COSEWIC
Assessment and Status Report

on the

Tall Bugbane
Actaea elata

in Canada

ENDANGERED
2018

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2018. COSEWIC assessment and status report on the Tall Bugbane *Actaea elata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 37 pp. (http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1).

Previous report(s):

COSEWIC 2001. COSEWIC assessment and status report on the tall bugbane *Cimicifuga elata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 15 pp.

Penny, J.L., and G.W. Douglas. 2001. COSEWIC status report on the tall bugbane *Cimicifuga elata* in Canada, *in* COSEWIC assessment and status report on the tall bugbane *Cimicifuga elata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-15 pp.

Production note:
Production note: COSEWIC would like to acknowledge Matt Fairbarns and Denis Knopp for writing the status report on Tall Bugbane, *Actaea elata*, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Del Meidinger, Co-chair of the COSEWIC Vascular plants Specialist Subcommittee.

For additional copies contact:

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

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

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la Cimicaire élevée (*Actaea elata*) au Canada.

Cover illustration/photo:
Tall Bugbane — Photo by Tom Kaye.

Catalogue No. CW69-14/126-2018E-PDF
ISBN 978-0-660-27901-5

COSEWIC
Assessment Summary

Assessment Summary – April 2018

Common name
Tall Bugbane

Scientific name
Actaea elata

Status
Endangered

Reason for designation
This large western North American plant is a relatively long-lived perennial herb that inhabits mixed coniferous-deciduous forests. The species requires sunlit canopy openings in mature and old forests. Its few, small subpopulations in southwestern British Columbia are scattered and isolated in a single mountain river valley, where they continue to decline as its forest habitat continues to be reduced or degraded by invasive alien plants, largely associated with disturbances related to increased road access and recreational activities. Competition from native plants on previously logged sites and herbicide drift are also potential threats.

Occurrence
British Columbia

Status history
Designated Endangered in May 2001.Status re-examined and confirmed in April 2018.

COSEWIC
Executive Summary

Tall Bugbane
Actaea elata

Wildlife Species Description and Significance

Tall Bugbane is a large (100-180 cm tall) perennial herb. Its erect stems arise from a woody, short, dark, tuberous rhizome. The deeply-lobed leaves are up to 80 cm long. The many small creamy-white flowers form a distinctive wand-like inflorescence, 7-17 cm long. The follicles (a type of dry fruit) resemble short, hairy pea pods.

Distribution

The range of Tall Bugbane extends from the lower Fraser Valley of British Columbia (BC) south along the Cascades Range to southern Oregon and west to the Puget Sound-Willamette Trough region of Washington and Oregon. There are 237 subpopulations in Oregon and 30 in Washington. In Canada, Tall Bugbane has been reported in the Abbotsford-Chilliwack area, between the Fraser River and the US border. Six subpopulations have been seen within the past 19 years; another five subpopulations first reported between 1957 and 1997 are now historical and presumed extirpated.

Habitat

In Canada, Tall Bugbane is restricted to a small area of southwestern British Columbia, mostly at elevations of 30–950 m, with warm and dry summers and varying amounts of snow in winter. Tall Bugbane is most closely associated with old and mid-aged coniferous and mixed forests that are most often dominated by Douglas-fir and Bigleaf Maple. The understorey often contains a relatively sparse cover of shade-tolerant shrubs and an open herbaceous layer composed of shade-tolerant plants. Forest canopy gaps, created by the fall of individual trees or small clumps of trees, create sunlit gaps where Tall Bugbane plants flourish. Some areas where Tall Bugbane is known to have occurred have been clearcut over the past 25 years. Their subpopulations appear to have survived the logging but evidently were lost as early seral thickets developed during post-logging vegetation succession. Habitat has also been damaged as the amount of trail bike and off-highway vehicle use has proliferated. Invasive weeds have spread from roadsides into adjacent habitat occupied by Tall Bugbane.

Biology

Tall Bugbane is a perennial plant that produces one or more shoots from a short rhizome. It rarely if ever reproduces vegetatively. In BC, Tall Bugbane flowers from June to mid-November. Its flowers may be visited by a variety of pollinators; most flowers are fertilized by pollen from other flowers on the same plant. Most flowers produce a single dry fruit containing 6-12 seeds, which lack structures to aid in dispersal and mostly remain near the parent plant. The seeds break dormancy if they experience a warm period followed by a prolonged cold period. Most seeds probably germinate within 12 months or die. Tall Bugbane plants may take many years to mature and can pass through periods of regression and progression as growing conditions wane and wax. The average age of mature individuals in healthy Canadian populations is probably between 20-30 years. Tall Bugbane populations probably expand and contract very slowly.

Population Sizes and Trends

Approximately 250 (243-264) individuals bore fruit or flowers during the most recent surveys of extant subpopulations. Two of the subpopulations contained fewer than 10 mature individuals when last surveyed. Population trends are not well understood. It appears that two of the largest subpopulations are in long-term decline; there is no comparable information on the other subpopulations. The nearest US subpopulation is a few kilometres from the Canada/US border but because the species migrates very slowly there is little chance that the US subpopulations will serve as a source for the establishment of new Canadian subpopulations except over the very long term.

Threats and Limiting Factors

The greatest impacts to Tall Bugbane result from (1) invasive and other problematic species and (2) road clearing and maintenance. Natural limiting factors, including the small size of most subpopulations, the low reproductive rate, and the low dispersal rate accentuate these impacts.

Protection, Status and Ranks

Tall Bugbane was last assessed as Endangered. It was ranked by NatureServe in 2015 as Globally Secure but the nearest subpopulations are in Washington State, where the species is ranked as Vulnerable.

In Canada, Tall Bugbane is listed as Endangered on Schedule 1 under the *Species at Risk Act*, and a federal Recovery Strategy is now available. One of the six subpopulations of Tall Bugbane occurs on federal land, and it is afforded some protection under the Act.

Portions of three subpopulations occurring on provincial crown lands are protected within Wildlife Habitat Areas, where specific management measures are in place to help protect Tall Bugbane. Portions of one subpopulation occur within a municipal park where logging is not permitted.

TECHNICAL SUMMARY

Actaea elata

Tall Bugbane

Cimicaire élevée

Range of occurrence in Canada: 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 (2011) is being used)	20-30 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes. *The loss of some subpopulations, population viability modeling for two of the largest populations, and measured declines in some subpopulations all suggest a continuing decline in the number of mature individuals.*
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown. *There are too few monitoring data and insufficient coverage by the population viability analysis models to calculate the rate of decline in mature individuals.*
[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 a. clearly reversible and b. understood and c. ceased?	a. partially b. partially c. no
Are there extreme fluctuations in number of mature individuals?	Unknown. *There are insufficient monitoring data to determine the scale of fluctuations*.

Extent and Occupancy Information

Estimated extent of occurrence	97 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	84 km²
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. yes b. yes *Most individuals are found in small subpopulations; largest two subpopulations showing decline based on population growth rates. Species migrates very slowly.*

Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	13
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes, observed. *Historical extent of occurrence was 241 km^2. Contemporary extent of occurrence is 97 km² for a decline of 60% Continuing decline likely due to small number of individuals in some subpopulations.*
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, observed. *Contemporary index of area of occupancy is 84 km² (19%) less than historical index of area of occupancy. Continuing decline likely due to small number of individuals in some subpopulations.*
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes, observed. *Contemporary number of subpopulations (6) is 45% fewer than number of subpopulations (11) observed over the past 3 generations. Continuing decline likely due to small number of individuals in some subpopulations.*
Is there an [observed, inferred, or projected] decline in number of “locations”*?	Yes. *Conservatively assuming that each of the apparently extirpated subpopulations constituted one location, the contemporary number of locations is 5 fewer than the number of locations observed over the past three generations (28 % reduction). Continuing decline likely due to small number of individuals in some subpopulations.*
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes. *The apparent loss of some historical subpopulations appears to have resulted from post-logging development of large scale mid-seral forests that are not suitable for Tall Bugbane. Continuing decline in habitat quality projected.*
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”∗?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Vedder Mountain North	53
Vedder Mountain South	112
Elk Mountain	77
Mount Thom	1-2
OPSEE East	0 - 18

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

OPSEE West	0 - 2
Total	243-264

Quantitative Analysis

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

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

Was a threats calculator completed for this species? Yes (October 20, 2016).
Participants: Del Meidinger, Matt Fairbarns, Bruce Bennett, Denis Knopp, Dave Fraser, Andy MacKinnon, Daniel Brunton, James Pojar, Brenda Costanzo, Jenifer Penny, Joanna James (Appendix 1)

i. Invasive alien species, largely associated with increased road access including logging roads (IUCN 8: High impact)
ii. Direct impacts associated with establishment of legal and illegal creation of roads and vehicle tracks, expansion of existing roads, and road maintenance activities (IUCN 4.1: Medium – Low impact)
iii. Construction of recreation trails (IUCN 1.3: Low impact)
iv. Competition from native plants in previously logged environments (IUCN 8.2: Low impact)
v. Herbicide drift associated with road maintenance, silviculture, agriculture and invasive species management (IUCN 9.3: Low impact)

What additional limiting factors are relevant?

Small size of subpopulations
Relatively long distances between subpopulations
Fragmentation of habitat
Slow migration rate of Tall Bugbane

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	S3 (Vulnerable) in Washington State
Is immigration known or possible?	Yes, but very slowly. *Migration rates are very slow and while migration is possible it would take many generations for plants from the nearest known US populations to migrate into Canada.*
Would immigrants be adapted to survive in Canada?	Likely. *There is mixed evidence of genetic differentiation among subpopulations but there is no evidence that the genetic composition of US subpopulations makes them incapable of surviving in Canada.*
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?[+]	Yes
Are conditions for the source population deteriorating?[+]	Unknown

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

Is the Canadian population considered to be a sink?[+]	No
Is rescue from outside populations likely?	Possible, but highly unlikely over three or fewer generations.

Data Sensitive Species

Is this a data sensitive species? No

Status History

COSEWIC: Designated Endangered in May 2001.Status re-examined and confirmed in April 2018.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v); C2a(i)
Reason for Designation: This large western North American plant is a relatively long-lived perennial herb that inhabits mixed coniferous-deciduous forests. The species requires sunlit canopy openings in mature and old forests. Its few, small subpopulations in southwestern British Columbia are scattered and isolated in a single mountain river valley, where they continue to decline as its forest habitat continues to be reduced or degraded by invasive alien plants, largely associated with disturbances related to increased road access and recreational activities. Competition from native plants on previously logged sites and herbicide drift are also potential threats.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Declines cannot be quantified as previous counts for this species did not always distinguish mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v), as EOO and IAO are below threshold. The population is considered to be severely fragmented and continuing declines are observed and inferred in in EOO, IAO, quality of habitat, number of subpopulations and locations, and number of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C2a(i), as total population has fewer than 2500 mature individuals, there is an observed continuing decline in numbers of mature individuals, and no subpopulation contains more than 250 mature individuals.
Criterion D (Very Small or Restricted Population): Not applicable. Close to meeting Endangered, D1, but there is uncertainty in population estimate of mature individuals.
Criterion E (Quantitative Analysis): Data not available to conduct analysis for entire population.

