COSEWIC
Assessment and Status Report

on the

Yellow False Foxglove Bundle

Smooth Yellow False Foxglove
Aureolaria flava

Fern-leaved Yellow False Foxglove
Aureolaria pedicularia

Downy Yellow False Foxglove
Aureolaria virginica

in Canada

Smooth Yellow False Foxglove *Aureolaria flava* - THREATENED
Fern-leaved Yellow False Foxglove *Aureolaria pedicularia* - THREATENED
Downy Yellow False Foxglove *Aureolaria virginica* - 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:

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Yellow False Foxglove Bundle — Photo by Mary E. Gartshore.

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COSEWIC
Assessment Summary

Assessment Summary – April 2018

Common name
Smooth Yellow False Foxglove

Scientific name
Aureolaria flava

Status
Threatened

Reason for designation
This perennial plant species has a distribution restricted in Canada to southwestern Ontario. There are few individuals remaining in a small number of locations within oak savannas and woodlands. Declines have been observed in its distribution and quality of habitat. Fire suppression and browsing by White-tailed Deer threaten the remaining extant locations.

Occurrence
Ontario

Status history
Designated Threatened in April 2018.

Assessment Summary – April 2018

Common name
Fern-leaved Yellow False Foxglove

Scientific name
Aureolaria pedicularia

Status
Threatened

Reason for designation
This short-lived plant species has a distribution restricted in Canada to southwestern Ontario. The remaining individuals occur in a small number of locations within oak savannas and woodlands. Declines have been observed in quality of habitat. Fire suppression and residential development threaten the remaining extant locations.

Occurrence
Ontario

Status history
Designated Threatened in April 2018.

Assessment Summary – April 2018

Common name
Downy Yellow False Foxglove

Scientific name
Aureolaria virginica

Status
Endangered

Reason for designation
This perennial plant species has a distribution restricted in Canada to southwestern Ontario. There are few individuals in the five remaining locations within oak savannas and woodlands. Declines have been observed in its distribution and quality of habitat. Fire suppression and browsing by White-tailed Deer threaten the remaining extant locations.

Occurrence
Ontario

Status history
Designated Endangered in April 2018

COSEWIC
Executive Summary

Yellow False Foxglove Bundle

Smooth Yellow False Foxglove
Aureolaria flava

Fern-leaved Yellow False Foxglove
Aureolaria pedicularia

Downy Yellow False Foxglove
Aureolaria virginica

Wildlife Species Description and Significance

The three species of Yellow False Foxglove that occur in Canada are herbaceous plants with showy yellow flowers. The Smooth Yellow False Foxglove (*Aureolaria flava*) has smooth stems whereas the stems and leaves of the Downy Yellow False Foxglove (*Aureolaria virginica*) are covered by fine downy hairs. The stems and leaves of the Fern-leaved Yellow False Foxglove (*Aureolaria pedicularia)* are covered by sticky glandular hairs. The leaves of the latter species are more dissected than the lobed leaves of the other two species. Yellow False Foxgloves are hemi-parasites which can take up water and nutrients by attaching to the roots of oaks or other host plants.

Distribution

Yellow False Foxgloves occur only in eastern North America. A small part of the global range of the three species extends into southwestern Ontario. All three species have disappeared from many former sites. Seven subpopulations of Smooth Yellow False Foxglove persist. Six subpopulations of Fern-leaved Yellow False Foxglove were confirmed in 2016, along with five subpopulations of Downy Yellow False Foxglove.

Habitat

In Canada, Yellow False Foxgloves are found in dry, open to semi-open, upland oak ecosystems. Fern-leaved Yellow False Foxglove is found in open savanna and woodland habitats along with Black Oak, its preferred host tree. The other two species can persist under dappled light conditions and occur in oak woodlands and forests, typically with White Oak present. All three species are shade intolerant to varying degrees. Their hemi-parasitic behaviour provides them with a competitive advantage on drought-prone soils provided they can attach to a suitable host.

Biology

Smooth Yellow False Foxglove and Downy Yellow False Foxglove are perennial herbs that send up multiple flowering stalks each year. In contrast, Fern-leaved Yellow False Foxglove is a short-lived species, which flowers only once, typically in its second year. All three species reproduce only from seeds. The flowers are pollinated by bumble bees and other insects. Fern-leaved Yellow False Foxglove plants can self-pollinate, whereas the other two species require pollen from other plants to set seeds.

Population Sizes and Trends

Little was known about the size of Canadian populations of Smooth Yellow False Foxglove and Fern-leaved Yellow False Foxglove prior to 2016. Downy Yellow False Foxglove was the focus of a targeted survey in 1990.

The Canadian population of Smooth Yellow False Foxglove is estimated to be between 464 and 1409 mature individuals. Over 60% of the population is found at three sites in the Ojibway Prairie Complex subpopulation. Population trend information is not available.

The Canadian population of Fern-leaved Yellow False Foxglove is estimated to be between 7602 and 11820 plants. About 85% of the population occurs in the Pinery Complex and Turkey Point Complex subpopulations. Population trend information is not available.

The Canadian population of Downy Yellow False Foxglove is very small, consisting of about 400 mature individuals in five subpopulations. Three-quarters of the population is at a site near Cambridge, Ontario where the number of plants has increased 15-fold since 1990. There have been serious declines at the other four sites.

Threats and Limiting Factors

All three species face a suite of similar threats due to their association with open to semi-open oak ecosystems. Oak ecosystems across eastern North America are in decline for a variety of reasons. Fire suppression and invasive species are threats to the persistence of Yellow False Foxgloves in Canada because they result in increased shading and competition from other species. Active habitat management, including prescribed burning and invasive plant control, is taking place at several Yellow False Foxglove sites to restore and maintain open oak ecosystems.

Moderate to severe damage to plants due to browsing by White-tailed Deer was observed at most sites during 2016 fieldwork. Deer occur at high densities in southern Ontario as their diet is supplemented by agricultural crops. Deer browsing is affecting the perennial species especially, resulting in greatly reduced seed production at most subpopulations. Residential development is a potential threat at one site supporting a substantial portion of the Fern-leaved Yellow Foxglove population. Some small subpopulations of each species are at considerable risk of extirpation as the plants are situated near heavily used recreational trails.

Protection, Status and Ranks

These species have not been previously assessed by COSEWIC and they do not have any special legal status anywhere in Canada. In the United States, some species are protected in a few states on the periphery of the species' range. All three species are considered globally secure. Downy Yellow False Foxglove has a non-legal status rank of critically imperilled in Canada and Ontario. Smooth Yellow False Foxglove and Fern-leaved Yellow False Foxglove were both ranked as imperilled in Canada and Ontario, although these rankings are flagged as tentative as recent survey information was not available at the time.

TECHNICAL SUMMARY - Smooth Yellow False Foxglove

Aureolaria flava

Smooth Yellow False Foxglove

Gérardie jaune

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

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	Unknown but estimated to be 7-15 years.
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Possibly. Past abundance information is lacking for the larger subpopulations, but other extant sites have experienced declines that are likely to continue due to ongoing threats.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Uncertain. Past abundance information is not available for the larger subpopulations.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Uncertain. Past abundance information is not available for the larger subpopulations.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Uncertain but suspected that losses of mature individuals will occur if threats not addressed.
[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. Data are lacking.
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Possibly at most sites b. Possibly at most sites c. No
Are there extreme fluctuations in number of mature individuals?	Unknown, but unlikely.

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	11,646 km² for seven extant subpopulations. Including the one historical (presumed extant) subpopulation does not increase the EOO.
Index of area of occupancy (IAO) (Always report 2x2 grid value).	40 km² for extant subpopulations. 44 km^2 if historical subpopulation is included.

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. Uncertain. Area needed to support viable population unknown. Ojibway Prairie (40% of IAO) and Walpole Island (at least 10% of IAO) complexes likely have sufficient habitat to maintain a viable subpopulation if threats are mitigated. All other subpopulations are in small to very small habitat patches. b. Yes. All subpopulations are widely separated, habitat patches are isolated fragments, seeds have no active dispersal mechanism, and species is not self-fertile so unlikely to disperse significant distances.
Number of "locations" (use plausible range to reflect uncertainty if appropriate)	7-9 known extant locations; lower number is based on extant subpopulations, higher number is based on property parcels and includes one presumed extant subpopulation. See Table 1.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes, observed although timing of extirpations is uncertain. At least 5.7-17.6% reduction over three generations (21-45 years) based on year last observed.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, observed although timing uncertain. At least 23.1-56.5% reduction over three generations (21-45 years) based on year last observed.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes, observed. Of the 17 extirpated or presumed extirpated subpopulations, at least 2-7 subpopulations became extirpated during the past 21-45 years.
Is there an [observed, inferred, or projected] decline in number of "locations"?	Yes, observed. At least 2-9 locations extirpated over past three generations (21-45 years), lower number is based on subpopulations extirpated since 1995, higher number is based on property parcels extirpated since 1972.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred ongoing decline in habitat quality due to forest succession and mesophication and/or due to invasive non-native plants at most sites. Inferred decline in habitat extent at these sites as open areas close in. Habitat is being actively managed for savanna structure and species at Ojibway Prairie Complex and Branchton Railway subpopulations but current condition is degraded due to legacy of fire suppression and invasive species. Habitat condition for Walpole Island subpopulation is not known.
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
Ojibway Prairie Complex, Essex (3 extant sites, 1 historical site, 1 extirpated site; 7 patches counted, additional patches observed but not counted, additional habitat not checked)	163 individuals tallied during partial count in 2016, estimate of 286 to 1036 individuals
Walpole Island, Walpole Island FN (subpopulation not included in 2016 fieldwork, possibly up to 4 patches)	Incidental observation of about 10 plants in 2015 and 50 plants in one patch in 2008. Estimate of 50 to 200 individuals
Venison Creek, Norfolk (3 patches)	74 (2016 count)
Fifty Road Escarpment, Hamilton	31 (2016 count)
Branchton Railway Oak Knoll, Waterloo (3 patches)	11 (2016 count)
Sixteen Mile Creek Complex, Halton (extant patch at one site; extirpated patch at another site)	7 (2016 count)
Sudden Bog, Waterloo	5 individuals tallied during partial count in 2016, estimate of 5 to 50 individuals
London Riverbend East, Middlesex (nonviable)	0 (1 plant in 2016 count but single plants are not capable of producing recruits)
Longwoods Road Conservation Area, Middlesex (nonviable)	0 (1 plant in 2016 count but single plants are not capable of producing recruits)
Total	291 mature individuals (plus 2 single individuals) counted in 2016. 50 plants observed in 2008 at the extant subpopulation not checked in 2016. Total count of 341 plants, estimated population of 464 to 1409 mature individuals (midpoint = 936.5)

Quantitative Analysis

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

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

Was a threats calculator completed for this species? Yes. April 4, 2017 by Jana Vamosi, Del Meidinger, Bruce Bennett, Vivian Brownell, Alistair Mackenzie, Graham Buck, Audrey Heagy, Jenny Heron, Joanna James (Appendix 4).

Overall threat impact calculated to be very high to high

i. Fire suppression (medium impact)
ii. Problematic native species (medium impact)
iii. Recreational activities (medium - low impact)
iv. Invasive non-native species (low impact)

What additional limiting factors are relevant? Species is hemi-parasitic on oak. Oak woodland/savanna habitat is rare, declining and fragmented in southwestern Ontario. Low dispersal capability.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Species is secure (S5) in New York, and present (status not ranked) in Ohio, Pennsylvania, and Michigan.
Is immigration known or possible?	Not known and very unlikely as no long-distance dispersal mechanism
Would immigrants be adapted to survive in Canada?	Probably yes
Is there sufficient habitat for immigrants in Canada?	Likely not
Are conditions deteriorating in Canada?	Yes
Are conditions for the source population deteriorating?	Probably; oak savanna and woodlands in northeastern United States face similar threats as in Canadian range.
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species? No

Status History

COSEWIC: Designated Threatened in April 2018.

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric codes:** B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v); C2a(i); D1
Reasons for designation: This perennial plant species has a distribution restricted in Canada to southwestern Ontario. There are few individuals remaining in a small number of locations within oak savannas and woodlands. Declines have been observed in its distribution and quality of habitat. Fire suppression and browsing by White-tailed Deer threaten the remaining extant locations.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. May meet Endangered, A2c. Data are lacking to determine the percentage of reduction, but past declines in IAO could potentially infer declines in mature individuals of more than 30% over three generations.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Threatened, B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v), with restricted EOO and IAO, there are fewer than 10 locations, continued declines observed in EOO, IAO, habitat, and number of locations, and projected declines in mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Meets Threatened, C2a(i). The number of mature individuals is small and meets the threshold for Endangered (<2,500). A decline in the number of mature individuals is projected and no subpopulation is estimated with a midpoint value >1000 mature individuals.
Criterion D (Very Small or Restricted Population): Meets Threatened D1, with the total population estimated with a midpoint lower than 1000 mature Individuals.
Criterion E (Quantitative Analysis): Not done.

TECHNICAL SUMMARY - Fern-leaved Yellow False Foxglove

Aureolaria pedicularia

Fern-leaved Yellow False Foxglove

Gérardie fausse-pédiculaire

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

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	2 years (range of 1 to about 3 years).
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown, limited data and numbers of mature individuals fluctuate.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Uncertain; habitat declines may infer declines in individuals but there is limited data and the numbers of mature individuals fluctuate.
[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. Possibly, although viability of seed bank not known. b. Yes c. No
Are there extreme fluctuations in number of mature individuals?	Not applicable (biennial species).

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	6,825 km^2 (6 extant subpopulations) or 12,890 km^2 if two historical subpopulations are included.
Index of area of occupancy (IAO) (Always report 2x2 grid value).	36 km^2 for extant subpopulations. 44 km^2 including two historical subpopulations.
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No, Turkey Point Complex (extant IAO 12 km^2) and Pinery Complex (IAO 8 km^2) have sufficient habitat to maintain viable subpopulations if threats are managed. b. Yes, sites are isolated and seeds have no active dispersal mechanism and unlikely to disperse significant distances.

Number of “locations” (use plausible range to reflect uncertainty if appropriate)	6-10 known extant or presumed extant locations, lower number is based on known extant subpopulations, higher number is based on property parcels and includes two presumed extant subpopulations. See Table 2.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Inferred 0-67% reduction in EOO over the past 10 years based on sites where species was last observed within past 10-40 years.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Inferred reduction of 0-50% in IAO over the past 10 years based on sites where species was last observed within past 10-40 years.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Possibly, inferred 0-7 subpopulations lost in past 10 years based on number of extirpated subpopulations where species was last observed within past 10-40 years.
Is there an [observed, inferred, or projected] decline in number of “locations”?	Possibly, inferred 0-7 locations lost in past 10 years based on number of extirpated locations where species was last observed within past 10-40 years.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, long-term decline in extent of Black Oak savanna habitat in southern Ontario. Inferred ongoing decline in habitat quality at extant sites due to invasive non-native plants (all or most sites). At two protected areas with 52% of population, habitat is being actively managed to restore and maintain Black Oak savanna. Inferred decline in habitat quality due to forest succession, invasive species and/or management activities at extirpated sites.
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 (*numbers vary annually, range of variability not known but extreme fluctuations are possible*)
Turkey Point Complex, Norfolk (5 patches at 2 sites, large)	2928 (2016 approximate count), estimate of 3000 to 5000.
Pinery Complex, Lambton (6 patches at 2 sites, additional patches not counted, and additional areas not checked)	2559 (2016 approximate count), estimate of 3500 to 5000
Hendrie Valley, Halton (2 patches, additional areas not checked)	814 (2016 count), estimate 900 to 1500

Cootes Paradise South Shore, Hamilton (2 patches, additional areas not checked)	132 (2016 count), estimate 150 to 250
Sixteen Mile Pond Island, Niagara	42 (2016 count), estimate 42 to 50
Fifteen Mile Creek, Niagara	~10 (2016 estimate), estimate 10 to 50
Total	6485 mature individuals counted in 2016, estimated population of 7602 to 11,820

Quantitative Analysis

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

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

Was a threats calculator completed for this species? Yes. April 4, 2017 by Jana Vamosi, Del Meidinger, Bruce Bennett, Vivian Brownell, Alistair Mackenzie, Graham Buck, Audrey Heagy, Jenny Heron, Joanna James (Appendix 5)

Overall threat impact calculated to be high

i. Fire suppression (medium impact)
ii. Housing and urban areas (medium impact)
iii. Invasive non-native species (medium - low impact)
iv. Recreational activities (low impact)
v. Tourism & recreation areas (low impact)
vi. Problematic native species (low impact)

What additional limiting factors are relevant? Species is hemi-parasitic on oak. Black Oak savanna habitat is rare, declining and fragmented in southwestern Ontario. Low dispersal capability.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Species is present in counties near the Canadian border in western New York (Apparently Secure, S4), southeastern Michigan (status not ranked), and northern Pennsylvania (status not ranked). Both varieties found in Ohio are Critically Imperilled (S1) and endangered.
Is immigration known or possible?	Not known and very unlikely as no long-distance dispersal mechanism
Would immigrants be adapted to survive in Canada?	Probably yes
Is there sufficient habitat for immigrants in Canada?	Likely not (potentially some suitable restored habitat along Niagara River corridor or Lake Ontario shoreline)
Are conditions deteriorating in Canada?	Yes, except in some managed protected areas
Are conditions for the source population deteriorating?	Probably; oak savanna in United States faces similar threats as in Canadian range
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species? No

Status History

COSEWIC: Designated Threatened in April 2018.

