osoyoos. No Toothcup plants were observed in the South Okanagan Valley during searches in 2011 (Table 4).

Table 4. British Columbia estimates for Toothcup by survey year.

Subpopulation	Site	Year Discovered	Survey Results (estimates)												
			1981	1991	1994	1995	1996	1997	1999	2002	2003	2004	2005	2009	2011
Kamloops	Mission Flats 1	2011													5
Kamloops	Mission Flats 2	2011													>5,000
Kamloops	Mission Flats 3	2011													100-200
Kamloops	Mission Flats 4	2011													50-100
Kamloops	Mission Flats 5	2011													10 – 20
Kamloops	McArthur Island 1	1980	1,000		0		0	0		0		3			0
Kamloops	Rabbit Island 1	2011													>250
Kamloops Totals			**1,000**		**0**		**0**	**0**		**0**		**3**			**>250**
South Okanagan Valley	Mica Spit 1	1980			200 – 1,000	2,250			>5,000	0	4	160 -180	~50	0	0
South Okanagan Valley	North Osoyoos Oxbows 1 (Deadman Lake) (status uncertain)	1995				4-5									0
South Okanagan Valley	Veronica Lake (East Osoyoos small lake) Private property	1994			~600							~12,000			
South Okanagan Valley	Haynes Point (extirpated)	1953		0	0	0		0	0	0				0	
South Okanagan Valley	Town of Osoyoos (pond) (extirpated)	1977												0	
South Okanagan Valley	Inkaneep Creek (locality unconfirmed)	1995													
South Okanagan Valley Totals					**800 – 1,600**	**~2,255**			**>5000**		**4**	**~12,180**	**~100**		**0**
Totals			**1,000**		**800 – 1,600**	**~2,255**			**>5000**		**4**	**~12,180**	**~100**		**>5,500**

Note: Blank cells indicate no survey/no information at a particular site in a given year.

For the Kamloops subpopulation, the highest estimate was between 5,415 and 5,575 individuals in 2011. A total of seven sites have been found along about 4.2 km of shoreline (excluding the observation of Budd in 1948, which may or may not be one of the recent discoveries). Five of the sites are on the south shore, one on an island, and one on the north shore. The highest estimate for the previously reported McArthur Island site (not found in 2011) was 1,000 in 1981 (Table 4).

Fluctuations and Trends

Being an annual plant reliant on dynamic flood regimes, Toothcup can undergo large fluctuations from year to year. While long-term trend data are lacking for Canadian subpopulations, there are short-term data that illustrate this.

Ontario (Great Lakes Plains DU)

Counts for Ontario subpopulations are summarized in Table 3. No documented Toothcup losses have occurred at Puzzle Lake or Sheffield Long Lake / Clare River, and both subpopulations lack adequate long-term data to make any meaningful interpretations of trends. Puzzle Lake has been the most consistently monitored subpopulation, having four surveys completed over an eleven year period (2000-2011). No large fluctuations have been observed here, and new sites have been continually found with increased search effort.

Large fluctuations have been observed at Sheffield – Long Lake / Clare River. In 2004, site S04 contained 1,000-3,000 plants, while in 2011 no plants were seen. At site S03, 1,400 plants were observed in 2004 and in 2011 only 305 were counted.

The Norfolk County subpopulation was destroyed when the habitat was converted to row crops in the late 1980s, and is considered extirpated.

British Columbia (Southern Mountain DU)

Counts for BC subpopulations are presented in Table 4. Although the Kamloops subpopulation is extant, the status of the South Okanagan Valley subpopulation is less clear although some sites have been extirpated (Table 4).