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

PREFACE

COSEWIC designated Tall Bugbane as Endangered in May 2001 based on a status report published that year (COSEWIC 2001). Five of the subpopulations noted in the 2001 status report have not been found in recent years despite targeted searches, which suggests they may have become extirpated. This loss represents a 45% decline in the number of subpopulations reported in the 2001 status report.

Increased protection has come through the recent establishment of Wildlife Habitat Areas covering portions of three of the extant subpopulations. In 2016, some areas from which Tall Bugbane has been eradicated have been replanted with nursery stock derived from local material.

A recovery strategy was completed in 2017 by adding critical habitat to the 2014 provincial Recovery Plan.

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 (2018)

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

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

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

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

Environment and Climate Change Canada
Canadian Wildlife Service
Environnement et Changement climatique Canada
Service canadien de la faune
Canada

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

COSEWIC Status Report

on the

Tall Bugbane
Actaea elata

in Canada

2018

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Actaea elata* (Nutt.) Prantl

Synonyms: *Cimicifuga elata* Nutt.; *Thalictrodes elata* (Nutt.) Kuntze

Common English Names: Tall Bugbane

Common French Name: Cimicaire élevée

Family Name: Ranunculaceae (Buttercup Family)

Actaea elata var. *elata* is the only subspecific taxon in Canada. *Actaea elata* (Nutt.) Prantl var. *alpestris* (H.W. Lee & C.W. Park) Cubey is known from Oregon. Compton *et al.* (1998) combined *Cimicifuga* into *Actaea*.

Morphological Description

Tall Bugbane (Figures 1, 2) is a large (100-180 cm tall) perennial herb. Its erect stems, which are branched above, arise from a woody, short, dark, tuberous rhizome. The leaves are alternately arranged along the stem, have stalks to 40 cm long, and have blades to 80 cm long. The leaves are usually parted into three (occasionally five) main lobes, each of which is parted again into threes. The leaflets are heart- or egg-shaped, 5-18 cm long and 7-23 cm long. Each leaflet is usually sharply 3-lobed, the lobe margins with gland-tipped teeth. The stems and the lower surfaces of the leaves are finely hairy and the stems bear small glands, especially near the inflorescence (Hitchcock *et al.* 1964).

The flowers are densely arranged on a glandular-hairy, wand-like inflorescence, 7-17 cm long. The individual flowers are borne on 1-8 mm long stalks. The flowers lack petals and their white or pinkish sepals are usually shed soon after the flower opens. The cream-coloured stamens are showy, giving the appearance of narrow petals. The upper flowers usually produce a single dry fruit called a follicle, which resembles a short, hairy pea pod but only opens along one line. The lower flowers often produce two (sometimes three) follicles. Each follicle contains about 10 red to purple-brown seeds. More detailed descriptions may be found in Hitchcock *et al.* (1964) and Whittemore and Parfitt (1997).

Tall Bugbane is distinctive when in flower or fruit and is unlikely to be confused with any other species that occurs within its Canadian range. Plants in vegetative condition may occasionally be confused with other robust species with divided leaves (Fairbarns pers. obs. 2015).

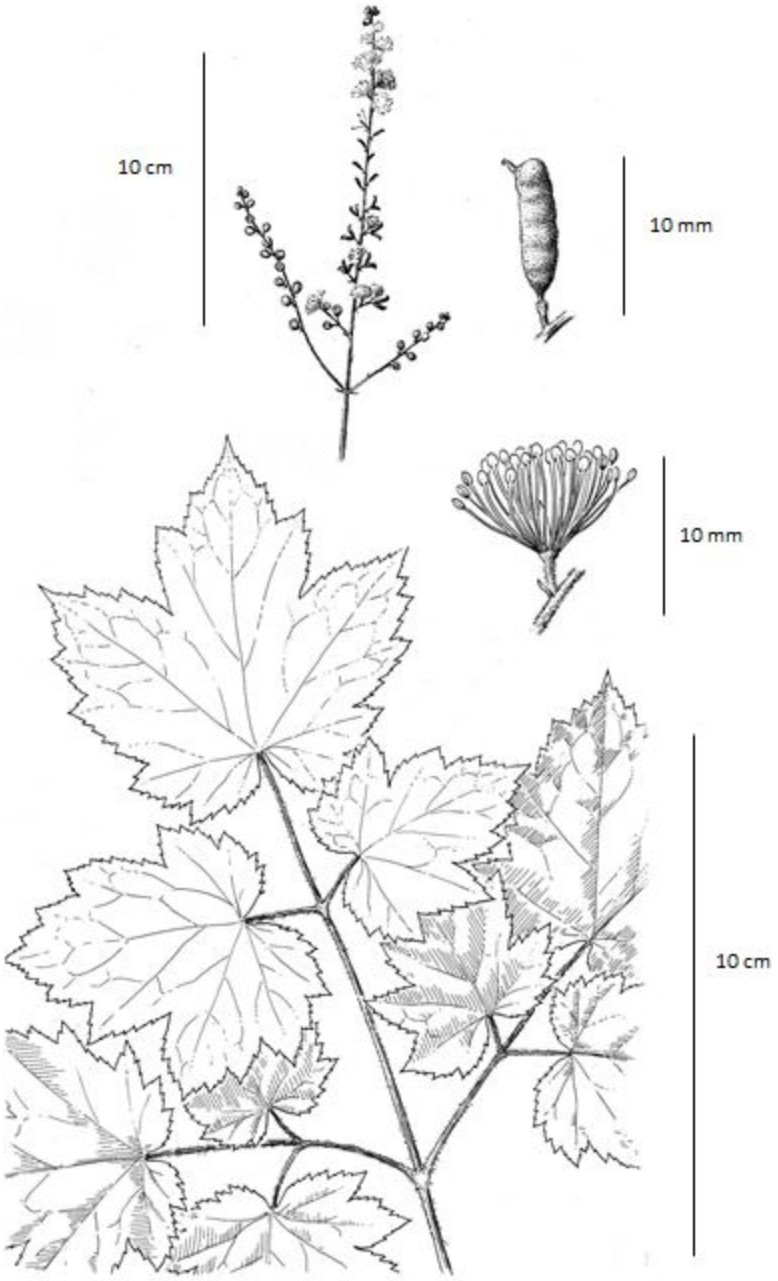

Figure 1. Tall Bugbane**.** Top left: inflorescence beginning to open up. Top right: follicle (fruit). Middle right: flower. Bottom: leaf. Illustration by J. Janish from Hitchcock *et al.* 1964 with permission.

Figure 2. Large Non-flowering Individual**.** Photo by Denis Knopp, with permission.

Red Baneberry (*Actaea rubra*) is the species most likely to be confused with Tall Bugbane when not in flower or fruit. Each leaf of a Red Baneberry is usually greatly subdivided (2-3 times divided into threes), more so than Tall Bugbane. The foliage of Red Baneberry bears sparse hairs while the foliage of Tall Bugbane bears abundant fine hairs. Large non-flowering specimens of Tall Bugbane tend to have slightly bulbous basal wings on the leaf stalks that clasp the stem; these are lacking in Red Baneberry. (Hitchcock *et al.* 1964; Knopp pers. comm. 2015; Fairbarns pers. obs. 2015).

For a more detailed morphological description of Tall Bugbane and its close relatives see Ramsey (1987).

Population Spatial Structure and Variability

There is no clear evidence regarding genetic variation among or between Canadian subpopulations. Mayberry (2008) found little genetic variation between two Canadian subpopulations but indicated that the lack of variation in nearly all allozymes investigated in her thesis and lack of differentiation between US and British Columbia (BC) populations suggest that the genetic results should be treated with some caution. In contrast, Liston and Gray (1998, *ex* Tall Bugbane Recovery Team 2014) found that throughout its range (including two Canadian subpopulations), Tall Bugbane subpopulations were genetically distinct.

Designatable Units

There is no clear evidence of genetic distinctiveness among Canadian subpopulations; there are no natural disjunctions between substantial portions of the species' geographic range in Canada; and Canadian subpopulations all lie within the Pacific National Ecological Area. For these reasons the Canadian subpopulations comprise a single designatable unit.

Special Significance

Bugbanes are attractive, widely grown garden plants (Burrell 1999). The closely related Black Cohosh (*Actaea racemosa*) has been suggested as a treatment for some forms of cancer, for menstrual cramps, and for help with the symptoms and side effects of menopause but there does not appear to have been any study of the medicinal properties of Tall Bugbane.

DISTRIBUTION

Global Range

The range of Tall Bugbane (Figure 3) extends from the lower Fraser Valley of BC south along the Cascades Range to southern Oregon and west to the Puget Sound-Willamette Trough region of Washington and Oregon (BC Conservation Data Centre 2016; Consortium of Pacific Northwest Herbaria 2016). Outlier subpopulations have been reported from the Olympic Mountains of northwestern Washington, and Idaho County in central Idaho (Consortium of Pacific Northwest Herbaria 2016). Kaye (1994) reported approximately 100 subpopulations in Oregon and 30 in Washington (Kaye 1994). Subsequent survey work has raised the number of known occurrences in Oregon to 237 (L. Wise pers. comm. 2018).