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric codes:** B1ab(iii)+2ab(iii)
Reasons for designation: This short-lived plant species has a distribution restricted in Canada to southwestern Ontario. The remaining individuals occur in a small number of locations within oak savannas and woodlands. Declines have been observed in quality of habitat. Fire suppression and residential development threaten the remaining extant locations.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Data are lacking to determine the percentage of reduction.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Threatened, B1ab(iii)+2ab(iii), because EOO and IAO are below thresholds, there are only 6-10 extant sites, and there are observed declines in the quality of habitat.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Although the species likely is below the threshold in terms of number of mature individuals, the sub-criteria are not met.
Criterion D (Very Small or Restricted Population): Not applicable. Species exceeds thresholds
Criterion E (Quantitative Analysis): Not done.

TECHNICAL SUMMARY - Downy Yellow False Foxglove

Aureolaria virginica

Downy Yellow False Foxglove

Gérardie de Virginie

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

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	Unknown, estimated to be 7-15 years.
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Uncertain, observed ongoing decline at 4 of 5 subpopulations; 15-fold increase in numbers at 5^{th} subpopulation since 1990 but not known when the increase occurred or if it is continuing.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Uncertain, but likely less than 20% over 14 to 30 years as no evidence of decline at the largest subpopulation.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Uncertain, due to some inconsistencies in 1990 survey efforts (See **Fluctuations and Trends**). Potential 325% increase over 26 years in total number counted (15-fold increase at one site, but 67% decrease at other 4 sites).
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown, trajectory of largest subpopulation not known.
[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.	Inferred to be less than 10% over 21 to 45 years as no evidence of decline at the largest subpopulation.
Are the causes of the decline a.clearly reversible and b.understood and c. ceased?	a. Possibly at most sites b. Possibly at most sites c. No
Are there extreme fluctuations in number of mature individuals?	Unknown, but unlikely.

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	1,315 km^2 (5 extant subpopulations) or 1,405 km^2 if two historical subpopulations are included.
Index of area of occupancy (IAO) (Always report 2x2 grid value).	20 km^2 (5 extant subpopulations) or 28 km^2 if two historical subpopulations are included.

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. Likely not, yet most habitat patches are likely sufficient to maintain subpopulations only if threats mitigated. b. Yes. Most habitat patches are isolated fragments, seeds have no active dispersal mechanism, and species is not self-fertile so unlikely to disperse significant distances.
Number of “locations” (use plausible range to reflect uncertainty if appropriate)	5 confirmed extant locations. There are 7 locations if the two historical locations are presumed extant.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes, observed although timing is uncertain. At least 57-60% reduction in EOO over three generations (21 to 45 years) due to loss of 15 Mile – 16 Mile Creek Valley subpopulation since last observed in the 1980s. Lower number includes the two historical subpopulations as presumed extant.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, observed although timing is uncertain. At least 12.5-37.5% reduction in IAO over past 21 to 45 years. Lower number includes the two historical subpopulations as presumed extant.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes, observed. At least one subpopulation extirpated during the past 21-45 years.
Is there an [observed, inferred, or projected] decline in number of “locations”?	Yes, observed. At least one location extirpated in past 21-25 years.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred decline in habitat quality due to forest succession and mesophication, trampling from recreational activities, and/or invasive plants at four sites; no indication of change in habitat at site with the largest subpopulation.
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
Shep’s Subdivision, Waterloo	287 (2016 count)
Normandale Fish Hatchery, Norfolk	66 (2016 count)
Clappison Escarpment Woods, Halton	14 (2016 count)
Spencer Gorge, Hamilton	12 (2016 count)
Spottiswood Lakes, Brant	9 (2016 count)

Total	388 individuals counted in 2016 Population estimate of 400 mature individuals

Quantitative Analysis

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

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

Was a threats calculator completed for this species? Yes. April 4, 2017 by Jana Vamosi, Del Meidinger, Bruce Bennett, Vivian Brownell, Alistair Mackenzie, Graham Buck, Audrey Heagy, Jenny Heron, Joanna James (Appendix 6).

Overall threat impact calculated to be high

i. Fire suppression (medium impact)
ii. Problematic native species (medium impact)
iii. Logging and wood harvesting (medium – low impact)
iv. Recreational activities (medium – low impact)
v. Invasive non-native/alien species (medium – low impact)

What additional limiting factors are relevant? Species is hemi-parasitic on oak. Open oak woodland habitat is rare, declining and fragmented in southwestern Ontario. Low dispersal capability.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Species is secure (S5) in New York, and present (status not ranked) in Ohio, Pennsylvania, and Michigan.
Is immigration known or possible?	Not known and very unlikely as no long-distance dispersal mechanism
Would immigrants be adapted to survive in Canada?	Probably yes
Is there sufficient habitat for immigrants in Canada?	Likely not
Are conditions deteriorating in Canada?	Yes
Are conditions for the source population deteriorating?	Probably; oak woodlands in northeastern United States face similar threats as in Canadian range.
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species? No

Status History

COSEWIC: Designated Endangered 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)
Reasons for designation: This perennial plant species has a distribution restricted in Canada to southwestern Ontario. There are few individuals in the five remaining locations within oak savannas and woodlands. Declines have been observed in its distribution and quality of habitat. Fire suppression and browsing by White-tailed Deer threaten the remaining extant locations.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Data are lacking to determine the percentage of reduction.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v), as it is found in 5 extant locations, EOO and IAO are below thresholds, and there are declines in EOO, IAO, habitat, number of locations, and number of individuals.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Comes close to meeting Endangered as there are fewer than 2500 mature individuals and only one subpopulation exceeds the threshold of 250 mature individuals. Meets Threatened, C2a(i) with inferred continuing declines and with no subpopulations estimated to contain > 1000 mature individuals.
Criterion D (Very Small or Restricted Population): Not applicable. Meets Threatened, D1, with a total estimated population size of 400 mature individuals.
Criterion E (Quantitative Analysis): Not done.

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

Yellow False Foxglove Bundle

Smooth Yellow False Foxglove
Aureolaria flava

Fern-leaved Yellow False Foxglove
Aureolaria pedicularia

Downy Yellow False Foxglove
Aureolaria virginica

in Canada

2018

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Smooth Yellow False Foxglove

Scientific name: *Aureolaria flava* (L.) Farw.

Synonyms: *Agalinis flava* (L.) Boivin*, Gerardia flava* L.

Common names: Smooth Yellow False Foxglove, Gérardie jaune

Other common names: Smooth False Foxglove, Yellow False Foxglove

Infraspecific taxon: Various treatments have recognized variation within this species as infraspecific taxa (Pennell 1928; 1935; Kartesz 2015; Hassler 2016). Other authors, including the Flora of North America provisional account (Morawetz 2012), adopt a broad species concept and do not recognize any infraspecific taxa. Recent Canadian and Ontario plant lists have not included infraspecific taxa (Oldham and Brinker 2009; Brouillet *et al.* 2016; NHIC 2016b). Two infraspecific taxa have been recognized as occurring in Canada: *A. flava* var. *flava* and *A. flava* var. *macrantha* (Pennell 1928; Kartesz 2015; NatureServe 2016b). Many specimens from Canada have not been not identified to variety (Oldham pers. comm. 2017).

Fern-leaved Yellow False Foxglove

Scientific name: *Aureolaria pedicularia* (L.) Raf. ex Pennell

Synonyms: *Agalinis pedicularia* (L.) Blake*, Gerardia pedicularia* L.

Common names: Fern-leaved Yellow False Foxglove, Gérardie fausse-pédiculaire

Other common names: Annual False Foxglove, Fernleaf Yellow False Foxglove, Fern-leaved False Foxglove, Pedicelled False Foxglove, Woodland Fern-leaf

Infraspecific taxon: Five infraspecific taxa were described by Pennell (1928, 1935). Four varieties are accepted by the North American vascular flora list (Kartesz 2015) and World Plants list (Hassler 2016). The Flora of North America provisional account (Morawetz 2012), and the Canadian and Ontario plant lists (Oldham and Brinker 2009; Brouillet *et al.* 2016; NHIC 2016b) do not recognize any infraspecific taxa. Three of Pennell's infraspecific taxa have been verified as occurring in Ontario: *A. pedicularia* var. *pedicularia*, *A. pedicularia* var. *intercedens*, *A. pedicularia* var. *ambigens* (Pennell 1928; Kartesz 2015; Oldham pers. comm. 2017). Many specimens from Canada have not been not identified to variety (Oldham pers. comm. 2017).

Downy Yellow False Foxglove

Scientific name: *Aureolaria virginica* (L.) Pennell

Synonyms: *Agalinis virginica* (L.) Blake*, Gerardia virginica* (L.) Britton, Sterns & Pogg., *Rhinanthus virginica* L.

Common names: Downy Yellow False Foxglove, Gérardie de Virginie

Other common names: Downy False Foxglove, Downy Oak Leach

Infraspecific taxon: No recognized infraspecific taxon (Pennell 1928, 1935; Morawetz 2012; Kartesz 2015; Hassler 2016).

Aureolaria is a small North American genus with eight species (three species in Canada). In the past, these species have been considered part of *Gerardia* or *Agalinis.* The rationale for treating *Aureolaria* as a separate genus is reviewed in Pennell (1918). The genus name refers to the golden-yellow colour of the flowers.

The genus *Aureolaria* is now assigned to Orobanchaceae (Broom-rape Family) based on results of molecular phylogenetic studies of various chloroplast DNA loci (Bennett and Mathews 2006; Kartesz 2015). This genus was traditionally placed in the Scrophulariaceae (Figwort Family) (e.g., Pennell 1935) and some sources have not yet been updated (e.g., Newmaster and Ragupathy 2012; NatureServe 2016a). The newer placement has been adopted by the Angiosperm Phylogeny Group (APG, Stevens 2016), and the North American flora database (BONAP, Kartesz 2015).

During the first half of the 20th century there was some confusion in the use of the species epithets *flava* and *virginica* as they were erroneously interchanged in the seventh edition of Gray's Manual of Botany (Robinson and Fernald 1908) and in Britton and Brown (1913). These errors were corrected in the subsequent editions of these reference manuals (Fernald 1950; Gleason 1952). Due to the interchange of the species concepts in the earlier manuals all literature records from this time are suspect (Soper 1962; McLeod 1990). All Yellow False Foxglove voucher specimens from Ontario in major herbaria were verified for the Atlas of Rare Vascular Plants in Ontario (ARVPO) project (Argus *et al.* 1987; Oldham pers. comm. 2017).

Morphological Description

All three species of Yellow False Foxglove are herbaceous forbs with lobed leaves with short leaf-stalks (petioles) in an opposite arrangement on upright stems. All species have many large, showy, yellow flowers (Figures 1, 2, 3). The funnel-shaped flowers have five regular parts and form on short pedicels arising from the axils of the upper leaves (bracts). Seeds are formed in seed capsules (Figure 4).

Figure 1. Smooth Yellow False Foxglove (*Aureolaria flava*) at Ojibway Prairie Provincial Nature Reserve, Essex County, Ontario (Photo by Mary E. Gartshore, 2 August 2016).

Figure 2. Fern-leaved Yellow False Foxglove (*Aureolaria pedicularia*) at Turkey Point Provincial Park, Norfolk County, Ontario (Photo by Mary E. Gartshore, 13 August 2016).

Figure 3. Downy Yellow False Foxglove (*Aureolaria virginica*) at Shep's Subdivision, Waterloo Region, Ontario (Photo by Mary E. Gartshore, 29 July 2016).

Figure 4. Downy Yellow False Foxglove (*Aureolaria virginica*) at Spencer Gorge, City of Hamilton, Ontario (Photo by Mary E. Gartshore, 8 August 2016).

Smooth Yellow False Foxglove

Smooth Yellow False Foxglove is a tall, herbaceous perennial that can reach a height of 2.5 m, though in Ontario are typically much shorter (0.5-1.5 m). Individual plants form clumps of several to many (100 or more) stems arising from a central root. Stems are often not branched. Stems are characteristically smooth (glabrous) with a glaucous bloom, and range in colour from green to purple-tinged. The lower leaves are up to 15 cm long and deeply lobed. Upper leaves (technically bracts) are progressively smaller and vary from shallowly lobed or toothed to entire. The flowers are on short stalks (pedicels), 5-10 mm long. The lobed calyx at the base of the flower is about 5 mm in length and the bell-like yellow corolla is 35 to 60 mm. The smooth, ovoid capsules containing the seeds are 12-16 mm long. The seeds are about 2 mm long with thin wings.

Two varieties of Smooth Yellow False Foxglove have been reported from Ontario: *A. flava* var. *flava* and *A. flava* var. *macrantha* Pennell (Kartesz 2015). The latter can be distinguished by the longer calyx lobes (5-14 mm versus 2-5 mm) and larger corolla (35 to 60 mm versus 35 to 40 mm) (Pennell 1928).

Downy Yellow False Foxglove

The morphology of the Downy Yellow False Foxglove is very similar to the Smooth Yellow False Foxglove but differs in that the stems are shorter (0.1-1.5 m) and downy (finely pubescent) rather than smooth. The flower structure is very similar to Smooth Yellow False Foxglove except the pedicels are shorter (1-3 mm) and the lobes on the calyx tend to be longer. The deeply cut lobes on the lower leaves of Downy Yellow False Foxglove are typically blunter than the pointy lobes typical of Smooth Yellow False Foxglove. The seed capsules are downy and 12-15 mm long. The seeds are about 2 mm long with thin wings.

Fern-leaved Yellow False Foxglove

While similar in general appearance, the Fern-leaved Yellow False Foxglove differs from the other two species in several respects. Each mature plant consists of a single densely branching stem to 1.5 m in height. The stem, leaves and pedicels are hairy and sticky (glandular). The leaves are short (to ~7 cm long), and the leaf stalks, if any, are very short (3 mm or less). As suggested by the common name, the leaves of this species are more finely divided (bipinnatifid) than in the other Yellow False Foxglove species. The flowers are similar in size and shape to the other species found in Ontario, but the flower stalks are somewhat longer (to 25 mm), the seed capsules (~10 mm) are shorter, and the seed lengths (to 1 mm) are smaller. Immature plants form a rosette of basal leaves (Figure 5).