Within the South Okanagan Valley subpopulation, two sites, at Hayne's Point and in the town of Osoyoos, are considered extirpated. Most of the other sites appear to have declined in the past decade and may also be extirpated (fluctuations and trends for the sites on private properties are unknown). The Osoyoos oxbow site was small to begin with (4-5 plants) and may be extirpated given the high degree of invasive plant cover at the site observed in 2011. Open soil was fairly common at this site in 1995 (F. Lomer pers. comm. 2011). The Mica Spit sites have declined, especially over the past eight years, mainly due, probably, to a marked increase in the presence of invasive grasses. Marked fluctuations were noted at some sites on Mica Spit between 1980 and 2004, possibly due to natural climate and drawdown factors as related to seed germination. Douglas and Oldham (2002)

noted that between 1994 and 1995 numbers at one site increased from 200 to 250 plants and in another site, increased from 50 to 2,000. Five thousand plants were reported from one site in 1999.

The National Toothcup Recovery Team (2008) stated that ~5,000 plants were observed in the South Okanagan Valley subpopulation in 2006, but this is a reporting error (McIntosh conducted surveys for rare plants in 2006 on the spit and no Toothcup plants were observed, Table 4).

New discoveries in 2011 greatly expanded the number of known occurrences and mature individuals at the Kamloops subpopulation. As a result, the Kamloops subpopulation has more known mature individuals than in the past. However, the McArthur Island site has declined since its discovery in 1981, when 1,000 plants were estimated to be present. Only three plants were observed in 2004, and none were found in 1994, 1996, 1997 and 2002 (BCCDC 2012), and none in 2011 (Table 4). Water levels were unusually high in 2011 and germination may not have occurred. Suitable habitat appears to remain available along the banks at this site.

Rescue Effect

The likelihood of a natural immigration event of Toothcup from outside Canada is extremely low, though possible. Its highly vagile seeds and self-compatibility increase the likelihood of chance medium- to long-range dispersal and establishment, either by birds or perhaps by water or wind from adjacent jurisdictions in New York, Michigan, Ohio, and Washington. Such an event from adjacent US states is increasingly unlikely, however. In the New England States, Toothcup has declined from 26 known occurrences to only 9 (two in Massachusetts, two in Rhode Island, and five in Connecticut) (Mattrick 2001) and the species is threatened in New York State.

THREATS AND LIMITING FACTORS

The major limiting factor across the Canadian range of Toothcup is its restriction to seasonally flooded, nutrient poor, gently sloping or flat, sandy shorelines of lakes, ponds, and wet depressions. These areas are particularly vulnerable to human-related disturbance, in particular, shoreline development and agricultural activities, degradation by altered flood regimes, and invasion of exotic plants.

Ontario (Great Lakes Plains DU)

<u>Shoreline Disturbance</u>

Shoreline disturbance associated with waterfront development and recreational activities pose the most immediate threat to Toothcup habitat for the Puzzle Lake and Sheffield – Long Lake / Clare River location. Currently, impacts to Toothcup sites appear minor here, as much of the shoreline is too rocky to develop. However, areas with boat launches, docks, boathouses, and patios along shorelines were observed. Such activities

don’t appear to have eliminated any sites, though some areas containing plants are quite small and easily lost. In 2011, two boats stored along the north shore at one particular site on Puzzle Lake were directly shading plants. Another site on Puzzle Lake is amidst a dock at a private lodge and some plants were trampled on the adjacent beach. Excessive vehicular and foot traffic was observed at a private boat launch on Sheffield – Long Lake where another site exists and no plants were seen here in 2011. Roughly one third of the shoreline on Puzzle Lake and two thirds on Sheffield Long Lake / Clare River are currently under private ownership, with ongoing and potential long-term impacts for Toothcup.

Campsite development within Puzzle Lake Provincial Park is expected and may slightly reduce the amount of potential suitable habitat, though the presence of any existing occupied Toothcup habitat will be considered in future management decisions regarding campsite development (Brdar pers. comm. 2012).

Water Management

Lake levels have been manipulated on Puzzle Lake in the past to control natural water draw downs, and the remains of a dam exist at the southern end of the lake, though stop logs are no longer present (Bonta 2004). Currently, the remnants of the dam appear to remain unchanged, although beavers occasionally augment it with debris, which landowners have been known to remove (Bonta pers. comm. 2012).