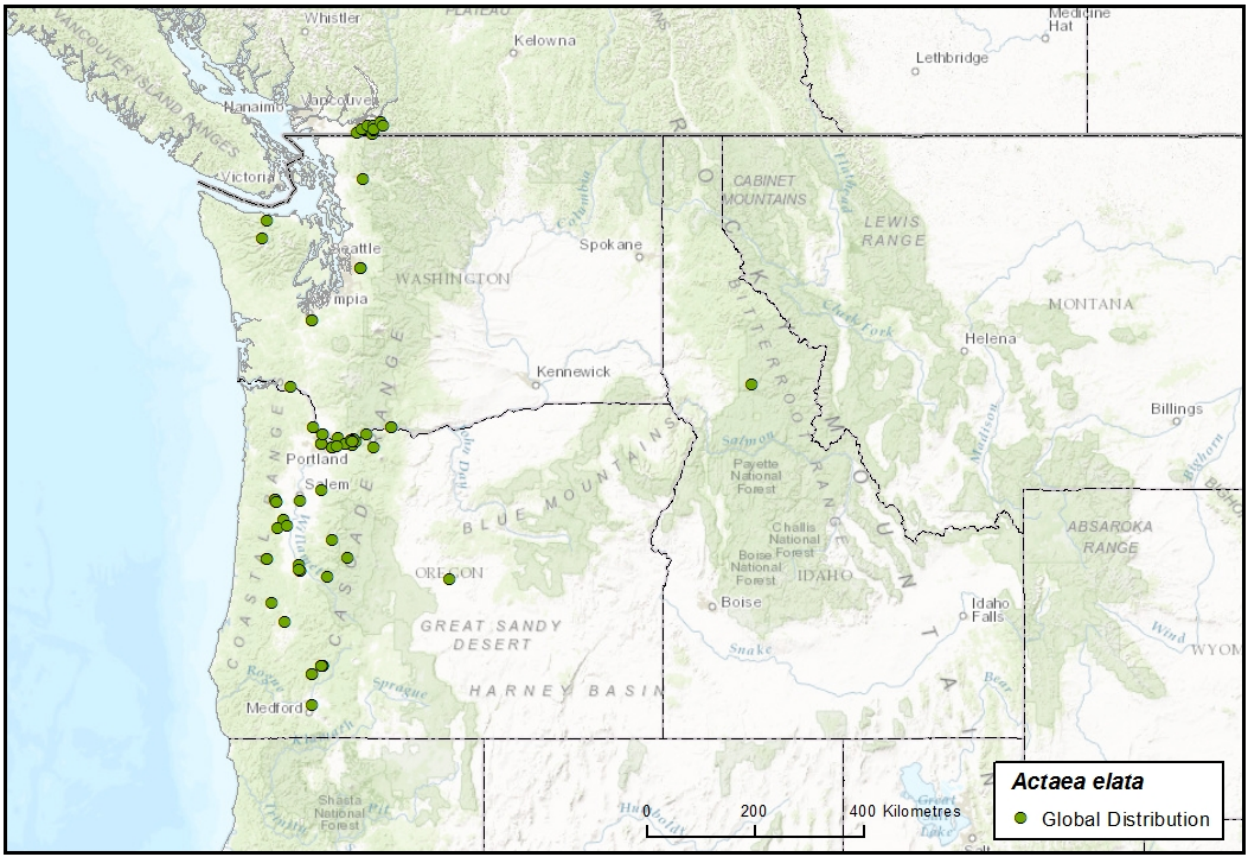

Figure 3. Global Distribution of Tall Bugbane (*Actaea elata*).

Canadian Range

In Canada, Tall Bugbane has been reported from the Pacific National Ecological Area, more specifically within the Coastal Western Hemlock and Mountain Hemlock biogeoclimatic zones (Figure 4) in the Abbotsford-Chilliwack area, between the Fraser River and the US border (BC Conservation Data Centre 2016). Six subpopulations have been recently seen (Table 1). Five subpopulations first reported between 1957 and 1997 are now presumed extirpated (Knopp pers. comm. 2015). Although Sumas Mountain (1986 – see Table 1) was reported as a subpopulation by the Fraser Valley Regional District, its presence is considered erroneous (Knopp pers. comm. 2003).

Table 1. Tall Bugbane Subpopulations in Canada.

Subpopulation	# of Locations	Surveyor(s)/ Date	Mature Individuals	Ownership
Vedder Mountain North	2	Knopp 2009	546 plants, maturity class unknown	Provincial Crown
		Knopp 2015	367 plants: 53 reproductive; 60 large non-reproductive, 254 small non-reproductive	
Vedder Mountain South	3	Knopp 2009	621 plants, maturity class unknown	Private/ Provincial Crown
		Knopp 2015	829 plants: 112 reproductive; 140 large non-reproductive; 577 small non-reproductive	
Upper Tamihi	0	Penny and Hartwell 1997	7	Provincial Crown
		Knopp 2003	failed to find (late season survey)	
		Barsanti 2005	Failed to find	
Chipmunk Creek	0	Fontaine and Hartwell 1997	Single low-vigour, non-reproductive chlorotic plant	Provincial Crown
		Knopp 2003	Failed to find (late season survey)	
		Barsanti 2005	Failed to find	
Elk Mountain	4	RBCM 1997	23 flowering, 3 non-flowering	Provincial Crown, First Nations Woodlot, Municipal
		Barsanti 2006	28 flowering	
		Knopp 2009	240 plants; not counted by maturity class	
		Knopp 2015	278 plants: 77 reproductive; 62 large non-reproductive; 139 small non-reproductive	
Mount Thom	2	Barsanti 2006	5 plants (partial population)	Municipal/ Provincial Crown
		Barsanti 2007	57 plants; 8 reproductive	
		Welstead, Kerr, Libal, Ramey and Slater 2007	43 plants; not counted by maturity class	
		Knopp 2014	About 5 plants; 1-2 reproductive.	
OPSEE east	1	Knopp 2010	86 plants: 6 reproductive; 5 large non-reproductive; 75 small non-reproductive	Federal leasehold (DND)

Subpopulation	# of Locations	Surveyor(s)/ Date	Mature Individuals	Ownership
		Knopp 2014	72 plants: 18 large (some of which may have been reproductive); 54 small, non-reproductive	
OPSEE west	1	Knopp 2010	18 plants: 2 reproductive; 1 large non-reproductive; 15 small non-reproductive	
		Knopp 2014	7 plants: 2 reproductive; 5 small non-reproductive	
Cheam Peak; south facing slope in recent clearcut in CWH	0	Scagel 1989	“a number of plants”	Provincial Crown
		Hartwell Aug 14, 1997	Failed to find; clearcut now heavily overgrown thickets	
		Barsanti and Iredale, 2005 and 2006	Failed to find	
Sumas Mountain*	0	Ryder ~ 1986	unknown	Municipal/ Provincial Crown
Liumchen Mountain	0	Beamish, Vrygtman 1957	unknown	Provincial Crown
Tamihi Trail	0	Scagel 1982	unknown	Provincial Crown
Chilliwack River	0	Macoun 1901	unknown	unknown
Mount Cheam	0	Gowan 1895	unknown	unknown

* Sumas Mountain was reported as a subpopulation by Fraser Valley Regional District but person noted as reporting site reported to Denis Knopp (Knopp pers. comm. 2003) that he has never seen species on Sumas Mountain.

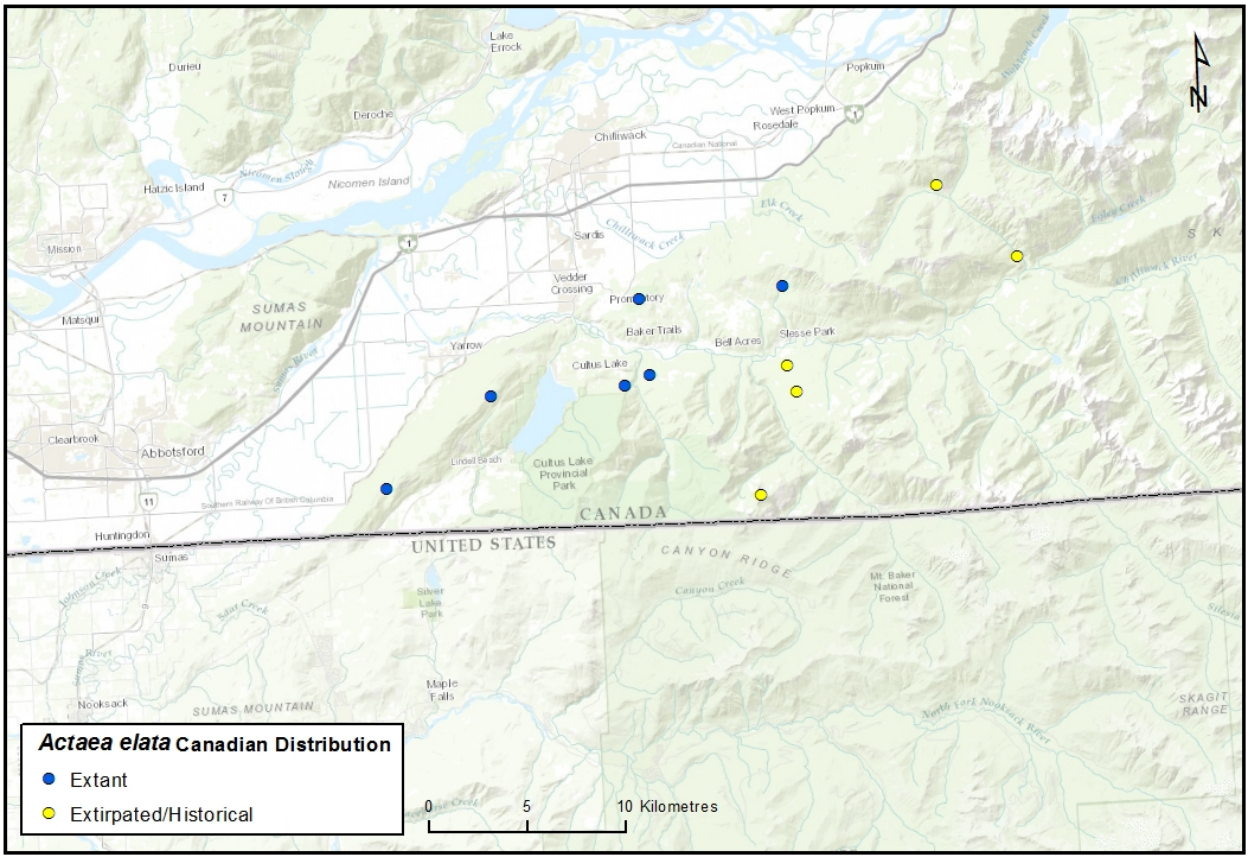

Figure 4. Canadian distribution**.** Blue dots show sites of recently confirmed subpopulations. Yellow dots show sites of extirpated and historical subpopulations.

Extent of Occurrence and Area of Occupancy

The maximum documented extent of Tall Bugbane in Canada was approximately 241 km^2. Based on the presumption that five subpopulations have been extirpated (Knopp pers. comm. 2015), the current extent of occurrence of the Canadian population is 97 km^2. Both the maximum historical extent of occurrence in Canada and the most recently documented extent of occurrence in Canada represent less than 1% of the lowest plausible estimate of its global extent of occurrence (125,462 km^2, assuming the report of a widely disjunct population in Idaho is valid).

If indeed five subpopulations have been lost over the past three generations (Knopp pers. comm. 2015), then the Canadian extent of occurrence has plausibly declined by 60% from 241 km^2 to as little as 97 km^2 over the past three generations (generation time is estimated at 25 years - see **Life Cycle and Reproduction**).

In 2016, some areas from which Tall Bugbane has been eradicated were replanted with nursery stock derived from local material. Two of these planting sites, Chipmunk Creek and Upper Tamihi, are in the general vicinity of subpopulations apparently extirpated between 1997 and 2003. The third site was within the South Vedder subpopulation (Welstead pers. comm. 2016). These re-introductions/augmentations are too recent to make any assumptions about medium- or long-term success and are not considered in the quantitative assessment of risk presented in this status report.