Figure 5. Fern-leaved Yellow False Foxglove (*Aureolaria pedicularia*) rosette at Cootes Paradise South Shore, City of Hamilton, Ontario (Photo by Mary E. Gartshore, 15 August 2016).

Fern-leaved Yellow False Foxglove is quite variable in form, and several varieties have been recognized, distinguished primarily by the density of glandular hairs on the leaves and upper plant (Pennell 1928).

<u>Similar Species</u>

The common name False Foxglove refers to the general resemblance to the common garden foxgloves that belong to the Eurasian genus *Digitalis*. Plants in the closely related genus *Agalinis* are also referred to as False Foxgloves. All *Agalinis* species found in Canada have pink flowers and are unlikely to be confused with *Aureolaria*.

The closely related Mullein-Foxglove, *Dasistoma macrophylla*, has similar morphology to the Yellow False Foxglove species. Mullein-foxglove is pubescent like Downy Yellow False Foxglove but the flowers and seed capsules are much smaller. It has not been reported from Ontario but does occur in Wayne County, Michigan, across the Detroit River from Windsor (Reznicek *et al.* 2011b).

The species epithet for Fern-leaved Yellow False Foxglove refers to similarities in leaf shape with plants in the genus *Pedicularis,* such as the Canada Lousewort, *Pedicularis canadensis*, which can occur in the same habitat as the Yellow False Foxgloves.

Population Spatial Structure and Variability

Information on population spatial structuring and variability for these species in Canada is based primarily on varietal assignments of herbarium specimens (Pennell 1928; Oldham pers. comm. 2017). Soper (1962) did not discuss sub-specific variation.

Of the Smooth Yellow False Foxglove collections from Ontario identified to variety, most were determined as var. *flava* including specimens from sites in Essex, Halton, Middlesex, Niagara, Toronto, Walpole Island, Waterloo and Wellington regions. A few specimens have been determined as var. *macrantha*, including collections from Toronto, Middlesex and Waterloo (Pennell 1928; Oldham pers. comm. 2017).

Of the Fern-leaved Yellow False Foxglove collections from Ontario identified to variety, specimens determined as var. *ambigens* came from sites in Lambton and Toronto, var. *intercedens* specimens from sites in Niagara and Norfolk, and var. *pedicularia* specimens from sites in Lambton, Niagara, Norfolk and Toronto (Pennell 1928; Oldham pers. comm. 2017).

Downy Yellow False Foxglove is monotypic with no recognized varieties. Pennell (1928) described it as “remarkably stable” relative to the plasticity he noted in most other Yellow False Foxglove species.

Variability in appearance was observed in all three species during the 2016 fieldwork, but no attempt was made to assign occurrences to the varietal classifications. Information on genetic variability or gene flow within or between sites is not available for the Canadian populations.

Designatable Units

There is no strong evidence to support segregating the Canadian population of any of these species into distinct designatable units (DUs) at this time. In Canada, all three species occur only within the Great Lakes Plains Ecological Area. The Canadian populations are not disjunct from populations in the United States.

Two varieties of Smooth Yellow False Foxglove and three varieties of Fern-leaved Yellow False Foxglove have been verified from Ontario. However, they are not considered herein as designable units as there is uncertainty as to the taxonomic status of these subspecific taxa, and insufficient information on their past and present distribution in Canada.

Special Significance

The larvae of the False-foxglove Sun Moth, *Pyrrhia aurantiago*, feed only on the seeds of Fern-leaved Yellow False Foxglove and Smooth Yellow False Foxglove. This moth is considered rare throughout its range in the United States and is known from only a few sites in Canada. A COSEWIC report is currently being prepared for False-foxglove Sun Moth.

All Yellow False Foxglove species are hemi-parasites, and often secure some of their water and nutrients by tapping into the roots of other plants, particularly oak species (*Quercus* spp.). The impact of this parasitism on the host is likely minor (Cunningham

2000). See **Biology** section for details.

Yellow False Foxgloves are considered highly conservative plants and all three *Aureolaria* species found in Ontario have been assigned the maximum Coefficient of Conservatism score of 10 (Oldham *et al.* 1995). Coefficients of conservatism range from 0 to 10 and represent the estimated probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be pre-European settlement condition. A Coefficient of Conservatism of 10 is applied only to those plants that are almost always restricted to high quality remnant natural areas.

Yellow False Foxgloves are part of a suite of species that occur in oak savanna and oak woodlands in southern Ontario. Some other species associated with these habitats are legally listed as species at risk in Canada (e.g., Virginia Goat's-rue *Tephrosia virginiana*; Slender Bush-clover *Lespedeza virginica*) or as species of conservation concern.

The Flora Ontario Integrated Botanical Information Centre (Newmaster and Ragupathy 2012) and Native American Ethnobotany database (Moerman 2017) cite documented medicinal uses of Smooth Yellow False Foxglove (treatment of dysentery and apoplexy), Fern-leaved Yellow False Foxglove (treatment of dysentery and apoplexy, as an emetic, and for prevention of scurvy) and Downy Yellow False Foxglove (dysentery treatment).

Yellow False Foxgloves are attractive wildflowers but are not generally cultivated. A few seed sources in the United States are listed on wildflower gardening websites.

These species are not considered data-restricted species by the Natural Heritage Information Centre (NHIC 2016c), or as data sensitive species under the guidelines used by COSEWIC (2011).

DISTRIBUTION

Global Range

Yellow False Foxgloves are endemic to eastern North America. Plants in this genus occur from Minnesota to Maine, including southwestern Ontario, and south to Florida, eastern Texas and northern Mexico (Morawetz 2012; Kartesz 2015).

The Smooth Yellow False Foxglove range (Figure 6) extends from southeastern Wisconsin to Maine, south to Florida and eastern Texas (Kartesz 2015). The Fern-leaved Yellow False Foxglove range (Figure 7) extends from eastern Minnesota to Maine, south to South Carolina and Kentucky (Kartesz 2015). The Downy Yellow False Foxglove range (Figure 8) extends from Michigan to northeastern New York, south to Florida and eastern Texas (Kartesz 2015).

Figure 6. Global range of Smooth Yellow False Foxglove (*Aureolaria flava*) (after Kartesz 2015).

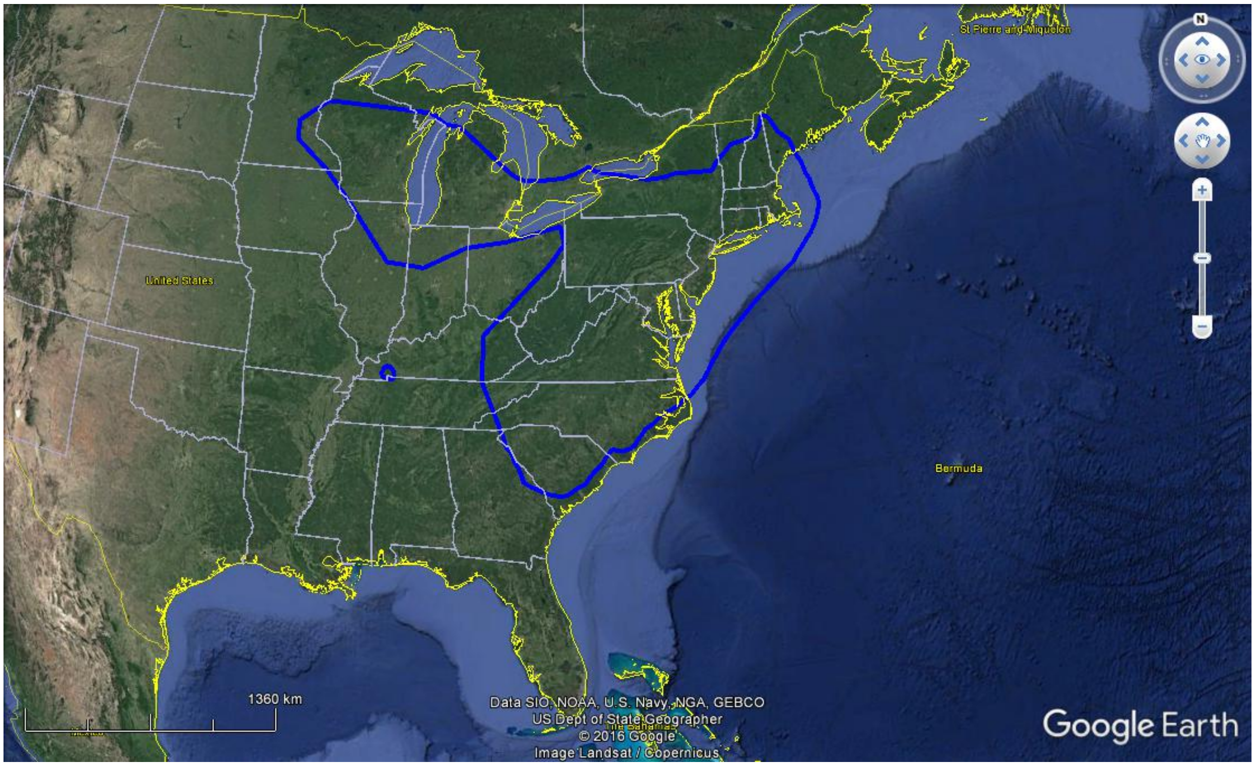

Figure 7. Global range of Fern-leaved Yellow False Foxglove (*Aureolaria pedicularia*) (after Kartesz 2015).

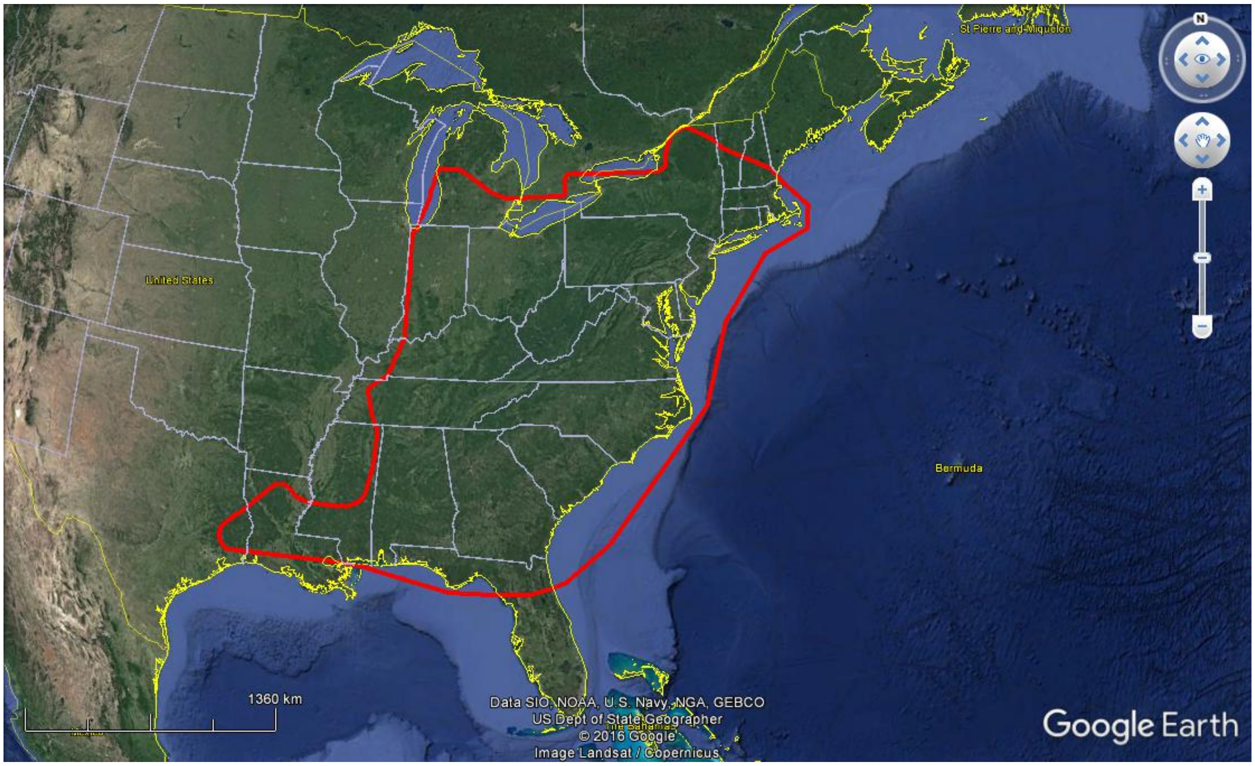

Figure 8. Global range of Downy Yellow False Foxglove (*Aureolaria virginica*) (after Kartesz 2015).

Smooth Yellow False Foxglove and Downy Yellow False Foxglove have very similar geographic distributions. The range of Fern-leaved Yellow Foxglove extends further northwest than the other two species, but does not extend as far south and southwest. Within their ranges, the distribution patterns for all three species vary from widespread to local.

Canadian Range

All known occurrences of Yellow False Foxglove in Canada are within the southern portion of the Great Lakes Plain Ecological Area in southwestern Ontario (Figures 9, 10, 11). As with many other rare plant species in Ontario, the Yellow False Foxgloves are largely restricted to the Carolinian ecoregion (Soper 1962; Argus 1992). The northern limit of the species' range appears to be determined by climatic conditions as the Canadian ranges of the various oak species frequently parasitized by the Yellow False Foxglove species are more widely distributed, although still largely restricted to the Great Lakes Plain Ecological Area except for a few species (Red Oak, *Quercus rubra,* in particular) that extend into the Atlantic and southern Boreal Ecological Areas.

The Canadian ranges of the three Yellow False Foxglove species are small relative to their global distribution (about 1% for Downy Yellow False Foxglove, 2% for Smooth Yellow False Foxglove, and 5% for Fern-leaved Yellow Foxglove).

Note on terminology:

For each species covered by this status report, the term **population** refers to the sum total of all mature plants of that species in Canada (consistent with COSEWIC definition). **Subpopulation** refers to all plants of that species within 1 km of each other, consistent with the general standard for delineating element occurrences (EO) used by NatureServe (2002) and the Ontario Natural Heritage Information Centre (NHIC 2016a). The term **patch** is used here to describe plant distribution within a subpopulation; a patch consists of a discrete spatial group of one or more plants that are not separated from each other by a distance of greater than about 10 m in the case of the perennial species, Smooth Yellow False Foxglove and Downy Yellow False Foxglove*,* and by not greater than approximately 100 m in the case of Fern-leaved Yellow False Foxglove (area occupied by the latter is an order of magnitude greater than for either the perennial species, and occupied areas can shift by more than 10 m from year to year)*.*

A **site** is defined here as a discrete geographic area, typically a single land management unit (e.g., land parcel, park or other tract), where a Yellow False Foxglove species occurs or has occurred. Records with imprecise locational information (e.g., herbarium specimen with nearby town given as the only locational reference) were considered as a separate subpopulation only if the "general site" encompassing all suitable habitat within 10 km radius of the given geographic reference met the 1 km separation criterion. Subpopulations encompassing multiple sites are referred to as a **complex** (e.g., Ojibway Prairie Complex, Turkey Point Complex). A **location** refers to a geographically or ecological distinct area in which a single threatening event can rapidly affect all plants (COSEWIC 2015, Definitions and Abbreviations).

The current status of each site and subpopulation is classed as **extant** if mature individuals were observed during the past 20 years (since 1996) and not known to be recently extirpated; **historical** if recent search effort is lacking or very limited but the species has been observed within the past 40 years (since 1976) and is presumed extant as suitable habitat likely persists**; extirpated** if failed to find on last thorough search or if the habitat is likely no longer suitable; or **presumed extirpated** if the last observation was more than 40 years ago (prior to 1977) but suitable habitat likely persists. These definitions are consistent with the NatureServe species occurrence ranking approach (Hammerson *et al.* 2008).