British Columbia (Southern Mountain DU)

Invasive Species

Invasive exotic plant species pose the greatest threat to extant subpopulations of Toothcup in British Columbia. The Osoyoos oxbows subpopulation may have been lost because available habitat is mostly absent due to the dramatic increase of Reed Canary Grass in the area over the past 5-10 years. Since 2006, a few low areas at the Mica Spit site, in particular the largest lagoon, have been invaded by Common Cattail and Hard-stemmed Bulrush, completely covering much of the previously open soil. In Kamloops, invasive grasses, in particular Quackgrass and Smooth Brome, dominate most of the areas of previously suitable habitat on Rabbit Island and in the Mission Flats area. As noted above (see **Habitat Trends**), recent observations suggest Toothcup may be restricted to small areas that remain wet, and which are unfavourable to Quackgrass (Ryan, pers. comm. 2014).

Residential and Commercial Development

Habitat loss through development and habitat degradation has led to the extirpation of at least two sites near Osoyoos (Haynes Point and in the Town of Osoyoos).

Water Management

The modification of natural water levels of Osoyoos Lake by a dam appears to have destroyed one of the sites in the Mica Spit area (Douglas and Oldham 2002). Wave action and lakeside erosion have increased over the past few years as the water levels have been kept higher than normal for longer periods of time. Higher water levels may also keep the Mica Spit site wetter longer into the summer, which may also affect the site by allowing invasive plants to establish.

Recreational Activities

Recreational boating activities may have also contributed to erosion events alongside Osoyoos Lake (State of Washington Water Research Center 2011).

Agriculture

Livestock are a threat at the Mica Spit site. Although this area was fenced off about a decade ago, the fence is no longer functional and horses and occasionally cattle have free access to the site. Trampling and manure are common across most of the known Toothcup sites.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Toothcup was first designated as Endangered in Canada in April of 1999 by COSEWIC on the basis of few remaining sites and a limited occurrence across available habitat that is subject to continued threats from development and elevated water levels. Its status was re-examined and confirmed in May of 2000. Following this, Toothcup was listed on Schedule 1 of the federal *Species at Risk Act* (2002). A proposed federal recovery strategy was posted in August 2014. COSEWIC assessed the Great Lakes Plains population of Toothcup as Threatened and the Southern Mountain population as Endangered in November 2014. Elsewhere in North America, Toothcup has state-level legal status in several U.S. states: it is listed as Endangered in Connecticut, Massachusetts and Rhode Island, Threatened in Minnesota and New York, Sensitive in Washington and Rare in Pennsylvania (United States Department of Agriculture 2012).

Toothcup is not listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Ontario

Toothcup is listed as Endangered in the Ontario *Endangered Species Act*, *2007* (ESA). Under the ESA, Toothcup receives species-level and habitat-level protection as of June 30, 2013. Toothcup also receives protection in Puzzle Lake Provincial Park and Mellon Lake Conservation Reserve under the *Provincial Parks and Conservation Reserves Act* (2006).

British Columbia (Southern Mountain DU)

There is no specific provincial legal protection for Toothcup in British Columbia.

Non-Legal Status and Ranks

NatureServe Explorer (2012) provincial and state status ranks (SRanks) are provided in Table 5. Toothcup is not considered of high conservation concern across the core of its range, but is of conservation concern near the edge of its range where populations tend to be small and fragmented.

Table 5. Toothcup Subnational (S) Ranks based on NatureServe Explorer (2012) status designations.