The index of the area of occupancy of recently observed subpopulations is 84 km^2. The five subpopulations presumed lost since 1957 (Knopp pers. comm. 2015) each appear to have been small and likely occupied only one 2 km x 2 km grid cell, so they would have collectively contributed 20 km^2 to the historical index of the area of occupancy. Their loss would have constituted a 19% decline in the index over the past three generations.

The apparent loss of five subpopulations constitutes a 45% decline in the number of subpopulations over the past three generations.

Search Effort

Denis Knopp conducted 18 days of dedicated surveys for Tall Bugbane in 2015, examining almost all known sites of plants at North Vedder Mountain, South Vedder Mountain, Elk Mountain and Mount Thom (a small number of sites at Elk Mountain could not be safely accessed but fewer than 10 mature individuals had been seen at these sites in previous years). Mr. Knopp also conducted a partial survey of known subpopulations at the OPSEE (Operator Special Engineering Equipment) training area of the Department of National Defence in 2014. Data for the OPSEE East and OPSEE West subpopulations were supplemented with information collected throughout that property in 2010 and 2014 (Knopp pers. comm. 2016a).

The Cheam Peak subpopulation, initially discovered in 1989, could not be rediscovered during surveys conducted in 1997, 2005 and 2006. The site, which was a clearcut in 1989 when first discovered, has subsequently developed a thick cover of deciduous trees and shrubs and for this reason the subpopulation is believed to be extirpated (BC CDC 2016). The precise locality of the Mount Cheam subpopulation, reported in 1895, is unknown; it may be synonymous with the Cheam peak subpopulation.

There are also no recent records of Tall Bugbane at Upper Tamihi. This small subpopulation, described in 1997, could not be found in 2003 or 2005. The site, which had been clearcut, is now choked by regrowth and accumulated logging debris which may have led to the loss of the subpopulation (Knopp, pers. comm. 2016a). The precise locality of the Tamihi Trail subpopulation, reported in 1982, is unknown; it may be synonymous with the Upper Tamihi subpopulation.

The Chipmunk Creek subpopulation, discovered in 1997, could not be found in 2001. The original report was of a single chlorotic, low-vigour, non-reproductive individual (BC CDC 2016) and Knopp (pers. comm. 2016a) believes this subpopulation has been extirpated.

The Sumas Mountain subpopulation, discovered in about 1986, could not be found in surveys conducted in 2005/2006 (Environment and Climate Change Canada 2017). Knopp (pers. comm. 2003) stated that this subpopulation was erroneously reported.

There have been no recent surveys for the Liumchen Mountain subpopulation, which is reported based on a 1957 collection that lacks precise information on its locality. It is presumed extirpated (Environment and Climate Change Canada 2017). There have been no recent searches for the Chilliwack River subpopulation reported based on a 1901 collection. It is possible, given the vagueness of the collection information, that the 1901 collection may have come from one of the localities referenced above (Environment and Climate Change Canada 2017; Knopp pers. comm. 2016a).

HABITAT

Habitat Requirements

Tall Bugbane is usually associated with mesohabitats with elevated moisture levels, such as streamsides or areas with subsurface water flow (Kaye 1994, 2001a; Kaye and Kirkland 1999). Wentworth (1996) describes Tall Bugbane as occurring in moderately rich forest soils. Throughout much of its global range Tall Bugbane prefers moist patches of Bigleaf Maple (*Acer macrophyllum*) within mixed forests of conifers (most often Douglas-fir [*Pseudotsuga menziesii*], sometimes with an admixture of Western Hemlock [*Tsuga heterophylla*] and Western Redcedar [*Thuja plicata*]).

In Canada, Tall Bugbane is restricted to a small area of southwestern BC; primarily in the very dry maritime, dry maritime and moist submaritime subzones of the Coastal Western Hemlock biogeoclimatic zone (within the moist maritime subzone it is restricted to the southern variant). It is most closely associated here with 50 to 250-year-old coniferous and mixed forests that are most often dominated by Douglas-fir and Bigleaf Maple although Western Redcedar, Red Alder (*Alnus rubra*), and Western Hemlock may be present. Although U.S. subpopulations of Tall Bugbane prefer north-facing slopes (Kaye 1995, 2000), significant portions of several Canadian subpopulations occur on other slope aspects including south and west-facing slopes (Tall Bugbane Recovery Team 2014). Most Canadian subpopulations of Tall Bugbane occur at elevations of 30–950 m (BC CDC 2016); however, the historical subpopulation reported from near the top of Mount Cheam apparently occurred between 1200–1600 m (BC CDC 2016).

The understorey often contains a relatively sparse cover of shade-tolerant shrubs and the herbaceous layer is usually open and composed of shade-tolerant plants (Fairbarns pers. obs. 2015; BC CDC 2016; Knopp pers. comm. 2016a).

Forest canopy gaps appear to play a key role in the natural distribution of Tall Bugbane. Such canopy gaps, created by the fall of individual trees or small clumps of trees, create sunlit canopy gaps where Tall Bugbane plants flourish (Alverson 1986; Wentworth 1996). Gap openings in mature and old-growth forest can re-invigorate small plants of Tall Bugbane that may have been persisting in a static state for many years (Kaye pers. comm. 2003 *ex* Tall Bugbane Recovery Team 2014).

Small gaps are uncommon in young forests; however, the presence of deciduous trees such as Bigleaf Maple and Red Alder in such stands may allow higher levels of light to penetrate to the forest floor, especially in spring (Knopp pers. comm. 2015).

Forest roads and clearcutting may bring elevated light levels to the forest floor, temporarily improving conditions for Tall Bugbane (Kaye and Keddy pers. comm. 2003 *ex* Tall Bugbane Recovery Team 2014; Fairbarns pers. obs. 2015; Knopp pers. obs. 2015). Left untended, Tall Bugbane may initially thrive but subsequently decline in such situations as the tree canopy becomes re-established and/or as invasive shrubs and herbaceous weeds take over openings, especially near forest roads (Knopp pers. comm. 2015). As clearcut stands develop into dense young coniferous forests, light levels well below those found in old-growth stands may have a negative long-term impact on Tall Bugbane plants (Kaye and Cramer 2002).

Habitat Trends

Using habitat information for known subpopulations in Canada and from recent studies in the United States, Klinkenberg (2005) prepared a predictive model for Tall Bugbane distribution in Canada. He then applied the model to digital Terrestrial Resource Information Management (TRIM) and BC Ministry of Forest cover maps to identify areas predicted to have the greatest likelihood of supporting Tall Bugbane. The majority (69%) of known occurrences fell within areas that the model predicted would be most likely to support Tall Bugbane. A further 17% of the known occurrences occurred within areas predicted to have moderately high potential for Tall Bugbane.

There is no information on quantitative changes in the extent and quality of habitat. General information on habitat loss and degradation are addressed below; see **Threats**.

BIOLOGY

Life Cycle and Reproduction

Tall Bugbane is a perennial plant that produces one or more shoots from a short rhizome. There is no evidence that asexual reproduction plays a significant role in its population dynamics.

Tall Bugbane flowers in BC from mid- to late June through to late July and early August (Penny and Douglas 2001) and sometimes even into mid-November (Knopp pers. comm. 2016a). It may be pollinated by bumblebees, solitary bees, the introduced honeybee, hoverflies, beetles, and pollen-foraging flies, with solitary bees observed more often than any other pollinator (Pellmyr 1986; Penny and Douglas 2001).

It appears that self-fertilization through facultative geitonogamy (fertilization of a flower by pollen from another flower on the same plant) is the primary reproductive mechanism (Pellmyr 1986).

In Canada, Tall Bugbane flowers were visited infrequently by pollinators (2.78 visits per hour). Pollen addition was not found to increase seed production, nor did the exclusion of pollinators reduce fruit production (Mayberry 2008).

Each Tall Bugbane flower contains 1-3 carpels; each flower generally produces a single follicle but can occasionally produce up to three. The follicles split along a single line of dehiscence (the seed-bearing suture) releasing 6-12 seeds (Matlack 1994; Wentworth 1996; Kaye 2000; Penny and Douglas 2001). Most Canadian plants only produce a few seeds (Knopp pers. comm. 2016a).

Germination trials have indicated that cold stratification alone is not sufficient to break seed dormancy. Warm stratification for two weeks, followed by cold stratification for three months, is sufficient to break dormancy (Kaye and Kirkland 1994; Kaye 2001a).

Tall Bugbane exhibits epicotyl dormancy (Kaye pers. comm. 2016). In this process, which has also been observed in the closely related Black Cohosh, seeds which produce radicles are able to develop root systems in the autumn but do not produce epicotyls until the following spring (Baskin and Baskin 1985).

The length of seed viability in the soil is unknown (Wentworth 1996). Kaye and Pyke (2003) observed that seeds either may not persist in the soil or may have delayed germination. They also report that seeds stored in dry, room-temperature conditions do not readily germinate after one year, although they did not test the ungerminated seeds to determine whether they remained viable (Kaye pers. comm. 2016). In natural environments, however, Tall Bugbane passes through two winter cycles prior to germination (Larkin pers. comm. ex. Knopp pers. comm. 2016a).

It appears likely that the majority of plants are produced from seeds produced during the previous two growing seasons. It is plausible; however, that some of the population is derived from seeds that had remained dormant for three or more years.

Mortality is reported as highest for seedlings and lowest for reproductive plants (Kaye 2000). Under unfavourable conditions, such as low light levels, established individuals may not reproduce for many years. Plants can become more vigorous and may reproduce when conditions become more favourable, but flowering plants may regress to a non-flowering state under deteriorating conditions. Suppressed plants may also remain dormant, failing to produce shoots for 1-2 years. Some subpopulations may have very few dormant individuals in any given year (Mayberry 2008); however, Kaye (2000) found that up to 12% of the individuals in some subpopulations can be dormant in some years.

The average lifespan of Tall Bugbane at three sites in Oregon was estimated at 18.2 years (Garcia *et al*. 2008, using data from Kaye and Pyke 2003). Based on three years of data, Mayberry and Elle (2010) estimated the age at first reproduction at sites in Canada as 8-13 years (Elk Mountain) and 5 years (Vedder). They estimated the average lifespan was 30-45 years at Elk Mountain and 13 years at Vedder. The subpopulation at Elk Mountain appeared to be in slight decline (λ, the finite rate of population increase, was estimated as 0.94 for 2005-2006 and 0.98 for 2006–2007). The subpopulation at Vedder was in significant decline (λ, was estimated as 0.86 for 2005-2006 and 0.87 for 2006-2007) because its greater reproductive output was more than offset by higher levels of mortality (Mayberry and Elle 2010). While the population data presented above are far from conclusive, the average age of mature individuals in healthy Canadian subpopulations (including the period of seed dormancy), probably lies between 20-30 years—this was used as the generation time. In nursery trials, seeds stratified for three months and then germinated in January 2015 produced small numbers of flowering individuals as early as 17 months after germination (Knopp pers. comm. 2016a).