Smooth Yellow False Foxglove

Smooth Yellow False Foxglove has been reported from 45 sites in Canada since 1887, including 19 general sites with imprecise locational information and 18 sites based on sight records only (Appendix 1). Old sight records of Smooth Yellow False Foxglove (and Downy Yellow False Foxglove) could potentially have been misidentified due to past errors in the reference literature (see **Species Name and Classification**). McLeod (1990) cites three instances of Smooth Yellow False Foxglove collections that had been mistakenly attributed to Downy Yellow False Foxglove*.* No specimens were examined for this report but most or all specimens included in Appendix 1 were verified by Pennell (1928, 1935), Soper (1962), and/or for the ARVPO project (Argus *et al.* 1987; Oldham pers. comm. 2017).

Two records are considered erroneous: the report of Smooth Yellow False Foxglove at Ballinafad Pond attributed to the Halton Natural Areas Inventory in the NHIC database (2016a) is a data coding error (Finney pers. comm. 2016; Goodban pers. comm. 2016); and the sight report of Smooth Yellow False Foxglove at the Spottiswood Lakes site is presumed to be erroneous as Downy Yellow False Foxglove was found at this site during the 2016 fieldwork.

The 43 accepted records in Appendix 1 represent 25 known subpopulations for Smooth Yellow False Foxglove in Canada. Twelve records with imprecise locational information (general sites) are within 10 km of other records, and are not considered discrete subpopulations. Three subpopulations encompass multiple sites: Ojibway Prairie (5 sites), Sixteen Mile Creek (2 sites), and the Barrie's Lake - Altrieve Lake (2 sites) complexes. The Walpole Island subpopulation may also encompass multiple sites as the species was previously reported from four natural areas (Woodliffe and Allen 1988).

Occupancy was confirmed at ten sites (8 subpopulations) in 2016, including two sites (2 subpopulations) where only a single plant was observed. Isolated individuals of this species are not capable of producing new recruits (see **Biology** section) and do not represent a viable subpopulation (Table 1). The Longwoods Road and London Riverbend East subpopulations are, therefore, classified as extirpated. The eight other occupied sites comprise six potentially viable extant subpopulations.

Table 1. Smooth Yellow False Foxglove extant and presumed extant (historical) locations, abundance counts and estimates, 2016.

Subpopulation	Notes	Abundance (mature individuals)	
		2016 count	2016 estimate
Ojibway Prairie Complex, Essex	1-2 locations with 7+ patches. Additional patches present but not counted, additional habitat at occupied sites not checked. Recently extirpated at one site. One additional known site not visited in 2016.	163, partial count	286 to 1036
Venison Creek, Norfolk	1 location with 3 patches.	74	74
Walpole Island, Walpole Island First Nation	1 location with unknown number of plants. Incidental observation of about 10 plants in 2015 (Korol pers. comm. 2018) and 50 plants in one patch in 2008 (Buck pers. comm. 2017). Recorded in 4 natural areas in 1985-86 (Woodliffe and Allen 1988); habitat at these 4 known areas (all managed by the Walpole Island FN) is relatively intact (Woodliffe pers. comm. 2017). No other information on current habitat condition or occupancy but estimate of "likely ~200 plants but possibly more" (Woodliffe pers. comm. 2017).	n/a	50 to 200
Fifty Road Escarpment, Hamilton	1 location with 1 patch.	31	31

Subpopulation	Notes	Abundance (mature individuals)	
		2016 count	2016 estimate
Branchton Railway Oak Knoll, Waterloo	1 location with 3 patches.	11	11
Sixteen Mile Creek Complex, Halton	1 location with 1 extant patch (also 1 extirpated patch at adjacent site).	7	7
Sudden Bog, Waterloo	1 location. Habitat on adjacent property not checked.	5, partial count	5 to 50
London Riverbend East, Middlesex	Not considered a location. 1 plant in 2016 (not considered a mature individual using COSEWIC guidelines as a single plant of this self-incompatible species is not able to reproduce).	0, see notes	0
Longwoods Road CA, Middlesex	Not considered a location. 1 plant in 2016, non-viable subpopulation.	0, see notes	0
Dingman Creek, Middlesex	Possible location (0-1). Presumed extant subpopulation (last observed 1993). No information on past or current abundance.	n/a	n/a
Total	**7-9 locations**	**291**	**464 to 1409**

The Walpole Island subpopulation (up to 4 sites) was not checked in 2016 but is also considered extant based on incidental observations in 2015 (Korol pers. comm. 2018), 2008 (Buck pers. comm. 2017) and 2004 (NHIC 2016a). The historical Dingman Creek subpopulation (1 site) in Middlesex County has not been searched since 1993 but is presumed extant as suitable habitat is likely still present. The Black Oak Heritage Park site within the Ojibway Prairie complex was not checked in 2016 and is classified as a historical site within an extant subpopulation. An additional ten subpopulations (14 sites including 2 sites within extant subpopulations) are considered extirpated, and five subpopulations (5 sites) are presumed extirpated.

The distribution of the seven extant, one historical, and 17 extirpated Smooth Yellow False Foxglove subpopulations in Canada is shown on Figure 9. The species continues to occupy much of its historical Canadian range, but there has been some reduction along the northeastern, eastern, and southwestern extremities.

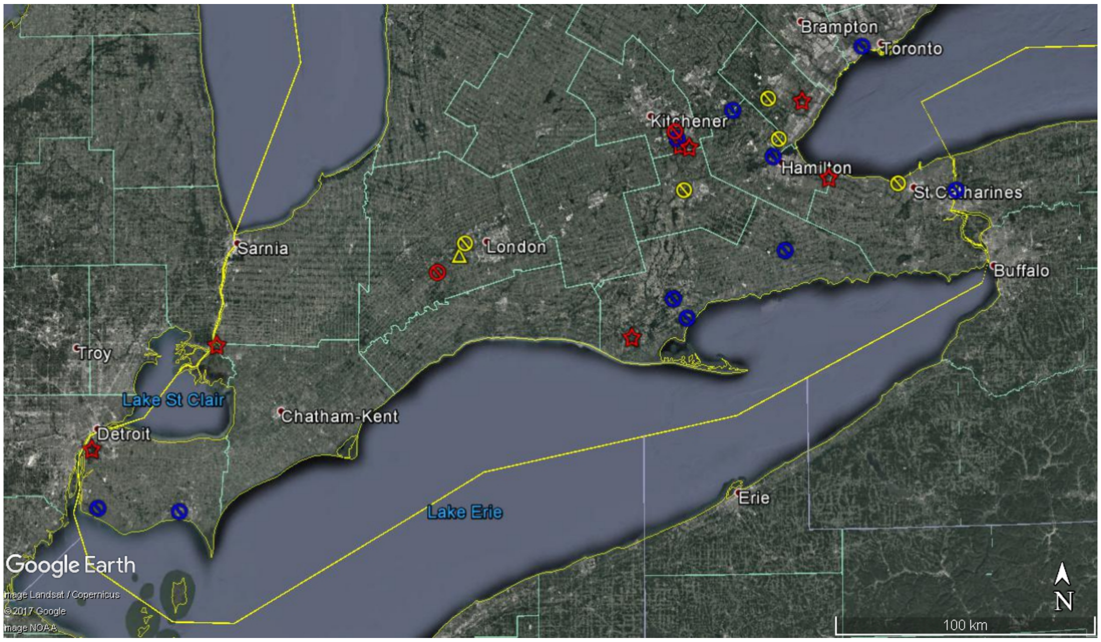

Figure 9. Canadian distribution of Smooth Yellow False Foxglove, by status (symbol) and time period when last are extirpated (includes presumed extirpated) subpopulations. Red indicates occupancy post-1995 (21 years), yellow indicates last known occupancy was in 1972-1995 period (22-45 years), and blue indicates the last observation was pre-1972 (more than 45 years).

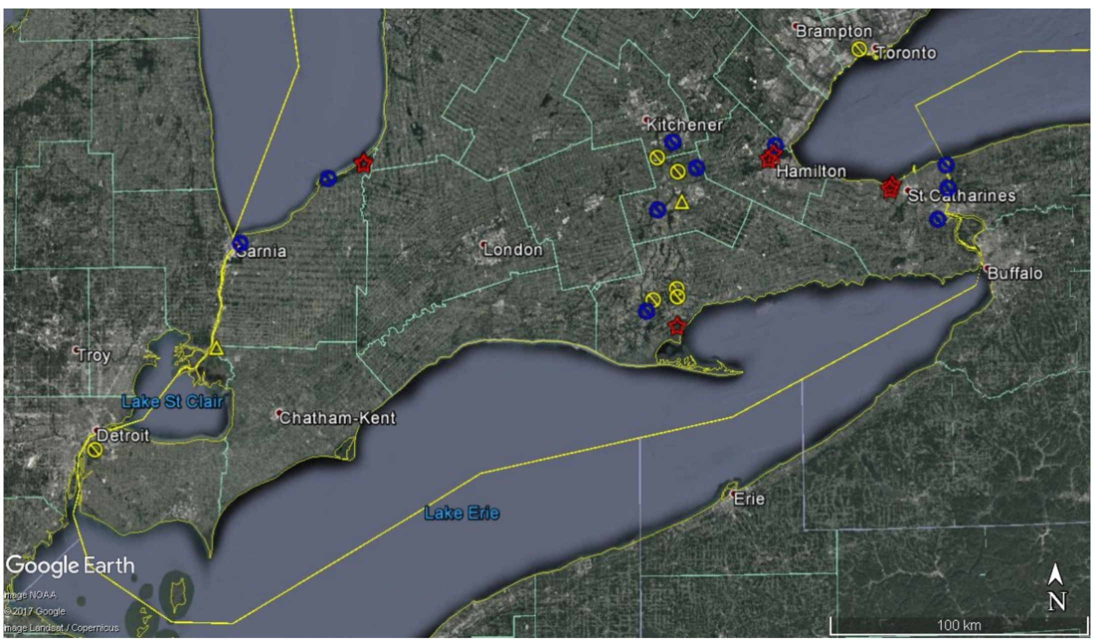

Figure 10. Canadian distribution of Fern-leaved Yellow False Foxglove, by status (symbol) and time period last observed (colour). Stars are extant subpopulations, triangles are historical subpopulations, and circles with slash are extirpated (includes presumed extirpated) subpopulations. Red indicates occupied post-2006 (10 years), yellow indicates last known occupancy in 1977-2006 period (11-40 years), and blue indicates last observation was pre-1977 (more than 40 years).

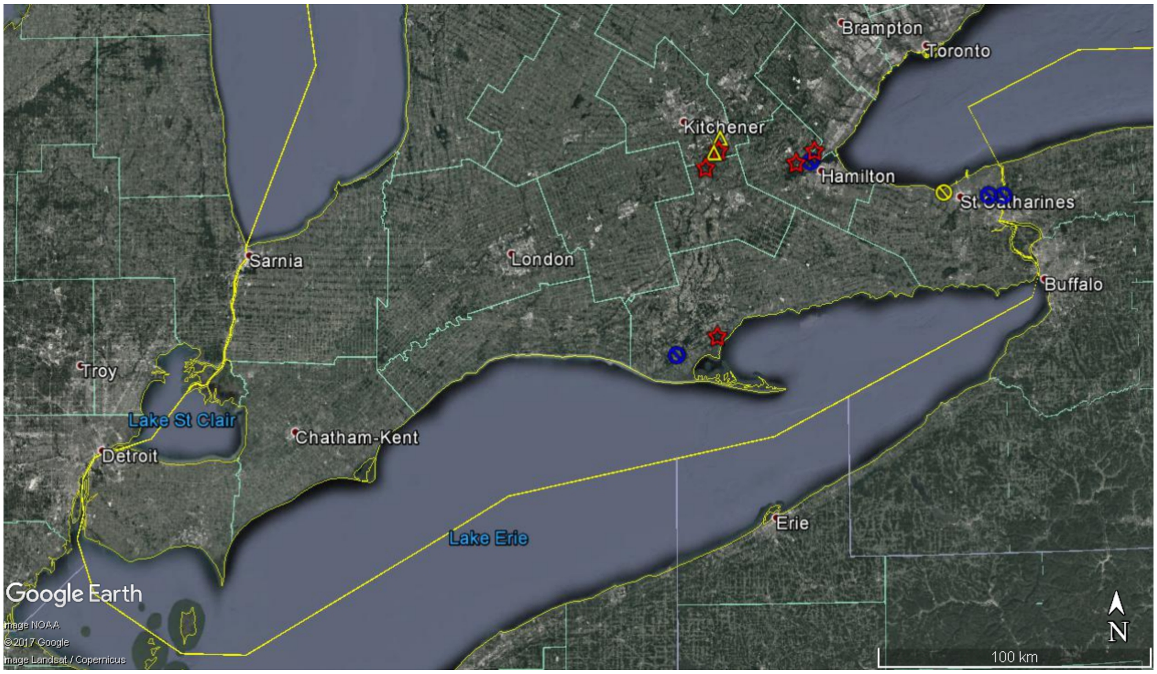

Figure 11. Canadian distribution of Downy Yellow False Foxglove, by status (symbol) and time period last observed (colour). Stars are extant subpopulations, triangle is historical subpopulation, and circles with slash are extirpated (includes presumed extirpated) subpopulations. Red indicates occupancy post-1995 (21 years), yellow indicates last known occupancy was in 1972-1995 period (22-45 years), and blue indicates the last observation was pre-1972 (more than 45 years).

The timing of the extirpations is uncertain as the survey data are sparse and many losses likely resulted from gradual habitat degradation. The observed pattern of extirpations as depicted on Figure 9 is based largely on last observation dates.

Two to seven subpopulations of Smooth Yellow False Foxglove evidently became extirpated within the period spanning the past three generations (21-45 years based on the estimated generation time of 7-15 years). These known recent extirpations include the Altrieve Lake – Barrie's Lake Complex (last report of occupancy 2006), Longwoods Road (2005), Crawford Lake - Rattlesnake Point Escarpment Woods (1994), Hardy Road Woods (1990), London Riverbend East (1990), Waterdown Escarpment Woods (1989), and Fifteen Mile - Sixteen Mile Creek Valleys (1980s) subpopulations. The Spring Garden site (last observed 2011) within the Ojibway Prairie Complex and the Red Pine Bluff site (1998) within the Sixteen Mile Creek Complex are also recent extirpations, although the species persists at other sites in these complexes (Appendix 1). The last observed dates for the other ten extirpated subpopulations range from 1957 to 1892.

Fern-leaved Yellow False Foxglove

Fern-leaved Yellow False Foxglove has been reported from about 43 sites in Canada since 1859, including 18 general sites with imprecise or uncertain locational information (Appendix 2). Twelve of the general sites situated within 10 km of other known sites are not considered discrete sites. Two other sites, both within 1 km of another known site, are not counted as discrete sites as there is uncertainty about their validity. Eighteen sites are based on sight records.

The 29 discrete sites correspond to 25 known subpopulations. Three subpopulations encompass multiple sites: Cootes Paradise (3 sites), Pinery (2 sites), and Turkey Point (2 sites) complexes.

Occupancy was confirmed for six subpopulations (8 sites) in 2016 (Table 2). Two historical subpopulations (2 sites) are presumed extant but require further search effort to establish their current status. The other 17 subpopulations (19 sites) are all considered extirpated or presumed extirpated.

Table 2. Fern-leaved Yellow False Foxglove extant and presumed extant (historical) locations, abundance counts and estimates, 2016.