Status	Jurisdiction
Canada	
S1 (Critically Imperilled)	British Columbia, Ontario
United States	
SH (Possibly Extirpated)	New Hampshire
S1 (Critically Imperiled)	Arizona, Colorado, Massachusetts, Montana, Rhode Island, Washington
S1S2 (Critically Imperiled to Imperiled)	Connecticut
S2 (Imperiled)	Minnesota, New York, Oregon,
S3 (Vulnerable)	Delaware, Iowa, Michigan, New Jersey, Pennsylvania, West Virginia
S3? (Maybe Vulnerable	Nebraska
S4 (Apparently Secure)	Kentucky
S4S5 (Apparently Secure to Secure)	Maryland
S5 (Secure)	Mississippi, North Carolina, Virginia
SNR (Unranked)	Alabama, Arkansas, California, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Louisiana, Missouri, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Wisconsin

The General Status for Toothcup in Canada was assessed in 2005 and it was given a rank of “At Risk” in Ontario, British Columbia (on the provincial Red List), and Canada (CESCC 2006).

Habitat Protection and Ownership

Ontario (Great Lakes Plains DU)

Ontario Toothcup subpopulations are on a mix of public and private land. Roughly half of all plants on Puzzle Lake occur within Puzzle Lake Provincial Park, Crown land managed by the provincial government. Ontario Parks staff are aware of the subpopulations and conduct monitoring along with Ministry of Natural Resources field staff. The remaining sites are on private land, and landowners are aware of their presence and are generally interested in the conservation of the species. Plants found on nearby Sheffield – Long Lake / Clare River occur on a mix of public and private land as well. Two of the three sites (consisting of roughly 53% of the total number of mature individuals) are on private land, while the third occurs within the Mellon Lake Conservation Reserve, owned and managed by the provincial government. One of the private sites is found at a boat launch on the east side of the lake and experiences seasonal vehicular traffic.

The extirpated subpopulation in Norfolk County occurred on private land. One of the two sites was recommended as a Significant Site in the Natural Areas Inventory of the Regional Municipality of Haldimand-Norfolk (Gartshore *et al.* 1987) though was never adopted into the region’s official plan and the site was subsequently destroyed.

British Columbia (Southern Mountain DU)

Toothcup subpopulations in British Columbia are on a mix of public and private land. In the Okanagan Valley, the Osoyoos Oxbows site is in the BC Parks’ South Okanagan Wildlife Management Area, the Mica Spit sites are on Osoyoos Indian Band property, the extirpated Hayne’s Point site is in a Provincial Park, and the other extirpated site is in the Town of Osoyoos. In the Kamloops area, two sites, one at McArthur Island and one at Mission Flats, are in Municipal Parks, and the remaining sites are on private land.

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INFORMATION SOURCES

Allen, C. 2006. *Rotala ramosior*. The Aquatic Gardener 19(1): 20.

Argus, G.W. 1992. The phytogeography of rare vascular plants in Ontario and its bearing on plant conservation. Canadian Journal of Botany 70: 469-490.

Argus, G.W., and D.J. White. 1977. The Rare Vascular Plants of Ontario. Syllogeus no. 14. National Museum of Natural Sciences, Ottawa, Ontario. 66 pp.

Baldwin, D.J.B., J.R. Desloges, and L.E. Band. 2000. Physical Geography of Ontario, in A.H. Perera, D.E. Euler, I.D. Thompson, eds. 2000. Ecology of Managed Terrestrial Landscape: Patterns and Processes of Forest Landscapes in Ontario. University of British Columbia Press, Vancouver, British Columbia.

Baskin, C.C., J.M. Baskin, and E.W. Chester. 2002. Effects of flooding and temperature on dormancy break in seeds of the summer annual mudflat species *Ammannia coccinea* and *Rotala ramosior* (Lythraceae). Wetlands 22(4): 661-668.

BC Conservation Data Center (BCCDC). 2012. Element occurrence records for *Rotala ramosior*. Details provided on July 18, 2011.

Björk, C. 2012., pers. comm. Email Correspondence with Terry McIntosh regarding population estimates at the Mica spit site. Research Associate with the University of British Columbia Herbarium.

Blackwell, W.H. Jr. 1970. The Lythraceae of Ohio. The Ohio Journal of Science 70(6): 346-352.

BONAP (The Biota of North America Program). 2011. North American Plant Atlas (NAPA). http://www.bonap.org/genera-list.html Accessed January 13 2012.