Physiology and Adaptability

The ability of Tall Bugbane plants to go through cycles of progression and retrogression (Kaye 2000; Mayberry and Elle 2010) presumably confers an advantage in old-growth forest environments, where the disturbance regime is characterized by the creation of short-lived canopy gaps and infrequent stand-destroying events.

The long lifespan of mature forest herbs such as Tall Bugbane reduces their dependence upon fecundity and enhances their probability of local persistence despite environmental variability. It is a good strategy to avoid local extinctions caused by scarce and unpredictable recruitment as well as large population fluctuations (Garcia *et al.* 2008).

Dispersal and Migration

The seeds are about 2 mm in diameter, relatively heavy and lack obvious structures to assist dispersal. They tend to remain within a few metres of the parent plant (Kaye and Kirkland 1994; Wentworth 1996), although Knopp (pers. comm. 2015) believes that Mountain Beaver (*Aplodontia rufa*) may serve as secondary dispersers, incidentally moving seeds around as they harvest foliage and drag it to their burrows. Subpopulations of the closely related and similar Black Cohosh expand and migrate very slowly (Matlack 1994) and the same may be true of Tall Bugbane.

Interspecific Interactions

See **Threats**, subsection Invasives and other problematic species, for a discussion of herbivory; see **Biology – Dispersal and Migration** for discussion of the possible role that Mountain Beaver may play in secondary seed dispersal; and see **Threats** for discussions of competition and suppression.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

The amount of time spent searching for Canadian occurrences of Tall Bugbane is discussed above (**DISTRIBUTION – Search Effort**). Tall Bugbane presents challenges to field surveys. Most subpopulations consist of scattered, small patches. Typically, there are 1-5 individuals per patch although some patches are much larger. Many patches have no flowering individuals. In such situations, Tall Bugbane may be difficult to distinguish from the much more frequent Common Baneberry (*Actaea rubra*) (see **Morphological Description**).

Very few new plants were discovered in 2015, suggesting that the data captured in previous years constituted most of the actual population. Approximately 140 hours were spent between late July and early October 2015 surveying and documenting the subpopulations at Vedder North, Vedder South and Elk Mountain. A few Tall Bugbane occurrences previously reported at Elk Mountain could not be accessed in 2015 due to safety considerations. The missed sites constituted less than 5% of the previously known sites from Elk Mountain (Knopp pers. comm. 2016a).

The surveys were conducted between late July and early October 2015, the optimum survey period for the species because plants had reached maximum size and those that had flowered bore flowers or fruits during this period of the year (D. Knopp pers. comm. 2016a).

All plants observed were counted according to the following maturity/size classes:

1. In fruit
2. In flower
3. Bearing reproductive stalks but flowers/fruits removed by grazing animals
4. Large non-reproductive plants with 3 or more full-sized leaves
5. Juvenile plants with fewer than three leaves, or with much smaller leaves than are observed in flowering plants.

The subpopulation size estimates (number of mature individuals) provided in this report are counts of mature, reproductive (flowering and/or fruiting individuals) and do not include non-reproductive plants.

Mountain Beaver burrows found near patches of Tall Bugbane were noted (because Mountain Beaver may serve as a secondary dispersal agent). Signs of disturbance by logging, mountain bike use and other human activities were also noted, as were the presence and identity of invasive plant species where they were abundant (Knopp pers. comm. 2016a).

Abundance

Information on the abundance of Tall Bugbane in each subpopulation is provided in Table 1. Approximately 250 (243-264) individuals bore fruit or flowers during the most recent surveys of extant subpopulations. Age-class distributions in successive years at two of the largest BC subpopulations[1] suggest that most large vegetative plants do not flower in the following year; they often regress to small vegetative plants or become dormant (Mayberry and Elle 2010). For this reason, large vegetative individuals were not included in the estimate of mature individuals. Two of the remaining subpopulations consist of fewer than 10 mature individuals.

Fluctuations and Trends

Population trends are not well understood for three reasons: (1) there are too few observations to distinguish trends from natural variability; (2) some records do not distinguish between mature and immature individuals; and (3) at some areas apparent increases in the number of observed plants may reflect the discovery of previously unknown patches of Tall Bugbane.

A demographic analysis of two of the largest subpopulations (Elk Mountain and Vedder Mountain South) found that both were in decline. Their population growth rates (λ) were estimated at 0.94-0.98 and 0.86-0.87, respectively (Mayberry and Elle 2010).

Long-term population fluctuations and trends may be further confounded by the dynamics of canopy gap formation and closure, which appear to drive changes in the size (and perhaps number) of individual patches of Tall Bugbane.

Severe Fragmentation

Most individuals are found in small subpopulations prone to extirpation. As noted above, the population growth rates of the two largest subpopulations show decline. IUCN (2016) considers a population to be severely fragmented when most of its individuals are found in small and relatively isolated subpopulations, thereby increasing the risk of extinction.

[1] These data are from three years of demographic study and were based on data from subsets of the two large subpopulations.

The COSEWIC definition of severe fragmentation requires that more than half the total area of occupancy is in habitat patches that are: 1) smaller than would be required to support a viable population; and, 2) separated from other habitat patches by a large distance. Table 2 presents the area of critical habitat mapped in the recovery strategy (Environment and Climate Change Canada 2017). The critical area mapping includes all the known sites for Tall Bugbane with a buffer of 200 m around each subpopulation. The two largest subpopulations, Vedder Mountain South and Elk Mountain, comprise 12 and 22% of the area of critical habitat, respectively. Although both are in decline, the Elk Mountain subpopulation is potentially viable (λ close to 1). If Elk Mountain is the only viable subpopulation, then 78% of the area of occupancy is in habitat patches that are too small to support a viable population. Trail *et al*. (2007) conducted a meta-analysis of minimum viable population (MVP) studies and found that, for plants (22 studies), the median MVP was 4,824, with 95% confidence intervals of 2,512-15,992. The total Canadian population of all sized individuals of Tall Bugbane is 1,558, which is considerably less than the MVP.

Table 2. Area of Critical Habitat by Subpopulation.

Subpopulation	Ha. of critical habitat (incl. buffer)	Percent of total area	High range of # of mature individuals
Vedder Mountain South	160	12%	112
Elk Mountain	292	22%	77
Vedder Mountain North	577	44%	53
Mount Thom	40	3%	2
OPSEE East & West	197	15%	18
Chipmunk Creek	20	2%	0
Upper Tamihi	20	2%	0
Totals	1306	100%	262

Table 3 presents the distances between various pairs of subpopulations. As Tall Bugbane appears to migrate very slowly, and there is unsuitable habitat between some of the subpopulations, the combination of distance and habitat would restrict recolonization of habitat patches. The recovery strategy (Environment and Climate Change Canada 2017) supports this with the statement: "... broader-scale connective habitat between Tall Bugbane populations is also required, to allow for population dispersal, dynamics, and response to changing habitat conditions in the presence of climate change and/or local threats."

Based on the best available information, the Canadian population of Tall Bugbane is severely fragmented.

Table 3. Distances Between Subpopulations.

Subpopulation	Distance (km	Closest subpopulation
Vedder Mtn South	4.0	Vedder Mtn North
Mount Thom	8.8	Elk Mtn
OPSEE East	1.5	OPSEE West
OPSEE East	4.1	Mt Thom

Rescue Effect

The nearest US subpopulation is on Vedder Mountain, a few km south of the Canadian subpopulation, so there is a plausible chance of a rescue effect despite Tall Bugbane's likely slow rate of migration (see **Biology – Dispersal and Migration**).

THREATS AND LIMITING FACTORS

Threats

This section describes threats to Tall Bugbane within the framework established by the World Conservation Union Conservation Measures Partnership unified threats classification system (Master *et al.* 2009). Within this framework threats are grouped into broad categories and the impact of each threat is considered with respect to its scope (proportion of the total population or occurrences facing the threat within the next 10 years), severity (level of damage to the species over the scope of the threat; scored as the likely impact on the population over the next 10 years or three generations), and timing (in the past, continuing, or in the future). The overall calculated and assigned threat impact is High (Appendix 1).

Invasive and other problematic species (IUCN 8.1 & 8.2)

Invasive and other problematic species pose a high impact threat to Tall Bugbane. Exotic herbaceous species such as Small Touch-me-not (*Impatiens parviflora*) (Fairbarns pers. obs.), Wall Lettuce (*Mycelis muralis*) and Roberts Geranium (*Geranium robertianum*) may prevent the establishment and spread of Tall Bugbane. Tall, fast-growing, exotic shrubs such as Himalayan Blackberry (*Rubus armeniacus*) may outcompete and shade Tall Bugbane plants (Fairbarns pers. obs.). These invasive species spread along logging roads, in ditches and into logging sites, particularly where fresh disturbances are not rapidly planted or seeded. Post-logging silvicultural treatments also may lead to strong competition from native species (D. Knopp pers. obs.).

Native herbivores may stress subpopulations of Tall Bugbane. Deer, Roosevelt Elk (*Cervus canadensis roosevelti*), and Mountain Beaver may graze on Tall Bugbane (Kaye and Cramer 2002). In studies in the U.S., Kaye (2000, 2001a,b,c) reports high levels of herbivory for some subpopulations some years.

Broadleaved stands at Vedder Mountain have greater herbivory and higher reproduction, but also higher mortality and notably smaller leaves compared to the coniferous stand at Elk Mountain.

Recreational Development (IUCN 1.3)

The development of recreation areas on Vedder and Elk mountains is an increasing concern. The expansion of the trail system through several of the sites has damaged habitat and resulted in the loss of plants. Dirt biking trail construction is an issue at the Sumas Mountain historical site, where ground cover is often completely eradicated, trees felled for “bridging” to create crossings over inaccessible areas, and other bike trail activities.

Roads (IUCN 4.1 & 7.3)

Road construction, upgrading and maintenance pose both direct and indirect moderate impact threats to Tall Bugbane. The direct threat comes from road maintenance as was observed on Vedder Mountain where road maintenance activities damaged tall Bugbane plants in 2016 (D. Knopp pers. obs.). The indirect impacts of road building, upgrading and maintenance include the introduction of invasive species (see above), increased access to people pursuing recreational activities such as hiking, mountain biking and off-road vehicle use (see below), and changes in habitat suitability because of microclimate changes and hydrological changes brought about by building culverts, and the impacts of canopy tree removal.