Subpopulation	Notes	Abundance (mature individuals)	
		2016 count	2016 estimate
Turkey Point Complex, Norfolk	1-2 locations with 5 patches. Count of largest patch was conservative	2928	3000 to 5000
Pinery Complex, Lambton	1-2 locations with 6 patches. Count of largest patch was conservative, additional patches not counted, additional habitat not checked, and additional sites suspected.	2559	3500 to 5000
Hendrie Valley, Halton	1 location with 2 patches. Additional potential habitat not checked.	814	900 to 1500
Cootes Paradise Complex, Hamilton	1 location with 2 patches. Additional known areas not checked.	132	150 to 250
Sixteen Mile Pond Island, Niagara	1 location with 1 patch. Limited habitat	42	42 to 50
Fifteen Mile Creek, Niagara	1 location with 1 patch. Approximate count from incidental report in 2016	~10	10 to 20
Forced Road Woods, Brant	Possible location (0-1). Presumed extant subpopulation (last observed 1990). No information on past or current abundance.	n/a	n/a
Highbanks, Walpole Island	Possible location (0-1). Presumed extant subpopulation (about 50 plants observed in 1987).	n/a	n/a
Total	**6-10 locations**	**6485**	**7602 to 11820**

The timing of extirpation is inferred from when the species was last observed (Appendix 2). No sites are known to have been lost in the past ten years. Seven of the extirpated subpopulations were still occupied within the past 40 years (since 1976), including the Spring Garden and High Park subpopulations that persisted into the 1990s. It is possible that some these subpopulations only recently became extirpated, particularly if persistence in the seedbank is considered. The last observed dates for the ten extirpated subpopulations range from 1958 to 1893.

The distribution of the extant, historical, and extirpated Fern-leaved Yellow False Foxglove subpopulations in Canada is shown on Figure 10. The colour-coding on Figure 10 indicates the time period (within past 10 years, 11-40 years ago, or more than 40 years ago) when each known Fern-leaved Yellow False Foxglove subpopulations was last observed.

Downy Yellow False Foxglove

Downy Yellow False Foxglove has been reported from 18 sites in Canada since 1891, including six sites with imprecise locational information and two sites based on sight records only (Appendix 3). Information on many of these records was summarized by McLeod (1990). Element occurrence status rankings were available for most sites (NHIC 2016a).

Three of the reported sites are considered erroneous. Reports of Downy Yellow False Foxglove at Waterdown Escarpment Woods (McLeod 1990, Table 1; NHIC 2006a) probably refer to the Clappison Escarpment Woods site, as only Smooth Yellow False Foxglove has been recorded at Waterdown Escarpment Woods. A specimen from the Niagara Glen (*Hamilton NFO 1939*) was correctly reported as Smooth Yellow False Foxglove in McLeod (1990), and erroneously reported as Downy Yellow False Foxglove in Oldham (2010). An 1893 record from Veitch's Lake of Smooth Yellow False Foxglove reported in Montgomery (1944) was erroneously changed to Downy Yellow False Foxglove in the NHIC (2016a) database.

The 15 accepted site records in Appendix 3 represent 12 subpopulations for Downy Yellow False Foxglove in Canada. No subpopulations are known to extend over more than one site. Three sites with poor locational information are within 10 km of other records, and are therefore not considered discrete subpopulations.

Occupancy was confirmed for five subpopulations in 2016 (Table 3). No other subpopulations have been confirmed extant in the past 20 years. The Sudden Bog and Cambridge Railway Woods subpopulations were last documented in the late 1970s and are considered historical but presumed extant as suitable habitat likely persists that has not been thoroughly searched.

Table 3. Abundance at extant and presumed extant Downy Yellow False Foxglove subpopulations (locations) in Canada visited in the 2016 fieldwork and 1990 (McLeod 1990).

Subpopulation	2016		1990		Other information
	Heagy & Gartshore		McLeod		
	Plants	Area (m^2)	Plants	Area (m^2)	
Shep's Subdivision, Waterloo	287	455 2 patches	19	300 1 patch	1 location. 20 plants counted in 1989.
Clappison Escarpment Woods, Halton	14	400	125	150	1 location. See Figure 12.
Spencer Gorge, Hamilton	12	12 2 patches	23	225	1 location. See Figure 13.
Normandale Fish Hatchery, Norfolk	66	175 2 patches	115	263 2 patches	1 location. See Figure 14.
Spottiswood Lakes, Brant	9	6	[~40]	?	1 location. Site not in McLeod report but 1 patch with about 40 plants identified as *A. flava* reported here in 1990
Sudden Bog, Waterloo	n/a	n/a	n/a	n/a	0-1 location. Presumed extant* site last observed in 1977. Parts of Sudden Bog were searched in 1990 and 2016 but not in the vicinity of the historical record.
Cambridge Railway Woods, Waterloo	n/a	n/a	n/a	n/a	0-1 location. Presumed extant* site last observed in late 1970s. Specific site uncertain.
Count total	**388**	**1048**	**322**	**938**	**5-7 locations**
Population Estimate	**400**				

***** The "presumed extant" categorization of this location is tenuous due to apparent absence from the site for over 40 years, but follows Hammerson *et al.* (2008) based on the continued presence of suitable habitat.

The other five subpopulations are considered extirpated based on unsuccessful searches and/or habitat loss or degradation since the last known occurrence. One of these subpopulations, the Fifteen Mile - Sixteen Mile Creek Valley area in Niagara Region, was last reported occupied in the 1980s, which may be within the time period corresponding to three generations (21-45 years based on the estimated generation time of 7-15 years). The other four extirpated subpopulations were last confirmed in the 1950s (Cootes Paradise and Walsingham) and 1940s (Niagara-Queenston and St. Davids in Niagara).

The distribution of the extant, historical, and extirpated Downy Yellow False Foxglove subpopulations in Canada is shown on Figure 11. The colour-coding on Figure 11 indicates the time period (within past 21 years, 21-45 years ago, or more than 45 years ago) when each subpopulation was last observed.

Extent of Occurrence and Area of Occupancy

The following calculations assume that all known sites were present in the past (i.e., no new sites have become established which is consistent with the Coefficient of Conservatism score of 10), and that the distribution maps (Figures 9, 10, 11) represent the historical Canadian range of each species.

Smooth Yellow False Foxglove

The extent of occurrence (EOO) within the Canadian range of Smooth Yellow False Foxglove is 11,646 km^2 for the seven confirmed extant subpopulations. Including the one historical subpopulation (presumed extant) does not increase the EOO. The EOO was at least 12,314 km^2 in 1996 (10 subpopulations) and 13,694 km^2 in 1972 (15 subpopulations). The total EOO for all 25 known subpopulations in Canada is 19,741 km^2.

The index of occupancy (IAO) is 40 km^2 for the seven extant subpopulations or 44 km^2 if the historical subpopulation is included. The IAO was at least 52 km^2 in 1996 and 92 km^2 in 1972. The total IAO of all known subpopulations and sites is estimated to be 132 km^2.

The total cumulative decline in the EOO is 41%. The total decline in IAO is 67-70%, depending on whether or not the historical Dingman Creek subpopulation is included.

There has been an observed 5.7% to 17.6% reduction in the EOO during the past 21 to 45 years (range of estimated three generation period). There has been an observed 23.1% to 56.5% reduction in the IAO during the past 21 to 45 years.

The patches surveyed in 2016 occupied 0.44 ha (4430 m^2). The current biological area occupied could be as much as 2 ha as extensive areas of suitable habitat within the Ojibway Prairie Provincial Nature Reserve (PNR) and at the four known sites on Walpole Island were not searched in 2016.

All of the extant subpopulations are widely separated and many are in habitat patches that may be smaller than needed to maintain a viable population. However, over half of the population within the Canadian EOO is in the Ojibway Prairie Complex, which likely includes sufficient habitat (if actively managed) to support a viable population. There is likely also sufficient habitat to maintain the Walpole Island subpopulation if threats are mitigated. The Canadian population is therefore not considered severely fragmented.

Fern-leaved Yellow False Foxglove

The EOO of Fern-leaved Yellow False Foxglove is 6,825 km^2 for the six extant subpopulations, 12,890 km^2 for the eight extant and two historical subpopulations, 20,835 km^2 for the 15 subpopulations known to have been occupied since 1976, and 23,750 km^2 for all 25 known subpopulations in Canada.

The IAO is 36 km^2 for the extant sites or 44 km^2 if the presumed extant sites are included. The IAO of the sites known to have been occupied within the past 40 years is 72 km^2. The total IAO for all known sites is 124 km^2.

The total cumulative decline in the EOO is in the range of 46-71%, depending on the current status of the historical subpopulation at Highbanks on Walpole Island. The total decline in the IAO is 65-71%.

The decline in the EOO within the past 10 years (three generation period) is 0-67%, with this range based on the number of extirpated subpopulations last observed in the past 10 and past 40 years, respectively. In the past 10 years, the IAO has declined by 0-50%.

The biological area occupied by the 17 patches mapped in 2016 was 11.4 ha, including 7 ha in five patches at Turkey Point Complex and 4 ha in six patches at the Pinery Complex. Additional patches are present at the Pinery Provincial Park site within the Pinery Complex (Gartshore pers. obs. 2016; Mackenzie pers. comm. 2017). During the 2016 fieldwork, it was noted that clumps of dried seed stalks of this species were often present in different areas than the clumps of flowering plants, indicating that within each site the distribution of plants may shift by 10 m or more between years. Patch size also varies from year to year.

The extant subpopulations are widely separated except for the two subpopulations in Niagara which are less than 2 km apart, and the Hendrie Valley and Cootes Paradise subpopulations which are less than 3 km apart. The Turkey Point and Pinery subpopulations are both large and have sufficient habitat (if actively managed to reduce threats) to support a viable subpopulation. The Canadian population is therefore not considered severely fragmented.

<u>Downy Yellow False Foxglove</u>

The EOO of Downy Yellow False Foxglove is 1315 km^2 for the five confirmed extant subpopulations or 1405 km^2 if the two historical (presumed extant) subpopulations are included. The EOO of the eight subpopulations in existence as of 1972 was 3277 km^2. The total EOO for the 12 known subpopulations in Canada is 4435 km^2.

The IAO is 20 km^2 for extant subpopulations, 28 km^2 if the historical subpopulations are included, 32 km^2 as of 1972, and 48 km^2 for the entire known population.

The total decline in the EOO is 68-70%, depending on the current status of the historical subpopulations at Sudden Bog and near Cambridge. The total decline in the IAO is 42-58%.

The observed decline in the EOO in the past 21 to 45 years (three generation period) is 57-60%, due to the extirpation of the Fifteen Mile – Sixteen Mile Creek Valley subpopulation last observed in the 1980s. The observed decline in the IAO during this period was 12.5-37.5%. These declines are shown as a range due to uncertainty as to the current status of the two historical subpopulations.

The total area occupied by the patches at the five extant sites surveyed in 2016 was 1048 m^2. This represents a slight increase over the 938 m^2 at the four sites included in the 1990 fieldwork (McLeod 1990). At the four sites surveyed in both years, there were large increases in reported patch size at two sites, and large to moderate decreases at the other two sites (Table 3). The observed changes in patch size are not considered an extreme fluctuation in the IAO or population.

The extant subpopulations are widely separated although at least one of the two historical subpopulations in Waterloo region is within 2 km of the Sheps Subdivision site. Most of the extant subpopulations are in habitat patches that are likely sufficient to maintain a viable subpopulation if threats are removed. The Canadian population is therefore not considered severely fragmented.

Search Effort

The Yellow False Foxgloves have received relatively little targeted search effort in Canada other than the fieldwork on Downy Yellow False Foxglove in 1990 (McLeod 1990), and the 2016 fieldwork for this status report. Understanding of the historical Canadian distribution of the other two species is based on collections by early botanists, observations during regional or local inventory work since the 1970s, and other incidental reports (Tables 4-6).

Table 4. Smooth Yellow False Foxglove subpopulations and sites considered extirpated or presumed extirpated, with information on year last observed and timing of extirpation and number of locations. Bolded subpopulations/sites became extirpated within past 21 years (since 1995). *Italicized* subpopulations and sites became extirpated in the past 22-45 years (1972-1995).

Extirpated subpopulation or site	Extirpation history		Notes on locations
	First year of unsuccessful search	Year last observed	
Spring Garden site within the Ojibway Prairie Complex	2016	2011	Extirpated site but not considered a separate location as other Windsor Parks sites in this subpopulation are extant or presumed extant.
Altrieve Lake site within Barrie's Lake – Altrieve Lake Complex, Waterloo	2015	2006	1 location (the other site in this complex also extirpated)
Longwoods Road CA, Middlesex	2016	2005	1 location. 1 plant observed in 2016, non-viable subpopulation.

Extirpated subpopulation or site	Extirpation history		Notes on locations
	First year of unsuccessful search	Year last observed	
Crawford Lake – Rattlesnake Point Escarpment Woods, Halton	2008	1994	1 location
London Riverbend East, Middlesex	2016	1990	1 location. 1 plant observed in 2016, non-viable subpopulation.
Hardy Road Woods, Brant	2006	1990	1 location
Sixteen Mile Creek Red Pine Bluff site within Sixteen Mile Creek complex, Halton	2016	1998-99	0-1 location as the other site in the Sixteen Mile Creek complex is extant.
Waterdown Escarpment Woods, Halton	2009	1989	1 location
15 & 16 Mile Creek Valley, Niagara	1990s	1980s	1 location
Barrie's Lake, within Barrie's Lake – Altrieve Lake Complex, Waterloo	2015	1976	0-1 location (the other site in this complex is also extirpated)
Cootes Paradise South, Hamilton	2016	1957	1 location
Queenston – Niagara Falls, Niagara	~2010	1954	1 location
Spooky Hollow, Norfolk	~1986	1949	1 location
Bill's Corners, Norfolk	n/a	1948	1 location
Puslinch area, Wellington	n/a	1937	1 location
Swansea/Humber Plains, Toronto	1980s	1934	1 location
Cayuga area, Haldimand	n/a	Pre-1902	1 location
Malden area, Essex	n/a	Pre-1902	1 location
Veitch's Lake, Waterloo	n/a	1893	1 location
Leamington area, Essex	n/a	1892	1 location
Total	**3-9 locations extirpated within past three generations**		

Table 5. Fern-leaved Yellow False Foxglove subpopulations and sites considered extirpated or presumed extirpated, with information on year last observed and timing of extirpation and number of locations. *Italicized* subpopulations and sites became extirpated in the past 40 years.

Extirpated subpopulation or site	Extirpation history		Notes on locations
	First year with unsuccessful search	Year last observed	
{Niagara Fish Hatchery}	2016	2008	Not included as a location as status uncertain
High Park, Toronto	Pre-2008	1990s	1 location

Extirpated subpopulation or site	Extirpation history		Notes on locations
	First year with unsuccessful search	Year last observed	
Spring Garden, Essex	2016	1990	1 location
Trout Creek Valley, Norfolk	2016	1985-1986	1 location
Hillcrest, Norfolk	n/a	1985-1986	1 location
Bill's Corners, Norfolk	n/a	1985-1986	1 location
Blue Lake, Brant	2008	1978	1 location
Little Turnbull Lake, Waterloo	2015	1978	1 location
Point Edward/Sarnia, Lambton	n/a	1958	1 location
St. George area, Brant	n/a	1955	1 location
Cootes Paradise North Shore	n/a	1955	0-1 location as site within the Cootes Paradise Complex
Cootes Paradise McMaster ravine	2016	1951	0-1 location as site within the Cootes Paradise Complex
Walsingham, Norfolk	Pre-1987	1949	1 location
Paradise Grove, Niagara	Pre-2016	Pre-1943	1 location
Ipperwash Beach, Lambton	n/a	1926	1 location
Queenston, Niagara	n/a	1908	1 location
Niagara	n/a	1908	1 location
Burford Plains area, Brant	n/a	Pre-1902	1 location
Veitch's Lake, Waterloo	n/a	1893	1 location
Total	**0 locations extirpated in past 10 years**		

Table 6. Downy Yellow False Foxglove subpopulations and sites considered extirpated or presumed extirpated, with information on year last observed and timing of extirpation and number of locations. Bolded subpopulation became extirpated within past 21 years (since 1995). *Italicized* subpopulation became extirpated in the past 22-45 years (1972-1995).