Bonta, C. 2004. 2004 Report on Ontario's Population of Toothcup, *Rotala ramosior* Draft Report. Ontario Ministry of Natural Resources. Unpublished report. 12 pp.

Bonta, C. 2008. Puzzle Lake Provincial Park 2008 Report on Toothcup, *Rotala ramosior*. Ontario Parks, Southeast Zone, Ministry of Natural Resources, Kingston Office. Unpublished report. 6 pp.

Bonta, C., pers. comm. 2012. Email correspondence with Sam Brinker regarding water level management at Puzzle Lake. Assistant Planner, Ontario Parks, Kingston, ON.

Bowles, J.M. 1990. A Life Science Inventory of Turkey Point Marshes ANSI. OMNR, Simcoe District. Manuscript. 160 pp.

Brdar, C., pers. comm. 2011. Telephone conversation and email correspondence with Sam Brinker regarding shoreline surveys for Toothcup in and future management plans at Puzzle Lake Provincial Park. Zone Ecologist, Ontario Parks, Kingston, ON.

Brinker, S.R. 2011. Unpublished personal observations of Sam Brinker made during COSEWIC fieldwork for Rotala ramosior update status report. Botanist, Natural Heritage Information Centre, Peterborough, ON.

Brownell, V.R. 1994. A Biological Inventory and Evaluation of the Kaladar Jack Pine Barrens ANSI. OMNR, Tweed District, Tweed. 98 pp. + maps.

Brownell, V.R. 1997. A Biological Inventory and Evaluation of the Puzzle Lake ANSI. Ontario Ministry of Natural Resources Open Field Ecological Report, Peterborough District, Kingston, Ontario. vii + 135 pp. + 2 folded maps.

Brownell, V.R. 2003. A Supplemental Biological Inventory and Evaluation of the Puzzle Lake Provincial Park. Ontario Parks, South Eastern Zone, Ministry of Natural Resources, Kingston.

Brownell, V.R., C.S. Blaney, and P.M. Catling. 1996. Recent discoveries of southern vascular plants at their northern limits in the granite barrens area of Lennox and Addington County, Ontario. Canada Field-Naturalist 110(2): 255-259.

CESCC (Canadian Endangered Species Conservation Council) 2006. Wild Species 2005: The General Status of Species in Canada. 141 pp.

Ceska, A., and O. Ceska., pers. comm. 2012. Email correspondence with Terry McIntosh regarding shoreline development at the Town of Osoyoos Toothcup site. Consulting Botanists, Victoria, BC.

Chapman, L.J. and D.F. Putnam. 1984. The Physiography of Southern Ontario. 3rded. Ontario Ministry of Natural Resources, Ontario Geological Survey. Special volume 2.

Cook, C.D.K. 1979. A Revision of the Genus *Rotala ramosior* (Lythraceae). Boissera 29: 3-156.

Correll, D.S., and H. B. Correll. 1972. Aquatic and Wetland Plants of the Southwestern United States (2 Volumes). Environmental Protection Agency, Washington. 789 pp.

COSEWIC. 2009. Status Reports, Guidelines for Recognizing Designatable Units, Approved by COSEWIC in November 2009. http://www.cosewic.gc.ca/eng/sct2/sct2_5_e.cfm#EcoMaps Accessed January 13, 2012.

COSEWIC. 2012. Instructions for the Preparation of COSEWIC Status Reports. http://www.cosewic.gc.ca/htmldocuments/Instructions_e.htm#14 Accessed January 13, 2012.

Crow, G.E., and C.B. Hellquist. 2000. Aquatic and Wetland Plants of Northeastern North America. 2 Volumes. University of Wisconsin Press, Madison, Wisconsin.

Deam, C.C. 1940. Flora of Indiana. Indianapolis: Indiana Department of Conservation. 1236 pp.