Development of Tourism and Recreation Areas

A newly constructed road on Elk Mountain, as well as numerous illegally constructed roads and tracks on Vedder Mountain, have provided access to hikers, mountain bikers, campers, dirt bikers, off-road drivers and “mud-boggers” whose trail-building and trail use may damage Tall Bugbane (D. Knopp pers. obs.). As the human population of the Fraser Valley continues to grow rapidly, particularly in and around Chilliwack and Abbotsford, the numbers of trails and people using them will presumably continue to grow and may pose a low impact but significant threat to Tall Bugbane.

Agriculture and Forestry Pollution (IUCN 9.3)

Spray drift from nearby herbicide treatments is a direct, though low impact threat. The Elk Mountain subpopulation has been exposed to drift from glyphosate applied to control roadside vegetation (Barsanti *et al.* 2007). Herbicides used for road maintenance, agriculture, invasive species management, and silviculture are a concern at several other sites, in particular subpopulations on Vedder Mountain. The Upper Tamihi, Chipmunk Creek and OPSEE subpopulations may also be exposed to herbicide drift associated with adjacent agricultural land use, roadside spraying and silviculture treatments. The threat of spray drift depends on slope and prevailing air movement.

Other threats

Five other threats were identified but their impacts were considered negligible: (1) gathering terrestrial plants for native plant gardening and herbal medicine (IUCN 5.2); (2) logging and wood harvesting (IUCN 5.3); (3) human intrusions and disturbances such as off-trail recreation (IUCN 6.1); (4) housing and urban areas (IUCN 1.1); and (5) landslides (IUCN 10.3).

Fire suppression (IUCN 7.1) has been mentioned as a threat to Tall Bugbane both in the United States (Kaye 2000) and in Canada (Penny and Douglas 2001) but its impact is unknown. Kaye (2000) suggests that fires may reduce competition, increase light levels, and provide a flush of nutrients that would allow Tall Bugbane to reach maximum densities. Tall Bugbane appears to tolerate at least some fire regimes; Alverson (1986) and Wentworth (1994) found large populations of Tall Bugbane in some areas where fires have occurred. Frequent low-intensity fires may prevent the buildup of high fuel loads. In contrast, areas where fuels have built up are more likely to experience infrequent, high-intensity fires which could kill seeds and rhizomes and lead to population declines, although Tall Bugbane's tolerance of intense fires has not been examined and its range in BC is characterized by rare, small-scale, high-intensity fires (B.C. Ministry of Forests 1995). Subpopulations of Tall Bugbane in the Chilliwack River Valley have persisted despite a severe fire which burned through much of the region in 1938 and may have extended into areas that now host patches of Tall Bugbane (Chilliwack Forest District 2003).

Military exercises (IUCN 6.2) pose an unknown threat at the OPSEE area. It is used for "dismounted field training" and it is not clear what the impacts on the plants would be.

Climate change (particularly increasing drought—IUCN 11.2) may pose a threat to the Canadian population of Tall Bugbane but the severity of impacts as a result of climate change events over the next 10 years/3 generations is unknown.

Overall, the Canadian population of Tall Bugbane faces a high overall level of threat due to the impacts associated with multiple threats of varying magnitudes.

Limiting Factors

Several of the subpopulations are small and widely separated from one another, which make them particularly susceptible to demographic collapse in the face of natural or human-caused disturbances (Whitlock and McCauley 1990; Byers and Waller 1999).

As the landscape within its Canadian range becomes increasingly fragmented by forestry, agriculture, recreation and residential development, the limited ability of Tall Bugbane to disperse to new environments becomes exacerbated by disturbances to areas where it presently occurs.

Number of Locations

Assuming each extirpated subpopulation consisted of a single location, there were 20 historical locations of which 18 were found in the past three generations (60-90 years).

There are thirteen extant Tall Bugbane locations in Canada based on a combination of threats and land management responsibility/protection. They are as follows:

- Vedder Mountain North (2 locations)
    - Provincial crown land within Wildlife Habitat Areas, where special provisions apply to protect Tall Bugbane
    - Provincial crown land outside of Wildlife Habitat Areas
- Vedder Mountain South (3 locations)
    - Provincial crown land within Wildlife Habitat Areas,
    - Provincial crown land outside of Wildlife Habitat Areas
    - Private lands
- Elk Mountain (4 locations)
    - Provincial crown land within Wildlife Habitat Areas
    - Provincial crown land outside of Wildlife Habitat Areas
    - First Nations woodlot
    - Municipal lands
- Mount Thom (2 locations)
    - Provincial crown land (none within Wildlife Habitat Areas)
    - Municipal lands (park)
- OPSEE East (1 location)
    - Federal lease land held by Department of National Defence
- OPSEE West (1 location)
    - Federal lease land held by Department of National Defence

PROTECTION, STATUS AND RANKS

Legal Protection and Status

The Province of British Columbia has no stand-alone species-at-risk legislation to protect subpopulations of species at risk on non-federal lands.

Tall Bugbane was assessed as Endangered (COSEWIC 2001) and is protected on federal lands under Schedule 1 of the federal *Species at Risk Act* (SARA) and afforded measures of nominal protection under that legislation.

A Recovery Team prepared a Tall Bugbane recovery plan for the BC Ministry of Environment in 2014 and the plan was included within the recovery strategy for Tall Bugbane (Environment and Climate Change Canada 2017). The goal of the strategy is "To ensure that the number of populations and quality and quantity of occupied habitat remains stable or increases across the Tall Bugbane's existing range, and where feasible, to restore additional populations and connective habitat within the Tall Bugbane's historical range in B.C."

The following provisions are in place to protect the habitat of Tall Bugbane on crown land in Canada (Environment and Climate Change Canada 2017):

1. Tall Bugbane is listed as a species that requires special management attention to address the impacts of forest and range activities under the *Forest and Range Practices Act* (FRPA) and/or the impacts of oil and gas activities under the *Oil and Gas Activities Act* (OGAA).
2. Seven Wildlife Habitat Areas (WHAs) in the Chilliwack Forest District were established in 2007 for Tall Bugbane.
3. To date, 71 ha of the 348 ha of core survival habitat described in the recovery strategy is protected by WHAs (B.C. Ministry of Environment 2016).
4. Ecological monitoring by the BC Conservation Corps has been initiated at several sites to obtain baseline information to monitor logging impacts (Iredale and Barsanti 2006; Barsanti *et al.* 2007).
5. Predictive mapping of habitat for Tall Bugbane has been undertaken in the lower Fraser Valley, south of the Fraser River.

Non-Legal Status and Ranks

In 2015 Tall Bugbane was ranked by NatureServe (2015) as G4 (globally secure). In Canada it is ranked as N1 (critically imperilled) according to NatureServe (2015) and has a General Status rank (Canadian Endangered Species Conservation Council 2011) of 1: At Risk.

In BC, Tall Bugbane is ranked S1 (critically imperilled). It is a priority 1 species under the BC Conservation Framework (Goal 1: contribute to global efforts for species and ecosystem conservation; Goal 3: maintain the diversity of native species and ecosystems). It is included on the BC Red List, which consists of species that have been assessed as endangered, threatened or extirpated. Inclusion on the Red List does not confer any legal protection (BC Conservation Data Centre 2015).

Tall Bugbane has been ranked S3 (vulnerable) in Washington State (NatureServe 2015). It is ranked S4 in Oregon, where there are 237 known occurrences and a total of over 50,000 plants (Oregon Biodiversity Information Center 2013; L. Wise pers. comm. 2018).

Habitat Protection and Ownership

Habitat ownership is summarized in Table 1. The OPSEE subpopulations occur on provincial crown land leased by the Department of National Defence and a portion of the Elk Mountain subpopulation lies on a First Nations woodlot. The rest of the subpopulations occur on non-federal lands.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

Rose and Brian Klinkenberg (University of British Columbia), and Jenifer Penny and Marta Donovan (BC Conservation Data Centre) provided useful background information.

Authorities Consulted

Dr. Rhonda L. Millikin. A/Head Population Assessment, Pacific Wildlife Research Centre. Canadian Wildlife Service, Environment and Climate Change Canada. Delta, British Columbia.

Jennifer Doubt. Chief Collection Manager – Botany. Canadian Museum of Nature. Ottawa, Ontario.

Dr. Jennifer Rowland. Director, Infrastructure and Environment, Environmental Stewardship and Protection. National Defence, Canada.

Dr. Patrick Nantel. Conservation Biologist, Species at Risk Program. Ecological Integrity Branch, Parks Canada Agency. Gatineau, Quebec.

David F. Fraser. Endangered Species Specialist, Ecosystem Branch, Conservation Planning Section. Ministry of Environment, Government of British Columbia. Victoria, British Columbia.

Jenifer Penny. Botanist. British Columbia Conservation Data Centre. Victoria, British Columbia.

INFORMATION SOURCES

Alverson, E. 1986. Status report on *Cimicifuga elata*. Washington Natural Heritage Program. Unpublished.

Barsanti, J., N. Sands, S. Pinkus, and J. Neilson. 2007. Survey and mapping of tall bugbane (*Actaea elata* [Nutt.] Prantl) in the Fraser Valley, British Columbia, Canada. British Columbia Conservation Corps for British Columbia Ministry of Environment and British Columbia Conservation Foundation. *ex* Tall Bugbane Recovery Team 2014.

Baskin, J. M., and C. C. Baskin. 1985. Epicotyl Dormancy in Seeds of *Cimicifuga racemosa* and *Hepatica acutiloba*. Bulletin of the Torrey Botanical Club 112:253-257.

BC CDC. 2016. British Columbia Species and Ecosystems Explorer. British Columbia Ministry of Environment. Victoria, British Columbia. Web site: http://a100.gov.bc.ca/pub/eswp/ [Accessed March 12, 2016]

B.C. Ministry of Forests. 1995. Biodiversity guidebook. Web site: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/biotoc.htm [accessed July 11, 2012]

Burrell, C.C. 1999. The soaring Cimicifugas. Horticulture 96:48.

Byers, D.L., and D.M. Waller. 1999. Do plant populations purge their genetic load? Effects of population size and mating history on inbreeding depression. Annual Review of Ecology and Systematics 30:479–513.

Canadian Endangered Species Conservation Council. 2011. Wild Species 2010: The General Status of Species in Canada. Web site: http://wildspecies.ca/ [accessed: March 16, 2016].

Chilliwack Forest District. 2003. 1:75 000 map showing the fire history of the Chilliwack Landscape Unit. February 26, 2003. British Columbia Ministry of Forests, Chilliwack, BC.

Compton, J.A., A. Culham, and S.L. Jury. 1998. Reclassification of *Actaea* to include *Cimicifuga* and *Souliea* (Ranunculaceae): Phylogeny inferred from morphology, nrDNA ITS, and cpDNA trnL-F sequence variation. Taxon 47:593–634.