Extirpated subpopulation or site	Extirpation history		Notes on locations
	Year with unsuccessful search	Year last observed	
15 & 16 Mile Creek Valley, Niagara	1990s	1980s	1 location
Cootes Paradise North, Hamilton	Pre-1990	1957	1 location
Walsingham, Norfolk	1987	1950s	1 location
Queenston Heights, Niagara	1990	Pre-1943	1 location
St. Davids, Niagara	n/a	1945	1 location
Total	**1 location extirpated within past three generations**		

General Search Effort

The Canadian range of these species has a long history of botanical collecting activity and is considered well-botanized (Argus 1992). The *Aureolaria* genus has attracted some attention in Canada as one of several flowering plant genera restricted to the Carolinian Zone (Soper 1962). In addition, these species typically persist only in high quality habitat remnants (Oldham *et al.* 1995), which are often foci for life science inventory efforts. These botanical hotspots are also attractive to casual botanists (Argus 1992).

The rarity of these species in Canada also led to additional search effort and documentation. Downy Yellow False Foxglove and Fern-leaved Yellow False Foxglove were included in the Atlas of Rare Vascular Plants of Ontario (ARVPO) but Smooth Yellow False Foxglove was ultimately excluded as it was considered too widespread or common at that time (Argus *et al.* 1987).

All three species are now considered provincially significant species of conservation interest and are tracked by the NHIC (See **Non-legal status** section). The data provided by the NHIC for this report includes many records that have not yet been fully reviewed and processed (NHIC 2016a).

<u>1990 Downy Yellow False Foxglove Field Verification Effort</u>

Eight known Downy Yellow False Foxglove sites in southern Ontario were searched in 1990 by Dave McLeod and others (McLeod 1990). Detailed information on patch size, demographics, habitat, and associates was collected at the four occupied sites. McLeod also examined herbarium specimens of both Downy Yellow False Foxglove and Smooth Yellow False Foxglove.

<u>2016 Field Verification Effort</u>

In 2016, all *Aureolaria* observation and element occurrence records in the NHIC database were obtained (NHIC 2016a). Several additional records were obtained from other sources (see **Acknowledgements and Information Sources**).

Search effort in 2016 targeted accessible sites where one or more of the target species had been reported in the past 50 years. No specific effort was made to locate records with imprecise locational information, or search in areas of potentially suitable habitat (except within about 100 m radius of occupied patches).

Targeted searches were carried out between 14 July and 29 August 2016. A total of 31 sites in nine counties/regions in southwestern Ontario were visited in 2016 by the report writers or collaborators. A minimum of one hour was spent searching in the vicinity of the previously reported position. A few sites were targets for more than one species and some sites included two or more patches. Total search effort was in excess of 200 person-hours.

The 2016 field verification work included the majority of known sites for all three species. All three species likely persist at known sites on Walpole Island First Nation lands that were not surveyed in 2016.

Of 23 target sites where Smooth Yellow False Foxglove had been previously reported in the past 50 years, 17 were checked in 2016 (Appendix 1). Audrey Heagy and Mary Gartshore visited 14 known sites; Graham Buck (pers. comm. 2016) and Anthony Goodban (pers. comm. 2016) provided information on visits to three other known sites. Of the other six target sites, the Ballinfad Pond record was found to be erroneous (Goodban pers.

comm. 2016), the Crawford Lake – Rattlesnake Point Escarpment Woods site was known to be extirpated (Finney pers. comm. 2016), locational information was inadequate for the Fifteen Mile – Sixteen Mile Creek Valleys, landowner permission was not obtained to access the Dingman Creek and Walpole Island sites, and the Black Oak Heritage Park in the Ojibway Prairie Complex was not checked due to time constraints. Landowner permission was obtained for only a small part of the Sudden Bog site.

Of 18 target sites where Fern-leaved Yellow False Foxglove had been previously reported in the past 50 years, 12 were surveyed in 2016 by Heagy and Gartshore. Heagy and Gartshore also visited the Paradise Grove site where the species was abundant prior to 1943 (Oldham 2010). Paul O'Hara (pers. comm. 2016) found a new site at Fifteen Mile Pond in 2016. Of the six target sites for Fern-leaved Yellow False Foxglove not surveyed in 2016, the High Park subpopulation was known to be extirpated (Varga 2008), Graham Buck searched part of the Forced Road Woods area but landowner permission was not obtained to access the main site, and four other sites (Hendrie Valley North, Hillcrest, Bill's Corners and Highbanks) were not checked due to time and access constraints. The latter five sites warrant further search effort to confirm their status. Dry clay bluffs with oaks situated along streams and shorelines at the western end of Lake Ontario (Lake Iroquois Plain physiographic region), and dry sand dunes with oaks in the Port Franks area (southern Huron Fringe physiographic region) were identified as targets for future search effort as several of the recently found patches were found in similar situations.

Four of eight target sites where Downy Yellow False Foxglove had been reported in the past 50 years were surveyed in 2016 by Heagy and Gartshore (Appendix 3). The Waterdown Escarpment Woods report in the NHIC database (McLeod 1990; NHIC 2016a) is considered erroneous. Graham Buck (pers. comm. 2016) visited a small part of the Sudden Bog historical site but did not have landowner permission to access the main site. Adequate locational information was lacking for the other two target sites: Fifteen Mile – Sixteen Mile Creek Valleys, and woods along a railway near Cambridge. In addition, Heagy and Gartshore found Downy Yellow False Foxglove at the Spottiswood Lakes site where only Smooth Yellow False Foxglove had been previously reported, and carried out a limited search of the Queenston Heights site where the species was very common prior to 1943 (Oldham 2010). Additional recent observation data are available for three of the extant sites (see **Sampling Effort** section). Further search effort is warranted at the three historical sites, if access can be arranged, particularly the Sudden Bog site where suitable habitat is still present.

Summary

The series of distribution maps for these species in Pennell (1928, 1935), Soper (1962), Canne *et al.* (1983), Cantrell and Canne (1987), McLeod (1990) and this report illustrate the cumulative increase in understanding of the distribution of the Canadian populations over the past century.

Soper's 1962 map of Smooth Yellow False Foxglove includes many sites not included on Pennell's earlier maps. The known Canadian range of this species has not changed substantially since 1962, even though about half of the known subpopulations were discovered in the past 50 years. A few of these finds could be re-discoveries of older sites with imprecise locational information. Two recently reported sites (Longwoods Road in Middlesex in 2005 and Venison Creek in Norfolk in 2012) represent new subpopulations within the known range.

The pattern for Fern-leaved Yellow False Foxglove is similar, with Soper's map showing many additional sites and a more extensive Canadian range than Pennell's maps, and with most sites reported by Pennell (1928) now considered extirpated or historical. The 12 new sites reported since the late 1970s include some new subpopulations, but all are within the Canadian distribution as mapped by Soper (1962), except for the Walpole Island subpopulation. A new site found by Paul O'Hara in 2016 was in the vicinity of known sites near St. Catharines.

In contrast, new sites in Canada have been added with each version of the Downy Yellow Foxglove range map since 1935 (Pennell1935; Soper 1962; Canne *et al.* 1983; McLeod 1990; Figure 11). Most of the extant and historical subpopulations were discovered during the late 1970s or 1980s (McLeod 1990). A few of these could be re-discoveries of older sites with imprecise locational information but most were newly discovered subpopulations. No new sites have been reported since 1990 (other than the new determination of the Yellow False Foxglove species present at Spottiswood Lakes site). As with the other two species, the Downy Yellow False Foxglove sites along the Niagara River corridor are now considered extirpated.

Some additional patches and sites for all three species will likely be found or re-discovered, particularly given heightened awareness of their rarity. However, these new occurrences are likely to be in similar situations and proximal to known sites within the known Canadian distributions of these species.

HABITAT

Habitat Requirements

In Canada, Yellow False Foxgloves are found in dry, open to semi-open, upland oak forests, woodlands and savanna habitats in southwestern Ontario. Here they occur on a variety of well-drained soils in various situations including sand dunes, sand plains, clay ridges, and slopes, stony loams on moraines, and shallow soils over carbonate bedrock on the rim of the Niagara Escarpment. Their hemi-parasitic behaviour provides them with a competitive advantage on drought-prone soils.

All three species are shade intolerant, although the perennial species can persist but not thrive under low light conditions. Due to their high light requirements, occupied patches in wooded areas are often found in specific topographic situations which result in increased light penetration, such as near open water, south- or west-facing slopes, or on ridge backs, valley rims, or escarpment rim. The presence of other sun-loving species in the same patches suggests that open conditions had been more prevalent in the past (Gartshore pers. obs. 2016). These topographic situations may also provide climatic benefits, such as moderated winter temperatures. Plants are usually found under oak trees, their normal host species. Other common habitat features include open understorey, sparse ground vegetation, and exposed mineral soils.

The various species differ somewhat in their specific habitat requirements. Although two or all three species have been reported from several locales in Ontario historically, only a single species was observed at any given site during the 2016 fieldwork. Relevant habitat features observed at the extant and some extirpated subpopulations visited during the 2016 fieldwork are summarized below. McLeod (1990) includes detailed habitat descriptions for four Downy Yellow False Foxglove sites. Available habitat information for the historical and extirpated subpopulations of the three species is not specific, other than to support the general association with open, upland oak woods.

There is no information on the minimum area of suitable habitat needed to support a viable population for any of these species.

Smooth Yellow False Foxglove

Throughout its range this species grows in dry upland woods. In Ontario, Smooth Yellow False Foxglove was observed growing in a wide range of situations at the occupied sites visited during the 2016 fieldwork. At two sites, the occupied patches were situated on clay ridges running perpendicular to valley or escarpment slopes. Two other sites were on the rims of steep-sided valleys, and another on a valley slope. One of the sites in Waterloo was situated on a small oak knoll surrounded by open wetlands and old fields. The occupied patches at the Ojibway Prairie PNR are associated with oak hummocks, which are open oak groves on slightly raised areas surrounded by open wet prairie. The patches at the two other occupied sites that comprise the large Ojibway Prairie subpopulation are in small openings in oak woodlands. For the Walpole Island subpopulation, air photos indicate that extensive areas of oak woodlands and savanna are present.

Although trees in the white oak group are considered the typical host species for Smooth Yellow False Foxglove, this is not always the situation at the extant sites in Ontario. Plants were spatially associated with Black Oak, *Quercus velutina*, at all patches at the Ojibway Prairie subpopulation, even when White Oak, *Q. alba*, was present nearby. At the Fifty Road Escarpment subpopulation in Hamilton, the only oaks near the plants were Red Oak. It is possible that Smooth Yellow False Foxglove was parasitizing the roots of other woody species present at these sites, such as Pale Blueberry, *Vaccinium pallidum*. White Oak (and often Red Oak) was present at the occupied patches at the other six extant subpopulations checked in 2016.

Based on Lee *et al.* (1998), occupied vegetation communities at the Ojibway Prairie sites included Dry Black Oak Tallgrass Savanna (TPS1-1) and Dry Black Oak – White Oak Tallgrass Woodland (TPW1-1) types, with canopy closure ranging from 20% to 60%. These vegetation types are extremely rare (S1) in Ontario (NHIC 2016b). Vegetation communities at other subpopulations were classified as Dry-Fresh Mixed Oak Deciduous Forest (FOD1-4), Dry-Fresh White Oak Deciduous Forest (FOD1-2), and Dry-Fresh Oak Hardwood Deciduous Forest (FOD2-4), with canopy cover 60% to 80% canopy closure. These oak forests range from uncommon to fairly widespread in Ontario, with conservative status ranks of S3S4, S4 and S5, respectively (NHIC 2016b). Within these forested situations, occupied patches appeared to be confined to more open microhabitats with combination of sparse ground cover and higher light condition. The availability of these specific habitat requirements was very limiting.

Most of the extant sites have relatively few exotic invasives in the immediate vicinity of the occupied patches, although woody invasives have been actively managed at the Branchton Railway Oak Knoll and Ojibway Prairie PNR sites.

Fern-leaved Yellow False Foxglove

In Ontario, Fern-leaved Yellow False Foxglove occurs in more open savanna and woodland habitats than the other two species. It is associated with Black Oak (potentially with Northern Pin Oak, *Quercus ellipsoides*, at some historical sites in Brant and Waterloo). Non-oak woody host species, including species in Ericaceae, have been reported at some subpopulations in the United States (Musselman and Grelen 1979; Werth and Riopel 1979).

The large extant Ontario subpopulations at the Pinery Complex and Turkey Point Complex are on dry, sandy soil. The four smaller subpopulations around the western end of Lake Ontario are situated on hard red clay soils, adjacent to open water or marshes. Several of the extirpated and historical sites are on sand deposits, but those along the Niagara River corridor are on shallow sand or clay soils over limestone (Allen pers. comm. 2016), and those in Waterloo Region are on sand and gravel outwash deposits. The distribution of plants within patches appeared to be linked to the presence of exposed soil.

Canopy cover estimates for the extant subpopulations mostly range from 20% to 60%, although some plants are in areas with higher canopy cover (e.g., ~75% cover at a small patch at the degraded Princess Point site).

Most of the extant sites have relatively few exotic invasives in the immediate vicinity of the occupied patches, but several exotics are present at the Cootes Paradise and Hendrie Valley patches. Several patches of Lesser Periwinkle, *Vinca minor*, are present within the large patch of Fern-leaved Yellow False Foxglove at Turkey Point Provincial Park. Exotic invasive control work and removal of planted pines has occurred at many of the sites in protected areas. Prescribed burns have been implemented to restore oak savanna and woodland habitat at Pinery Provincial Park, Turkey Point Provincial Park and recently at the Princess Point site.

Downy Yellow False Foxglove

The habitat requirements of this species are similar to those of Smooth Yellow False Foxglove. This species appears to require somewhat less light than the former as it is able to persist in mostly closed forests, with canopy cover, 70-90%. However, plants observed in more shaded settings were not vigorous. Although still quite open, ground cover was often denser and had less exposed soil relative to Smooth Yellow False Foxglove sites. Vegetation types at occupied patches included Dry-Fresh White Oak Deciduous Forest (FOD1-2), Dry-Fresh Mixed Oak Deciduous Forest (FOD1-4), and Dry-Fresh Oak Hardwood Deciduous Forest (FOD2-4). White Oak was present at all of the Downy Yellow False Foxglove patches.

Habitat Trends

Information on habitat trends at the occupied sites is quite limited but some relevant information is available for natural habitats in southwestern Ontario (Carolinian ecoregion, Ecoregion 7E), and for oak ecosystems in eastern North America.

Total natural land cover in southwestern Ontario is only about 16% and continuing to decline (Jalava *et al.* 2015). Total forest cover amounts to 8.4%, and much of this is lowland forest (Watkins 2011). Loss of upland forest since European settlement is above 70% in all counties in this region, and losses in Lambton, Middlesex, and Essex counties exceed 85% (Larson *et al.* 1999). Forest inventory data are not available for this region but only a small fraction of the remaining forest cover consists of the open oak-dominated habitats required by Yellow False Foxgloves.

Loss of prairie, savanna, and woodland habitat has been particularly extreme, exceeding 99% across southern Ontario (Bakowsky and Riley 1994). Black Oak communities are now restricted to a few remnants, and are often in a degraded state due to pine plantations, invasive species, and forest succession in the absence of fire.