Department of Ecology, State of Washington. 2013. Osoyoos Lake International Water Control Structure - Zosel Dam. Available at: http://www.ecy.wa.gov/programs/wr/dams/zosel.html

Douglas, G.W. 1994. Rare native vascular plants of the eastern shoreline of Osoyoos Lake. Internal report to the BC Conservation Data Center.

Douglas, G.W. 1999. Status of Toothcup in British Columbia. British Columbia Ministry of Environment, Lands and Parks Wildlife Branch and Resources Inventory Branch, Victoria, B.C. viii + 6 pp.

Douglas, G.W., and M.J. Oldham. 1999. COSEWIC status report on the Toothcup *Rotala ramosior* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 19 pp.

Draper, W.B., M.E. Gartshore, and J.M. Bowles. 2002. Life Science Inventory and Evaluation of St. Williams Crown Forest. Ontario Ministry of Natural Resources. xiv + 1,119 pp. + 15 folded maps, in 2 volumes.

Fernald, M.L., and L. Griscom. 1935. The variations of *Rotala ramosior*. Rhodora 37: 168-169.

Gartshore, M.E., D.A. Sutherland, and J.D. McCracken. 1987. The Natural Areas Inventory of the Regional Municipality of Haldimand-Norfolk. Norfolk Field Naturalists, Simcoe, Ontario. 2 Vols. 547 pp.

Gleason, H.A. 1952. The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada. Three Volumes. The New York Botanical Garden, Hafner Publishing Company Inc., New York, New York, U.S.A.

Gleason, H.A., and A. Cronquist. 1991. Manual of Vascular Plants of the Northeastern United States and Adjacent Canada. Second Edition. New York Botanical Gardens, New York.

Godfrey, R.K., and J.W. Wooten. 1981. Aquatic and Wetland Plants of Southeastern United States: Dicotyledons. The University of Georgia Press, Athens, Georgia.

Graham, S.A, pers. comm. 2001. Correspondence with Christopher Mattrick regarding seed dispersal in *Rotala ramosior*. Curator, Missouri Botanical Garden, St. Louis, MO.

Graham S.A., J. Hall, K. Sytsma, and S. Shi. 2005. Phylogenetic analysis of the Lythraceae based on four gene regions and morphology. International Journal of Plant Sciences 166(6): 995-1017.

Graham, S.A., M. Diazgranados, and J.C. Barber. 2011. Relationships among the confounding genera *Ammannia*, *Hionanthera*, *Nesaea* and *Rotala* (Lythraceae). Botanical Journal of the Linnean Society. 166: 1-19.

International Biological Program. 1969-1973. Checksheets completed by various individuals under the direction and auspices of the Committee of Terrestrial Ecosystems, International Biological Program.

International Osoyoos Lake Board of Control. 2012. Recommendations for Renewal of the International Joint Commission's Osoyoos Lake Order. Document prepared for the International Joint Commission.

International Union for Conservation of Nature (IUCN). 2013. Guidelines for Using the IUCN Red List Categories and Criteria Version 10. http://jr.iucnredlist.org/documents/RedListGuidelines. Accessed August 27 2013.

Jones, G.N., and G.D. Fuller. 1955. Vascular Plants of Illinois. University of Illinois Press, Springfield ILL. 593 pp.

Kartesz, J.T. 1994. A Synonymized Checklist of the Vascular Flora of the United States, Canada, and Greenland. Second Edition. Two Volumes. Timber Press, Portland, Oregon.

Kirk, D.A. 1988. A Life Science Inventory of South Walsingham Sand Ridges ANSI. OMNR, Simcoe District, Simcoe. Part 2 of 3.x + 129 pp. + maps.

Klinkenberg, R. 1980. Preliminary Inventory of Turkey Point Provincial Park. OMNR, Simcoe.

Lesica, P., and F.W. Allendorf. 1995. When are Peripheral Populations Valuable for Conservation? Conservation Biology 9: 753-760.