Consortium of Pacific Northwest Herbaria. 2016. Specimen data for *Actaea elata*. University of Washington Herbarium, The Burke Museum of Natural History and Culture. Seattle, WA. Web site: http://www.pnwherbaria.org [accessed: February 1, 2016].

COSEWIC 2001. COSEWIC assessment and status report on the tall bugbane *Cimicifuga elata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 14 pp.

Environment and Climate Change Canada. 2017. Recovery Strategy for the Tall Bugbane (*Actaea elata*) in Canada. Species at Risk Act Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. 2 parts, 15 pp. + 43 pp.

Garcia, M.B., F.X. Pico, and J. Ehrlen. 2008. Life span correlates with population dynamics in perennial herbaceous plants. American Journal of Botany 95:258-262.

Hitchcock, C.L., A. Cronquist, M. Ownbey, and J.W. Thompson. 1964. Vascular Plants of the Pacific Northwest, Part 2. University of Washington Press, Seattle, WA. 597 pp.

Iredale, F., and J. Barsanti. 2006. Inventory and mapping of historical and confirmed tall bugbane (*Actaea elata*) stations within the Chilliwack Forest District. Unpublished report for British Columbia Conservation Corps and British Columbia Min. Environ., Surrey, British Columbia. *ex* Tall Bugbane Recovery Team 2014.

IUCN Standards and Petitions Subcommittee. 2016. Guidelines for Using the IUCN Red List Categories and Criteria. Version 12. Prepared by the Standards and Petitions Subcommittee. Web site: http://cmsdocs.s3.amazonaws.com/RedListGuidelines.pdf [accessed: April 6, 2016]

Kaye, T.N. 1994. *Cimicifuga elata* – Tall Bugbane. Kalmiopsis:28–29.

Kaye, T.N. 1995. *Cimicifuga elata*: some comments on its ecology and distribution. Botanical Electronic News 121. December 9, 1995. Web site: http://www.ou.edu/cas/botany-micro/ben/ben121.html [accessed February 3, 2016]

Kaye, T.N. 2000. Population dynamics of tall bugbane and effects of forest management. Unpublished report for U.S. Department of Interior, Bureau of Land Management, U.S. Dep. Agric. For. Serv., and Oregon Dep. Agric., Plant Conservation Biology Program.

Kaye, T.N. 2001a. Propagation and population re-establishment for tall bugbane (*Cimicifuga elata*) on the Salem District, Bureau of Land Management. Second year report. Bureau of Land Management and Institute for Applied Ecology.

Kaye, T.N. 2001b. Population viability analysis of endangered plant species: an evaluation of stochastic methods and an application to a rare prairie plant. Ph.D. thesis. Oregon State University.

Kaye, T.N. 2001c. *Cimicifuga elata* Population monitoring in Medford District, Bureau of Land Management. U.S. Department of Interior, Bureau of Land Management and Institute for Applied Ecology. Department. of Agriculture, U.S. Department of Interior, Bureau of Land Management, and the U.S. Department of Agriculture, Forest Service.

Kaye, T.N., and J. Cramer. 2002. *Cimicifuga elata* population monitoring, Medford District, BLM. Progress report. U.S. Department of Interior, Bureau of Land Management, Medford District and Institute for Applied Ecology.

Kaye, T.N. and M. Kirkland. 1994. *Cimicifuga elata*: status, habitat analysis, monitoring, inventory and effects of timber management. Final report. Oregon Department of Agriculture, Salem, Oregon.

Kaye, T.N., and M. Kirkland. 1999. Effect of timber harvest on *Cimicifuga elata*, a rare plant of western forests. Northwest Science 73:159-167.

Kaye, T.N., and D.A. Pyke. 2003. The effect of stochastic technique on estimates of population vability from transition matrix models. Ecology 84:1464-1476.

Kaye, T., pers. comm. 2016. *E-mail to M. Fairbarns*. January 2016. Executive Director, Institute for Applied Ecology. Corvallis, Oregon.

Klinkenberg, B. 2005. Predictive mapping on potential habitat for Tall Bugbane (*Actaea elata*) in British Columbia. Unpublished report for BC Min. Environ. and the National Tall Bugbane Recovery Team.

Klinkenberg, Brian. (Editor) 2013. E-Flora BC: Electronic Atlas of the Flora of British Columbia. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver. Web site: http://ibis.geog.ubc.ca/biodiversity/eflora/ [accessed: February 1, 2016]

Knopp, D., pers. comm. 2003. *Email to Jenifer Penny, B.C. Conservation Data Centre*. January 7, 2003.

Knopp, D., pers. comm. 2015. *Conversation with M. Fairbarns.* July 2015. Member, Tall Bugbane Recovery Team.

Knopp, D., pers. comm. 2016a. *Telephone conversation with M. Fairbarns*. February 2016. Member, Tall Bugbane Recovery Team.

Knopp, D., pers. comm. 2016b. *Telephone conversation with M. Fairbarns and others*. October 20, 2016. Member, Tall Bugbane Recovery Team.

Liston, A., and S. Gray. 1998. Conservation genetics of *Cimicifuga elata*: results from the 1997 population samples. Oregon State Univ., U.S. Department of Interior, Bureau of Land Management and U.S. Department of Agriculture, Forest Service. Unpublished report.

Master, L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, J. Nichols, L. Ramsay, and A. Tomaino. 2009. NatureServe conservation status assessments: factors for assessing extinction risk. NatureServe, Arlington, Virginia. Web site: http://www.natureserve.org/publications/ConsStatusAssess_StatusFactors.pdf [accessed September 2015].

Matlack, G. 1994. Plant species migration in a mixed-history forest landscape in Eastern North America. Ecology 75:1491-1502.

Mayberry, R.J. 2008. The effect of environmental variation on the distribution, reproduction, and demography of a rare understory plant. M.Sc. thesis. Simon Fraser University, Burnaby, British Columbia.

Mayberry, R.J., and E. Elle. 2010. Conservation of a rare plant requires different methods in different habitats: demographic lessons from *Actaea elata*. Oecologia (4)164:1121–1130.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Web site: http://explorer.natureserve.org [accessed March 10, 2016].

Oregon Biodiversity Information Center. 2013. Rare, Threatened and Endangered Vascular Plant Species of Oregon. 42 pp. Web site: http://inr.oregonstate.edu/sites/inr.oregonstate.edu/files/2013-vascs.pdf. [accessed February 1, 2018]

Pellmyr, O. 1986. The pollination ecology of two nectarless *Cimicifuga* sp. (Ranunculaceae) in North America. Nordic Journal of Botany 6:1756-1051.

Penny, J.L., and G.W. Douglas. 2001. COSEWIC assessment and status report on the tall bugbane *Cimicifuga elata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-14 pp.

Ramsey, G.W. 1987. Morphological considerations in the North American *Cimicifuga* (Ranunculaceae). Castanea 52:129–41. Web site: http://www.jstor.org.ezproxy.library.uvic.ca/stable/4033602 [accessed: Apr 27 2015].

Trail, L.W., C.J.A. Bradshaw, and B.W. Brook. 2007. Minimum viable populations size: a meta-analysis of 30 years of published estimates. Biological Conservation 139:159-166.

Tall Bugbane Recovery Team. 2014. Recovery plan for tall bugbane (*Actaea elata*) in British Columbia. Prepared for the British Columbia Ministry of Environment, Victoria, British Columbia. 43 pp.

Welstead, K., pers. comm. 2016. *E-mail correspondence with Dave Fraser*. October 27, 2016. Ecosystem Biologist, British Columbia Ministry of Environment.

Wentworth, J. 1996. Report on the status in Washington of *Cimicifuga elata* Nutt. Washington Natural Heritage Program, Olympia, Washington. Unpublished.

Whitlock, M.C., and D.E. McCauley. 1990. Some population genetic consequences of colony formation and extinction: Genetic correlations within founding groups. Evolution 44:1717-1724.

Whittemore, A.T., and B.D. Parfitt / Flora of North America Editorial Committee, eds. 1997. Flora of North America North of Mexico, vol. 3: Magnoliophyta: Magnoliidae and Hamamelidae. Oxford University Press. Web site: http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=233500377 [accessed Apr 27, 2015].

Wise, L., pers. comm. 2018. *E-mail correspondence with Matt Fairbarns*. February 2, 2018. Oregon Biodiversity Information Center.

BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Matt Fairbarns has a B.Sc. in Botany from the University of Guelph (1980). He has worked on rare species and ecosystem mapping, inventory and conservation in western Canada for approximately 30 years.

Denis Knopp is a member of the Tall Bugbane Recovery Team and an authority on the distribution and ecology of Tall Bugbane in Canada.

COLLECTIONS EXAMINED

Collections at the herbarium of the Royal British Columbia Museum (V) were examined. Information from collections at the University of British Columbia Herbarium (UBC) was gathered from Klinkenberg (2013) and Consortium of Pacific Northwest Herbaria (2016).

Appendix 1. Threats Calculation Table for Tall Bugbane.

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Tall Bugbane (*Actaea elata*)
Element ID	**Elcode**
Date (Ctrl + ";" for today's date):	20/10/2016
Assessor(s):	Del Meidinger, Matt Fairbarns, Bruce Bennett, Denis Knopp, Dave Fraser, Andy MacKinnon, Daniel Brunton, James Pojar, Brenda Costanzo, Jenifer Penny, Joanna James
References:	Initial information compiled from BC Recovery Plan (BC 2014) and SARA Recovery Strategy (Canada 2016)

Overall Threat Impact Calculation Help:

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	1	1
C	Medium	1	0
D	Low	3	4
Calculated Overall Threat Impact:		High	High