Oak ecosystems in eastern North America are declining in abundance due to a widespread successional shift, with mesophytic hardwood species forming the younger cohorts in many oak woodlands (McEwan *et al.* 2011; Brose *et al.* 2014). This phenomenon has been termed forest mesophication, a positive-feedback loop in which microenvironmental conditions continually improve for shade-tolerant mesophytic species such a Red Maple, *Acer rubrum*, and deteriorate for shade-intolerant fire-adapted species such as oaks (Nowacki and Abrams 2008). Nowacki and Abrams (2008) and others identified fire as a primary driver of oak forest dynamics and attributed the ecological shift to the almost complete suppression of fire in the eastern deciduous forest biome over the past century. A considerable body of research has focused on this fire-oak hypothesis and management guidelines for the use of prescribed fire to regenerate and restore upland oak ecosystems have been developed (Brose *et al.* 2014). McEwan *et al.* (2011) proposed that multiple interacting ecosystem drivers are at work in oak woodlands including change in fire regimes, increased consumption of acorns and oak seedlings by increasing mammal populations, competition with invasive species, climate change, forest fragmentation, and oak forest management practices.

Fire suppression and the broader suite of ecological drivers identified by McEwan *et al.* (2011) are affecting oak woodlands in southwestern Ontario, resulting in the general decline of shade-intolerant, fire-adapted species. Shading due to Red Maple and Sugar Maple, *A. saccharum*, was noted at many of the occupied sites checked during the Yellow False Foxglove surveys in 2016. Excess shading, and the concomitant build-up of a thick, moist litter layer, is a much more immediate threat to the persistence of Yellow False Foxglove than the long-term shift from oak to maple as the dominant species in these woodlands.

Habitat management to restore and maintain natural Black Oak savanna and woodland communities is occurring at several of the Yellow False Foxglove sites, particularly in protected areas. At Pinery Provincial Park, Turkey Point Provincial Park, Ojibway Prairie PNR, and other sites in the Ojibway Prairie Complex, prescribed fire, invasive species control and other management activities have been implemented since the 1980s to restore Black Oak savannas and woodlands. Fire is a traditional management tool for savanna and woodland habitats on Walpole Island. These sites support a large part of the Smooth Yellow False Foxglove and Fern-leaved Yellow False Foxglove populations. Active ecological restoration efforts at these sites have, to varying degrees, offset the impacts of past fire suppression and management practices, and reduced competition and shading from invasive non-native and native species. Habitat management efforts in protected areas are continuing but prescribed burning in these areas is becoming more challenging to implement for a variety of reasons. Infestations of invasive non-native plants continue to become established and spread in protected areas despite ongoing efforts to control exotics.

Small-scale efforts to control exotic invasives and reduce shading to benefit perennial Yellow False Foxglove species have been implemented at a few White Oak woodland sites (Branchton Prairie, Clappison Escarpment Woods, Spencer Gorge, Cootes Paradise South Shore) with mixed results. White Oak forests at the private Shep’s Subdivision and Spottiswood Lakes sites are being managed for timber using selection harvest practices. The lack of woody regeneration at the Shep’s Subdivision site is atypical of managed hardwood forests in this region.

Habitat quality is continuing to deteriorate at other sites which are not being actively managed.

At Pinery Provincial Park, two recent extreme weather events (tornado in 2014, early season ice/snow storm in 2015) created canopy openings that may provide habitat suitable for Fern-leaved Yellow False Foxglove (Mackenzie pers. comm. 2016). Conversely, understorey vegetation in the park is responding to the reduction of White-tailed Deer, *Odocoileus virginianus*, numbers resulting in less favourable habitat conditions.

BIOLOGY

Information on the biology of the eight species in the Yellow False Foxglove genus is quite limited. The characteristics of the genus and species were described by Pennell as part of his work on the broader Scrophulariaceae *sensu lato* family (Pennell 1928, 1935). The taxonomy of *Aureolaria* species has been examined in a few comparative papers on seed structures and molecular phylogenetic relationships (Canne 1980; Neel and Cummings 2004; Bennett and Matthews 2006; Pettengill and Neel 2008; McNeal *et al.* 2013). There has been some research into the range of host species exploited by this root parasite (Pennell 1928, 1935; Musselman and Mann 1978; Musselman and Grelen 1979; Werth and Riopel 1979; Mann and Musselman 1981). Aspects of the life history of some Yellow False Foxglove species have been described in parts of their range including four species found in the southeastern United States, Fern-leaved Yellow False Foxglove and Large-flowered Yellow False Foxglove, *A. grandiflora*, in the midwestern United States (Musselman 1969), and Spreading Yellow False Foxglove, *Aureolaria patula*, in Tennessee (Cunningham 2000). McLeod (1990) summarized available information on the biology of Downy Yellow False Foxglove.

Life Cycle and Reproduction

Smooth Yellow False Foxglove and Downy Yellow False Foxglove are herbaceous perennials with similar life cycles and reproductive strategies. Age to maturity under natural conditions is unknown. Mann and Musselman (1981) speculated that plants grown from seed under controlled greenhouse conditions might have flowered in their first year, although none had flower buds when their experiment finished in late July. Recruitment rates are also not known and likely vary considerably by site and year. Only a few apparent seedlings were observed in 2016 fieldwork. No information is available on the maximum lifespan of perennial Yellow False Foxgloves. Some plants can become quite large (e.g., Smooth Yellow False Foxglove plant with 54 stems observed in 2016 fieldwork; Downy Yellow False Foxglove with 14 stems), suggesting they can survive for many years. Most plants in the largest extant subpopulation of Downy Yellow False Foxglove must be less than 26 years old as they were not observed in 1990. A four-year demographic study of Spreading Yellow False Foxglove in Tennessee found that seedlings typically did not produce flowers until their second or third year, flowering plants commonly survived for more than four years, plants can remain dormant for a year or more, and stems counts are not a reliable indication of age as plants can regress in size (Cunningham 2000).

The average age of reproducing Smooth Yellow False Foxglove and Downy Yellow False Foxglove is unknown but is more than 2 years, likely more than 5 years (based on survival data from the Spreading Yellow False Foxglove demographic study), but less than 25 years (most plants at the largest Downy Yellow False Foxglove subpopulation were not observed during 1990 survey). The generation time for these perennial species is estimated to be in the order of 7 to 15 years.

Fern-leaved Yellow False Foxglove has been variously described as an annual, winter annual or biennial, but in the northern part of its range it is typically biennial, forming a small rosette in its first year and flowering in its second year (Musselman 1969). It is also possible that some individuals of this species remain at the immature rosette stage for multiple years before flowering. The average generation time for Fern-leaved Yellow False Foxgloves in Ontario is about two years.

All three species reproduce exclusively by seeds. Seeds are dormant at dispersal time, but break dormancy following cold stratification. Optimum stratification conditions for Downy Yellow False Foxglove are about 10 weeks of cold stratification at 5°C followed by a spring-like thermoperiod with 20°/10°C diurnal cycle (King 1989). Germination rates were generally high and not affected by light conditions or presence of putative host species (Musselman 1969; King 1989; Cunningham 2000).

Information on soil seed banks is lacking but the perennial species are unlikely to have long-lived seed banks as seed viability in the perennial Spreading Yellow False Foxglove drops markedly after just one year (Cunningham 2000). Seed longevity for Fern-leaved Yellow False Foxglove has not been studied, but annual and biennial plants are more likely to form a persistent seed bank than perennial species (Rice 1979).

In lab situations, it has been demonstrated at least some Yellow False Foxglove species are facultative rather than obligate parasites as some seedlings can develop to maturity without gaining resources from a host species, and plants transplanted from the field to lab with no host species present were able to flower and set seed (Musselman 1969; Mann and Musselman 1981). However, it is thought that in field situations Yellow False Foxgloves generally must tap into the resources of a host species (not necessarily oaks) to survive and reproduce (Mann and Grelen 1979; Mann and Musselman 1981).

Seedling growth rates vary depending on availability of nutrients, water, light and host species. For perennial species, many plants remain as a rosette and do not reach maturity in their first year in field situations, and some may remain non-reproductive in subsequent years (Cunningham 2000). In the southern part of its range, Fern-leaved Yellow Foxglove completes its entire life cycle in a single year, but in the northern part of the range rosettes do not appear until late summer (Musselman and Mann 1978). Only 5% of Fern-leaved Yellow False Foxglove plants grown in the lab from seeds collected in Wisconsin and northern Illinois flowered in their first year (Musselman 1969).

Mature plants flower over an extended period in mid- to late-summer. Each day two flowers open on each stalk (Musselman and Mann 1978). Flower development on side stems formed after the main stalk has been damaged can be delayed, with some plants still flowering in late fall (Gartshore pers. obs. 2016). Typical flowering dates appear to be slightly staggered for the three species.

Downy Yellow False Foxglove flowering dates in Ontario range from early July through late August, with peak flowering likely occurring in last two weeks of July or first week of August (McLeod 1990). In 2016, plants at the large subpopulation in Waterloo Region had buds, flowers, and seed capsules on 29 July whereas plants at three smaller subpopulations visited on 7-8 August had largely finished flowering.

Smooth Yellow False Foxglove in Ontario appears to start flowering about a week to ten days later. In 2016, the first open flowers were observed on 2 August and plants with buds, flowers and seed capsules were observed at a different site on 7 August. Plants with tight buds were observed at late as 12 September 2016.

The Fern-leaved Yellow False Foxglove flowering period began around 4 August 2016, with peak flowering during the last two weeks of August, and many plants still flowering vigorously in late September.

The complete flowers (sepals, petals, stamens, and pistils present) are insect-pollinated. The two perennial Yellow False Foxglove species are self-incompatible; whereas, the Fern-leaved Yellow False Foxglove is self-compatible (Bell and Musselman 1982). Hybridization of the latter species with the two perennial species has been achieved through artificial pollination (Bell and Musselman 1982). Natural hybrids of *A. flava* and *A. pedicularia* have been observed in Michigan (Reznicek *et al.* 2011a).

Perennial Yellow False Foxglove species go dormant over the winter, but emerge in spring from buds just below the surface (Cunningham 2000). The rosettes of Fern-leaved False Foxglove also go dormant over the winter, and then bolt in the spring (Musselman and Mann 1978).

Cunningham (2000) observed that Spreading Yellow False Foxglove demonstrated extended dormancy, with individuals (in one instance an entire patch that had been flooded for a short period) remaining dormant over a full growing season before re-emerging (often with fewer or smaller stems than previously). In that study dormancy rates varied by site and year, ranging from 4% to 36%. Extended dormancy has not been reported in the other perennial Yellow False Foxglove species, but could be an important consideration.

Productivity measurements are not available, but the seed capsules of all species contain 300 to 500 seeds (Morawetz 2012) and each plant is capable of producing numerous seed capsules. In the southern United States, Fern-leaved Yellow False Foxglove is capable of prolific seed production (Musselman and Mann 1978). Availability of bare soil in proximity to plants appears to be an important factor in seed germination and recruitment for these species (Cunningham 2000; Gartshore pers. obs. 2016).

Physiology and Adaptability

Parasitism

All Yellow False Foxglove species are hemi-parasites, and often secure some of their water and nutrients by tapping in to the roots of oaks or other woody plants through highly modified root structures known as haustoria. Pennell (1928, 1935) considered all species dependent on particular oak species. However, subsequent studies by Musselman and Mann (1978), Musselman and Grelen (1979), Werth and Riopel (1979), Mann and Musselman (1981), and Cunningham (2000) found that Yellow False Foxgloves were capable of exploiting a wide range of woody tree and shrub species, although oaks are the most common host. Host specificity of Fern-leaved Yellow Foxglove to Black Oak and Northern Pin Oak is considered particularly strong (Mann and Musselman 1981). At most occupied patches in Ontario the expected host species were present, but some exceptions were noted for Smooth Yellow False Foxglove (see **Habitat** section).

All three species have brittle stems and leaves that are easily damaged by passing wildlife, people and equipment. Plants are capable of at least partial recovery from incidental damage or browsing by sending up reproductive side branches.

Dispersal and Migration

Seeds of the two perennial species are fairly small (1-3 mm) with small wings that could aid in dispersal (Pennell 1935; Canne 1980). Seeds of Fern-leaved Yellow False Foxglove are smaller (0.5-1 mm) and wingless (Canne 1980). Seed capsules split open when seeds ripen in fall. Seed dispersal mechanisms have not been studied, but some have speculated that the winged structures could aid in dispersal by wind or water (Pennell 1935; Cunningham 2000). McLeod (1990) speculated that wildlife could be a dispersal agent for Downy Yellow False Foxglove. In the absence of any specialized dispersal mechanism, long distance dispersal is not expected for Yellow False Foxglove. Perennial species are less likely to colonize new sites as they are self-incompatible.

Interspecific Interactions

Yellow False Foxglove species are capable of parasitizing the roots of a wide range of woody species, including commercially important tree species (Musselman and Mann 1978). The impact of this parasitism on the host species is not often mentioned in the literature, although Musselman and Mann (1978) state that large populations of Fern-leaved Yellow False Foxglove have the biological potential to be a forest plantation pathogen.

Yellow False Foxgloves are insect-pollinated and the flower structure is adapted to pollination by bumble bees, *Bombus* spp., (Pennell 1928, 1935). Common Eastern Bumble Bee, *Bombus impatiens*, along with a variety of other native bees and Lepidoptera were observed nectaring on Yellow False Foxglove flowers in 2016. European Honeybee, *Apis mellifera*, was observed robbing nectar from Fern-leaved Yellow False Foxglove at the

Hendrie Valley site. Three bumble bee species and a soldier beetle were observed foraging on Fern-leaved Yellow False Foxglove in New Jersey: Common Bumble Bee, Half-black Bumblebee, *Bombus vagans*, and Rusty-patch Bumble Bee, *Bombus affinis*, (Stiles 1977). The latter is a nectar robber, as is the Goldenrod Soldier Beetle, *Chauliognathus pensylvanicus*, that was also observed by Stiles (1977).

Yellow False Foxglove appears to be a preferred food for White-tailed Deer. Damage from browsing was observed at almost all sites for all three species during the 2016 field surveys. Despite the ability of these species to respond to browse damage by sending up side branches, reduced or no flower (and seed) production due to deer browsing was observed at many sites, particularly for the two perennial species. Adverse impacts of deer browse on Yellow False Foxglove species are also widespread in the United States (e.g., Cunningham 2000; Robertson 2015). In some circumstances, deer browse can have beneficial impact by reducing competition from woody and herbaceous understorey and ground cover species, although this was observed infrequently in 2016.

As noted earlier (see **Special Significance** section), the globally rare False-foxglove Sun Moth is entirely dependent on Smooth Yellow False Foxglove and Fern-leaved Yellow False Foxglove (but not Downy Yellow False Foxglove) as a larval food source. Surveys for False-foxglove Sun Moth larvae on Fern-leaved Yellow False Foxglove at sites in Ontario were negative, but larvae of two other moth species were observed feeding on seed capsules (Harris pers. comm. 2016). Verbena Bud Moth, *Endothenia hebesana*, a general seed predator, were common at one site; Dark-spotted Palthis, *Palthis angulalis*, a generalist feeding on dead or decaying plant material, were observed at another site (Harris pers. comm. 2016; Schmidt pers. comm. 2017). Only a small proportion of the seed capsules showed any insect damage.

In the central United States, the larvae of the Ozark Baltimore Checkerspot, *Euphydryas phaeton ozarkae,* feed on Smooth Yellow False Foxglove plants (Robertson 2015). This butterfly sequesters iridoid glycosides found in the plants, rendering the larvae unpalatable to birds (Belofsky 1989). The Baltimore Checkerspot subspecies, *E. phaeton phaeton*, found in Ontario is not known to feed on Yellow False Foxglove.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

For the 2016 survey work, the abundance of the target species was determined by counting or estimating the number of mature plants in each occupied patch. Methods varied by species.