Lindsay, K.M. 1984. Life Science Areas of Natural and Scientific Interest in Site District 7-2 West of the Haldimand Clay Plain. A Review and Assessment of Significant Natural Areas in Site District 7-2 West of the Haldimand Clay Plain. OMNR, Central Region, Richmond Hill, and Southwestern Region, London. SR OFER 8403.viii + 131 pp. + map.

Lomer, F., pers. comm. 2012. Email correspondence with Terry McIntosh regarding site conditions at the Osoyoos oxbow site. Consulting Botanist, Vancouver, BC.

Mattrick, C. 2001. New England Plant Conservation Program Conservation and Research Plan. Rotala ramosior (L.) Koehne. New England Wild Flower Society and United States Fish and Wildlife Service. Framingham, Massachusetts. 27 pp.

McIntosh, T.T. 2010. Foreshore plant Species at Risk inventory, Osoyoos Lake, BC. Report prepared for the BC Ministry of Environment, Penticton, BC.

McIntosh, T.T., 2012. pers. comm. Discussions with private landowners and sensitive population data at sites north of the Mica Spit. Consulting Botanist.

McIntosh, T.T. 2014. Results of a foreshore inventory for at risk plant species in the South Okanagan Valley, BC. Report prepared for Ministry of Forests, Lands and Natural Resource Operations, Penticton, BC. 22 pp. Available at: http://a100.gov.bc.ca/appsdata/acat/documents/r42360/2014ResultsofSOkForeshoreAtRiskPlantInventory_1395864916773_5863693007.pdf

Mei Zhou Jie Jie Cai. 2007. Rotala ramosior in Z.Y. Wu, P.H. Raven, and D.Y. Hong, eds. 2007. Flora of China. Vol. 13 (Clusiaceae through Araliaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis. Missouri Botanical Garden Press. 491 pp.

Michigan Flora Online. A.A. Reznicek, E.G. Voss, and B.S. Walters. February 2011. University of Michigan. http://michiganflora.net/home.aspx Accessed January 16, 2012.

Michigan Natural Features Inventory. 2012. Michigan's Natural Communities. http://mnfi.anr.msu.edu/communities/index.cfm Accessed January 19, 2012.

Minnesota Department of Natural Resources. 2012. *Rotala ramosior* (L.) Koehne. http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=PDLYT0B030 Accessed January 19, 2012.

Missouri Botanical Garden. 2012. *Rotala ramosior* (L.) Koehne. Webstie: http://www.tropicos.org/Name/19200259 [accessed January 18, 2012].

National Toothcup Recovery Team. 2008. Recovery strategy for the toothcup (*Rotala ramosior*) in British Columbia and Ontario. Prepared for the British Columbia Ministry of Environment, Victoria, BC, and the Ontario Ministry of Natural Resources, Peterborough, ON. viii + 22 pp.

NatureServe Explorer. 2004. Habitat-based Plant Element Occurrence Delimitation Guidance, 1 October 2004. http://www.natureserve.org/explorer/decision_tree.htm

NatureServe Explorer. 2012. Webstie: http://www.natureserve.org/explorer/index.htm[accessed January 17, 2012].

New York Natural Heritage Program. 2012. Tooth-cup *Rotala ramosior* (L.) Koehne. Webstie: http://www.acris.nynhp.org/guide.php?id=9185 [accessed January 19 2012].

Ontario Endangered Species Act. 2007. Website: http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_07e06_e.htm [accessed January 20, 2012].

Presant, E.W., and C.J. Acton. 1984. The Soils of the Regional Municipality of Haldimand-Norfolk. Volume 1. Report No. 57 of the Ontario Institute of Pedology. Land Resource Research Institute Research Branch, Agriculture Canada, Guelph, Ontario.100 pp. + maps.

Provincial Parks and Conservation Reserves Act.2006. Website: http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_06p12_e.htm#BK11 [accessed January 20, 2012].

Species at Risk Act. 2002. Website: http://www.sararegistry.gc.ca/approach/act/sara_e.pdf [accessed January 20, 2012].