Assigned Overall Threat Impact:	**B = High**
Impact Adjustment Reasons:	
Overall Threat Comments	Generation time 20-30 years.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Potential impact on South Vedder Mtn and Mount Thom. The Fraser Valley continues to be an area of concentrated land development and increasing urbanization. This is particularly true near Promontory and the Ryder Lake areas in Chilliwack and surrounding areas where extensive ongoing housing developments will likely impact not yet discovered populations. The Chilliwack population growth rate is projected to be an average of 8.3% per year over the next 10–15 years which is higher than the B.C. average and human population numbers are expected to reach 109,000 people in 2026. Additionally, there is currently extensive clearing for housing developments on Sumas Mountain in Abbotsford where a historical Tall Bugbane occurrence has been documented. In the next 10 years, impact likely negligible. Housing nearest Mt Thom subpopulation, but it is in a municipal park.
1.2	Commercial & industrial areas						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.3	Tourism & recreation areas	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	The development of recreation areas on Vedder and Elk mountains is an increasing concern. The expansion of the trail system through several of the sites has damaged habitat and resulted in the loss of plants through mud bogging, dirt biking trails, as well as hiking and mountain biking (see IUCN-CMP Threat 6.1). Dirt biking trail construction is an issue at the Sumas Mountain historical site, where ground cover is often completely eradicated, trees felled for “bridging” to create crossings over inaccessible areas, and other bike trail activities occur (Iredale and Barsanti 2006). With the ever-increasing population in the Fraser Valley and housing development in and around Chilliwack and Abbotsford, the numbers of trails and people using them is expected to continue to grow. Trail construction is main concern in this threat category, at this time.
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						
3	Energy production & mining						
3.1	Oil & gas drilling						
3.2	Mining & quarrying						
3.3	Renewable energy						Possible run-of-river hydro power projects, but only proposed project does not have Tall Bugbane. Not scored.
4	Transportation & service corridors	CD	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads	CD	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	Clearing for roads at any sites may cause direct mortality and indirect changes to the habitat suitability, change microclimate conditions, alter hydrological conditions (e.g., through culverting), and result in canopy removal. Tall Bugbane on Elk Mountain does inhabit a portion of the damp roadsides but these roads are narrow dirt forestry roads that do retain cover and are not ideal habitat given spraying, soil erosion, and other threats. Roads also increase access to the sites, which may enable other threats such as invasive species (scored in section 8.1 below), plant harvesting, trails, camping, mud bogging, etc. On Elk Mountain, a newly constructed road has potentially impacted that population both from direct and indirect increase in access. Illegally created roads are often created to access off-roading and mud bogging sites. On Vedder Mountain, legal and illegally created roads continue to be accessed and cleared. Road maintenance and expansion of roads is main concern. Recent (2016) road maintenance impacted on Vedder Mtn subpopulation. Considerable unknowns on impact, as maintenance often does not impact (may create habitat in the short-term in some sites but then graded out later). Where ditch clearing, what is done afterwards has impact on potential for invasives, etc.
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use		Negligible	Negligible (<1%)	Serious - Moderate (11-70%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	The collecting of plants and plant parts for native plant gardening and herbal medicine is a concern. Tall Bugbane is listed on several web sites and has been reported in general references as having medicinal value. On rare occasions, the plant may be collected for use in alternative medicine; this activity is likely infrequent because the plant is poisonous. Whole plants of Tall Bugbane may also be dug up for use as propagation stock by native plant nurseries. Seed may have been collected at one site but only once and would not affect the reproductive capacity of the population.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.3	Logging & wood harvesting		Negligible	Negligible (<1%)	Serious - Moderate (11-70%)	High (Continuing)	Tall Bugbane is threatened by logging operations that both directly and indirectly impact plant subpopulations through canopy loss, clearing of larger than natural gaps that are slow to regenerate, and habitat fragmentation. To date, at least two B.C. subpopulations have been lost due to clearcutting. Logging activities may include edge effects that alter environmental conditions such as growing conditions, light, and moisture into the forest adjacent to the road making the habitat less suitable. Logging is a threat at several sites. Seven Wildlife Habitat Areas (WHAs) were approved for Tall Bugbane in 2007, with general wildlife measures that afford some level of mitigation for the threat of logging. However, since 2007, 80% of the known occurrences of Tall Bugbane have been discovered outside the existing WHAs and may be susceptible to the threat of logging until additional WHAs that prevent or moderate this activity are approved. Both illegal and legal removal of large individual trees of Bigleaf Maple affects Tall Bugbane due to the ecological changes that occur. For instance, significant loss of canopy cover and changes in site hydrology and soil structure will reduce the suitability of the site for Tall Bugbane. The frequency of this threat is increasing with removal of Bigleaf Maple both with and without permits in the Chilliwack Valley. Over the short term, logging is not perceived to be a serious threat to this species, although this will be a long-term threat to subpopulations not protected by WHAs. Many subpopulations disappear after logging and some return; could depend on whether the site is replanted immediately which provides some shade for Tall Bugbane; if there is a lag in replanting, shrubs will increase and decrease available habitat for re-establishment for Tall Bugbane. Scope negligible over the next 10 years.
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Recreational activities are a concern at nearly all subpopulations. In particular dirt biking is an issue at the historical Sumas Mountain site where any ground cover is often completely eradicated. Recreational trails managed under Recreation Sites and Trails BC and illegal trails are also pervasive across Elk and Vedder mountains, directly impacting subpopulations. The North Vedder Mountain subpopulation was partially impacted by mud bogging in 2013 even though it was within a WHA area. All that remains is a deep flooded rectangular muddy ditch where some of the plants previously grew. Mt Thom subpopulation is adjacent to several park trails and requires careful management. Off-trail recreation is main concern.
6.2	War, civil unrest & military exercises		Unknown	Small (1-10%)	Unknown	High (Continuing)	The OPSEE area is used for "dismounted field training", it is not clear what the impacts on the plants would be. OPSEE is a leased area (Dept. of Defense/Prov. Crown).
6.3	Work & other activities						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7	Natural system modifications	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
7.1	Fire & fire suppression		Unknown	Small (1-10%)	Unknown	High (Continuing)	Fire suppression was identified as a threat to this species' survival in the previous COSEWIC status report (Penny and Douglas 2001). Kaye (2000) mentions fire suppression as a potential threat to this species, as this species may require a fire regime to reach maximum densities, a response to reduced competition, increased light, and a nutrient flush. Additionally, fire suppression could result in high fuel loading resulting in more intense fires. This may in turn kill seeds and rhizomes that might be able to resist mild surface fires. Alverson (1986) and Wentworth (1994) describe the presence of several populations of Tall Bugbane at U.S. sites where fires are known to occur and plant population numbers are high, indicating some degree of fire tolerance. However in B.C., the CWHdm subzone has a "natural disturbance type 2 (NDT2)," characterized by large-scale, catastrophic fires (average 5–50 ha) with a return interval averaging 150–350 years (B.C. Ministry of Forests 1995). In the Chilliwack River Valley, a severe fire was documented for the area in 1938 (Chilliwack Forest District 2003). Populations in this area have persisted despite these intense low frequency fires but the degree of fire resistance is still not quantified and the role of the fire cycle in sustaining healthy viable subpopulations is unknown. Any fires in this area would likely be fought right away (fires definitely could occur if the summers continue to be dry), and roads could be built for fire fighting purposes. However, there is no prescribed burning in the area.
7.2	Dams & water management/ use						
7.3	Other ecosystem modifications	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Roadside maintenance activities pose a threat to at least one known subpopulation of Tall Bugbane on Elk Mountain and likely other subpopulations on Vedder Mountain and Mount Thom. Roadway grading (treated under 4.1), as well as grass trimming and brush cutting, can damage habitat and smother plants. Planting of grasses after grading roadsides reduces potential habitat. Pesticides used on surrounding agricultural areas and land clearing can have a detrimental impact on the availability of pollinators for native species including Tall Bugbane.
8	Invasive & other problematic species & genes	B	High	Large (31-70%)	Serious (31-70%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species/diseases	B	High	Large (31-70%)	Serious (31-70%)	High (Continuing)	An indirect impact from increased access and logging roads is the increasing distribution of non-native species. For example, the invasive species Small Touch-me-not (*Impatiens parviflora*) has been documented at several Tall Bugbane sites. Other fast-growing opportunistic species such as Himalayan Blackberry (*Rubus armeniacus*) may outcompete and shade Tall Bugbane. Mayberry (2008) also found Wall Lettuce (*Mycelis muralis*) and Robert's Geranium (*Geranium robertianum*), which may act as competitors preventing expansion or re-establishment of Tall Bugbane. Invasion of logging sites, areas of roadside ditching, etc. all of concern. How and how quickly they are planted/seeded after disturbance influences potential impact.
8.2	Problematic native species/diseases	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)	Mayberry and Elle (2010) found that although subpopulations were more stable in coniferous stands than broadleaved stands, recruitment was lower in coniferous stands. Broadleaved stands at Vedder Mountain have greater herbivory and higher reproduction, but also higher mortality and notably smaller leaves compared to the coniferous stand at Elk Mountain. This suggests that the plants may be stressed due to herbivory. As a result of habitat modifications in the Chilliwack area herbivore numbers are increasing. Herbivores reported for Tall Bugbane include Deer, Roosevelt Elk, and Mountain Beaver (Kaye and Cramer 2002). In studies in the U.S., Kaye (2000, 2001a,b,c, 2002) reports high levels of herbivory for some subpopulations, although herbivory levels fluctuate from year to year. Kaye (1999) also concludes that herbivory by deer and Roosevelt Elk is more frequent in clearcuts and edges than in unmanaged old-growth forests. Recent indications are that herbivory by deer is quite low due to increased hunting the past few years. Native plant competition after logging is a concern -- depends on how site is treated after logging and would need to consider the seral stage of logged sites. Deer may eat seeds/plants but hunting pressure is high and not many deer particularly on Vedder mountain.
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	
9.1	Domestic & urban waste water						
9.2	Industrial & military effluents						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.3	Agricultural & forestry effluents	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	Spray drift from herbicide treatment is a direct threat because the species is susceptible to herbicide and can cause direct mortality. The threat of spray drift depends on slope and prevailing air movement. The Elk Mountain subpopulation has been subjected to herbicide spraying -- glyphosate to control roadside vegetation (Barsanti et al. 2007). Herbicides used for road maintenance, agriculture, invasive species management, and silviculture are a concern at several other sites in particular subpopulations on Vedder Mountain. Upper Tamihi, Chimpmunk Ck and OPSEE subpopulations are also susceptible depending on the adjacent land use, proximity to roads and silviculture prescription.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	As many of the subpopulations are associated with seepage areas, the likelihood of natural and induced landslides is substantial. Road cuts and clearing for helicopter landing pads (Elk Mtn), and clearcut logging (Upper Tamihi, Chipmunk Ck., and historical Cheam Peak & Liumchen Mtn), particularly on steeper slopes, can increase the risk of slides, slumps, or erosion (especially over time). Slides or slumps can change the soil structure and habitat suitability for Tall Bugbane. Although this is a potential threat at all these sites the scope of this threat is negligible as only a small portion of the subpopulations would ever be effected during any given 10-year period. Evidence to date is that slumps are small. A positive aspect is that slump may provide habitat for Tall Bugbane to seed into and then re-colonize.
11	Climate change & severe weather		Unknown	Pervasive - Large (31-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
11.1	Habitat shifting & alteration						
11.2	Droughts		Unknown	Pervasive - Large (31-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Climate models predict increasing drought in this area, primarily due to increased temperatures (heat). Although the impact on the hydrology and forest composition is unknown, it will be crucial to monitor these impacts as Tall Bugbane is closely associated with moist forest and seepage areas.
11.3	Temperature extremes						
11.4	Storms & flooding						
11.5	Other impacts						

Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).