State of Washington Water Research Center. 2011. Effects of Zosel Dam Water Regulation on Osoyoos Lake Water Quality (Study 4). Report submitted to Washington State Department of Ecology.

Steyermark, J. 1963. Flora of Missouri. University of Iowa Press, Ames. 1729 pp.

Straley, G.B., R.L. Taylor, and G.W. Douglas. 1985. The Rare Vascular Plants of British Columbia. Syllogeus no. 59. World Wildlife Fund (Canada). 165 pp.

Sutherland, D.A. 1987. Annotated Checklist of the Plants of Haldimand-Norfolk. Pages 1-152, in M.E. Gartshore, D.A. Sutherland and J.D. McCracken. 1987. The Natural Areas Inventory of the Regional Municipality of Haldimand-Norfolk. Volume 2: Annotated Checklists. Norfolk Field Naturalists, Simcoe, Ontario.

Sutherland, D.A., pers. comm. 2011. Conversation with Sam Brinker regarding the nature of occupied Toothcup habitat in Norfolk County. Zoologist, Natural Heritage Information Centre, Peterborough, Ontario.

Ugent, D. 1962.Preliminary Reports on the Flora of Wisconsin. No. 47. The Orders Thymelaeales, Myrtales, and Cactales. Wisconsin Academy of Sciences, Arts and Letters 51: 83-134.

United States Department of Agriculture. 2012. Plants Profile: *Rotala ramosior* (L.) Koehne. Website: http://plants.usda.gov/java/nameSearch?keywordquery=rotala+ramosior&mode=sciname&submit.x=0&submit.y=0 [accessed January 24, 2012].

Veit, L. 2000. Report on Toothcup (*Rotala ramosior*) Field Visit – Aug. 24,27 & Sept. 7, 2000. Ontario Ministry of Natural Resources. Unpublished report. 4 pp. + maps.

Washington Department of Natural Resources. 2012. *Rotala ramosior*, Lowland Toothcup. http://www1.dnr.wa.gov/nhp/refdesk/fguide/pdf/rotram.pdf Produced in part by the Natural Heritage Program and the U.S.D.I. Bureau of Land Management. Accessed January 19, 2012.

Voss, E.G. 1987. Michigan Flora. Part II. Dicots (Saururaceae – Cornaceae). Cranbrook Institute of Science Bulletin 59 and University of Michigan Herbarium, Ann Arbor, Michigan, 724 pp.

White, D.J. 1993. Life Science Areas of Natural and Scientific Interest in Site District 6-10: A Review and Assessment of Significant Natural Areas. OMNR, Eastern Region, Kemptville.122 pp. + map.

BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Samuel R. Brinker is a botanist with the Natural Heritage Information Centre, where he assists with maintaining provincial status ranks and rare species occurrences in Ontario. He also conducts botanical inventories throughout the province and occasionally further abroad. He has authored several status reports and status appraisal summaries. Prior to this, Sam received a Bachelor of Environmental Studies (BES) from the University of Waterloo. He has also held a number of positions with the Ontario Ministry of Natural Resources, as well as working as a consulting biologist focusing on botanical inventories, vegetation mapping and species at risk assessments.

Dr. Terry McIntosh is a consulting botanist who specializes in plants, in particular bryophytes, of arid land ecosystems. He is a Taxon Editor (for the bryophyte volumes) and board member of the Flora of North America project. He has authored nine COSEWIC status reports: Columbian Carpet Moss, Banded Cord-moss, Rusty Cord-moss, Silver-hair Moss, Nugget-moss, Alkaline Wing-nerved Moss, Margined Stream-side Moss, Twisted Oak Moss, and Bent Spike-rush. He has also completed seven National Recovery Strategies. Terry has a strong interest in conservation and natural history, and is working closely with the Osoyoos Indian Band in their conservation efforts.

COLLECTIONS EXAMINED

Ontario collections were examined from the Natural Heritage Information Centre Herbarium (NHIC), Peterborough.