Data collected for the two perennial species, Smooth Yellow False Foxglove and Downy Yellow False Foxglove, typically included counts of the number of individual mature plants, productive stems (stems with indications of buds, flowers and/or seed capsules), and vegetative stems. In addition, the number of stems in each category showing clear evidence of damage due to deer browsing was tallied. Individual plants could be readily discerned by tracing the stems to the central root. Plants with only one or two small, unbrowsed vegetative stems were considered immature plants (rarely observed). All plants were tallied at all sites visited except for two Smooth Yellow False Foxglove sites (Sudden Bog and extensive Ojibway Prairie PNR) where numbers were estimated based on limited searches. The extent of each patch was estimated visually or by pacing the length and breadth. At Ojibway Prairie PNR, the species is patchily distributed, presenting challenges in estimating abundance. Within a 3 ha area where the species was known to occur, partial counts were conducted on three patches (127 plants). A visual inspection of the patches revealed that up to half the individuals (especially those that had been browsed) could be hidden by dense vegetation, generating a lower estimate of 250 individuals at this site. Given the amount of suitable habitat remaining that was not searched, an upper estimate of 1000 individuals at Ojibway Prairie PNR (see Appendix 1) was considered reasonable.

Methods used for Fern-leaved Yellow False Foxglove differed somewhat as each mature plant has a single stem (though multi-branched), plants were less affected by deer browse (almost all mature plants appeared to be reproductive), and it was much more abundant than the perennial species. For this species, the number of mature plants and immature rosettes was tallied at most sites. However, for large dense subpopulations (100s to 1000s of plants), the number of mature plants was visually estimated based on the area of each clump and then summed for each patch. The areal extent of large patches was determined by mapping the distribution of clumps using a Garmin *Etrex* 30 GPS unit.

Comparable abundance information is available for extant Downy Yellow False Foxglove subpopulations from systematic counts by McLeod (1990). Additional count data for this species are available for Clappison Escarpment Woods (Finney pers. comm. 2016) and Spencer Gorge (McDonell pers. comm. 2016). Limited abundance information is included with some observation records in the NHIC database. Previous abundance information for Smooth Yellow False Foxglove and Fern-leaved Yellow False Foxglove is only available for a few sites.

Abundance

Available abundance information for each subpopulation, site, and patch is summarized in Appendices 1, 2, 3.

Smooth Yellow False Foxglove

Fieldwork in 2016 tallied a total of 291 plants in seven extant subpopulations (Table 1). These counts are incomplete as some patches at the Ojibway Prairie PNR site were not tallied, and additional habitat at the Ojibway Prairie and Sudden Bog subpopulations was not searched. The estimated population at these seven subpopulations searched in 2016 is 414 to 1209 individuals. As this species is not able to self-pollinate, the solitary plants at the Longwoods Road and London Riverbend East sites are unable to produce new recruits and are not included as mature individuals (COSEWIC 2015).

Abundance information for the Walpole Island subpopulation is based on an incidental observation of a patch with about 50 plants in 2008 (Buck pers. comm. 2017). The Walpole Island subpopulation is conservatively estimated to consist of 50 to 200 plants, as habitat at the four natural areas where this species was observed during a life science inventory completed in the mid-1980s is considered relatively intact (Woodliffe and Allen 1988; Woodliffe pers. comm. 2017).

Thus, the known Canadian population of Smooth Yellow False Foxglove is estimated to be between 464 and 1409 mature individuals.

The majority (62% to 74%) of the known population is found in the Ojibway Prairie subpopulation. Two subpopulations had less than a dozen plants in 2016.

Fern-leaved Yellow False Foxglove

Fieldwork in 2016 tallied a total of 6485 mature plants in six subpopulations (Table 2). The approximate counts of the largest patches are conservative. Additional patches at the Pinery Provincial Park site were not tallied and additional habitat at this and two other sites was not checked. The Canadian population of Fern-leaved Yellow False Foxglove in 2016 is estimated to be between 7602 and 11820 mature individuals (Table 2).

The Turkey Point Complex and the Pinery Complex each include multiple patches at multiple sites and together comprise 85% of the Canadian population. The two small subpopulations in Niagara each consist of a single patch. The other two subpopulations each include two known patches, although one patch at Cootes Paradise had only a few mature plants in 2016.

Downy Yellow False Foxglove

Abundance data from 2016 at the five extant Downy Yellow False Foxglove subpopulations, along with comparable count data from 1990, are summarized in Table 3. The 2016 fieldwork tallied a total of 388 mature plants (Table 3). The Canadian population estimate is 400 mature individuals. The Shep’s Subdivision subpopulation contains 74% of the population. The Normandale Fish Hatchery subpopulation was the second largest, with 17% of the population.

Fluctuations and Trends

Under normal circumstance, numbers of the two perennial species, Smooth Yellow False Foxglove and Downy Yellow False Foxglove, are unlikely to fluctuate much, although some plants may be dormant in any given year (Cunningham 2000).

The number of mature Fern-leaved Yellow False Foxglove may undergo extreme fluctuations from year to year due to variability in germination and maturation.

During the 2016 fieldwork, few rosettes of this species were observed relative to the number of flowering plants. It is possible that germination and/or rosette development was affected by the hot dry conditions in 2016. Incidental observations at several sites in 2017 (see Appendix 2) found as much as a 10-fold reduction in the number of flowering plants. There is not enough information on the persistence of the seed bank to determine if fluctuations in the number of mature individuals correspond to a change in the total population or a flux of individuals between different life stages.

All three Yellow False Foxglove species found in Canada have experienced reductions in EOO, IAO and the number of subpopulations (Tables 4-6). Population declines are suspected although comparable abundance information is limited.

Smooth Yellow False Foxglove

No past abundance information is available for the Ojibway Prairie Complex, Walpole Island or Sudden Bog subpopulations (Appendix 1). In 2016, the patches at the Ojibway Prairie PNR site appeared to be large and vigorous, unlike the patches at the other sites in the Ojibway Prairie Complex. None of the three patches in Venison Creek subpopulation appeared to be thriving in 2016, although the 59 “clumps” reported by Bill Draper in 2012 is similar to the 56 plants counted at that same patch in 2016. The current condition of the Walpole Island subpopulation is unknown. Plants at the Sudden Bog site were not flowering due to heavy deer browse (Buck pers. comm. 2016).

Several of the smaller subpopulations have experienced declines. The Sixteen Mile Creek subpopulation has declined from two widely separated small patches to a single patch within the past 20 years. One of two patches at the Fifty Road site disappeared sometime in the past 40 years. The Branchton Railway subpopulation which consisted of “two large colonies” in 1978 (NHIC 2016a) had only 5 plants when rediscovered in 2007. The habitat at this site has been actively managed since 2007 and the number of plants increased to 11 by 2016.

Past abundance information is available for a few of the 17 subpopulations that are now extirpated or presumed extirpated. A few stems were present at the Atrieve Lake site as recently as 2006 (Goodban pers. comm. 2016). The Longwoods Road site had about 20 plants in 2005 (NHIC 2016a), but was reduced to a single plant with four stems in 2016. The Rattlesnake Point subpopulation consisted of 20 plants in 1994 (NHIC 2016a), but was extirpated by 2008 (Finney pers. comm. 2016). The London Riverbend East subpopulation was described as “rare and local” in 1990 (NHIC 2016a), but only a single sprawling plant (with 55 stems) was observed in 2016.

While declines have been documented for several subpopulations in the past 21 to 45 years, the overall population trend is uncertain as nothing is known about changes in abundance at the three largest subpopulations which comprise about 90% of the known Canadian population.

Fern-leaved Yellow False Foxglove

There is insufficient past abundance information to determine population trends for this species (Appendix 2). Abundance at the two largest known patches appeared similar in 2015 and 2016 (Gartshore pers. obs. 2016; Stead pers. comm. 2016). However, noticeably fewer plants were present at these and other sites that were checked in 2017 (Gartshore pers. obs. 2017; Heagy pers. obs. 2017; Jones pers. comm. 2017). The number of mature plants of this short-lived species are expected to vary annually, but the range of variability is unknown.

The species is now extirpated at many former sites (Table 5), including Paradise Grove in Niagara where it was once abundant (Hamilton 1943 in Oldham 2010) and High Park in Toronto where it was formerly common (Varga 2008). Extensive habitat restoration efforts have been implemented at the latter sites but this species has not reappeared, suggesting the seed bank may not be able to persist for extended periods.

Downy Yellow False Foxglove

Changes in abundance from 1990 and 2016 at the five extant Downy Yellow False Foxglove subpopulations are summarized in Table 3. Additional count data for three of these subpopulations are plotted in Figures 12, 13, and 14.

As noted earlier, there were substantial differences in the extent of the occupied area in 2016 and 1990 at the four sites with comparable data, with increases at two sites offsetting decreases at the other sites (Table 3). The increase in total number of plants at the five extant sites, from 322 in 1990 to 388 in 2016, was due entirely to the fifteen-fold increase in abundance at the Shep's Subdivision subpopulation. In contrast, two-thirds fewer plants (101 versus 303) were counted at the other four sites.

Monitoring data for the Clappison Escarpment Woods subpopulation (Figure 12) indicates the decline in the number of plants began prior to 1990. The decline in the number of plants at Spencer Gorge since 2001 (Figure 13) has been attributed to increased trail usage resulting in trail widening and increased trampling. The increase in the total number of stems and reproductive stems in recent years at the Clappison Escarpment Woods and Spencer Gorge subpopulations suggests that recent management actions to reduce shading and alien invasive plants are benefiting the remaining plants, although the number of plants has not increased.

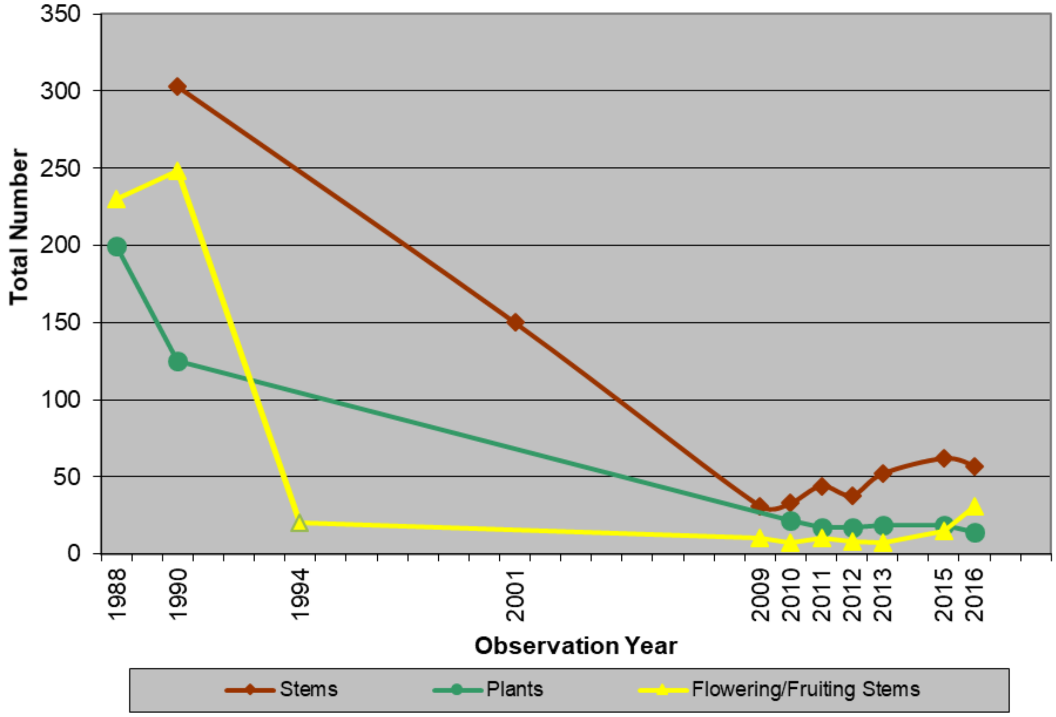

Figure 12. Downy Yellow False Foxglove count data, Clappison Escarpment Woods subpopulation, 1988-2016 (data source: Conservation Halton 2016).

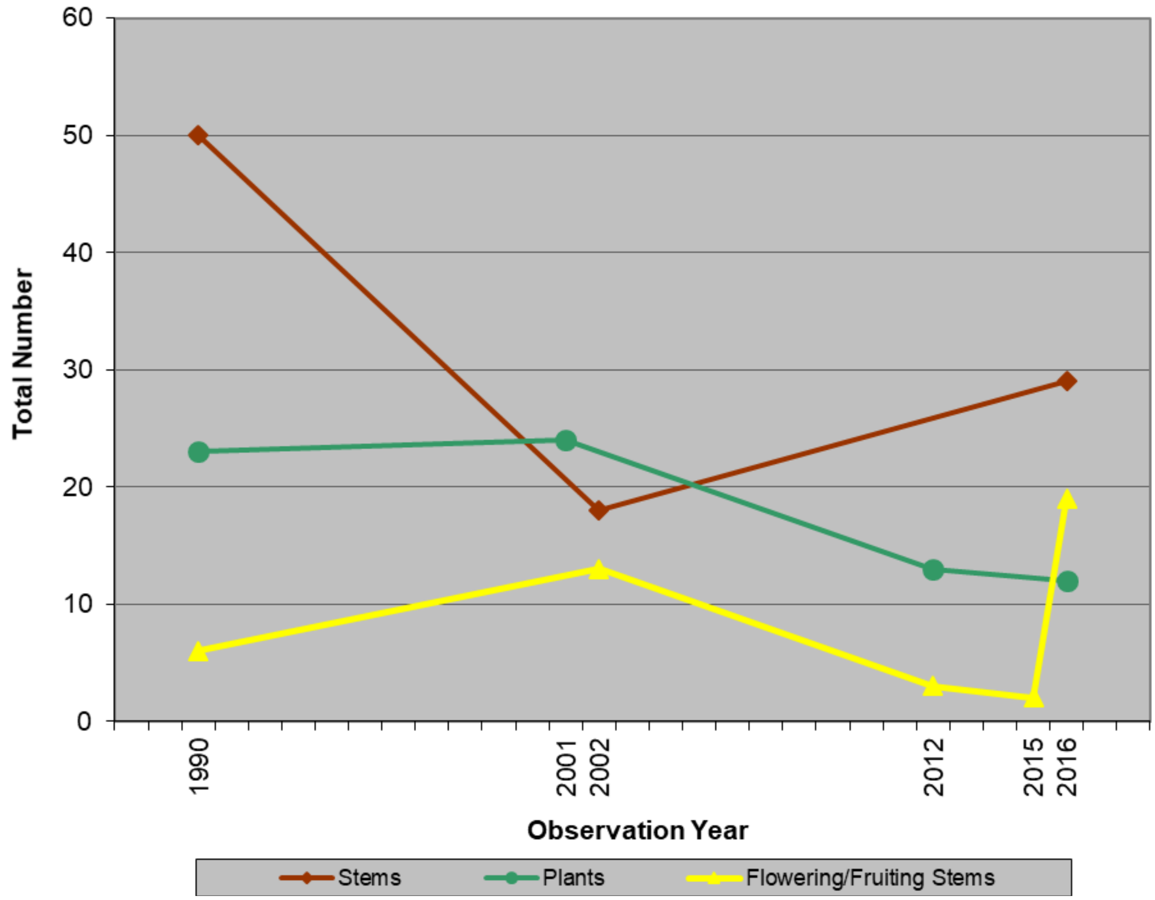

Figure 13. Downy Yellow False Foxglove count data, Spencer Gorge subpopulation, 1990-2016 (data source: Hamilton Region Conservation Authority 2016).

The pattern of changes in abundance at the Normandale Fish Hatchery (Figure 14) is less clear as it is not known if the 1989 and 2008 counts included both patches. The 2016 and 1990 counts for this subpopulation used comparable methods and effort and indicate that the number of plants, stems and flowering stems all declined markedly. The proportion of flowering stems in 2016 (19%) was very low due to intensive deer browse.

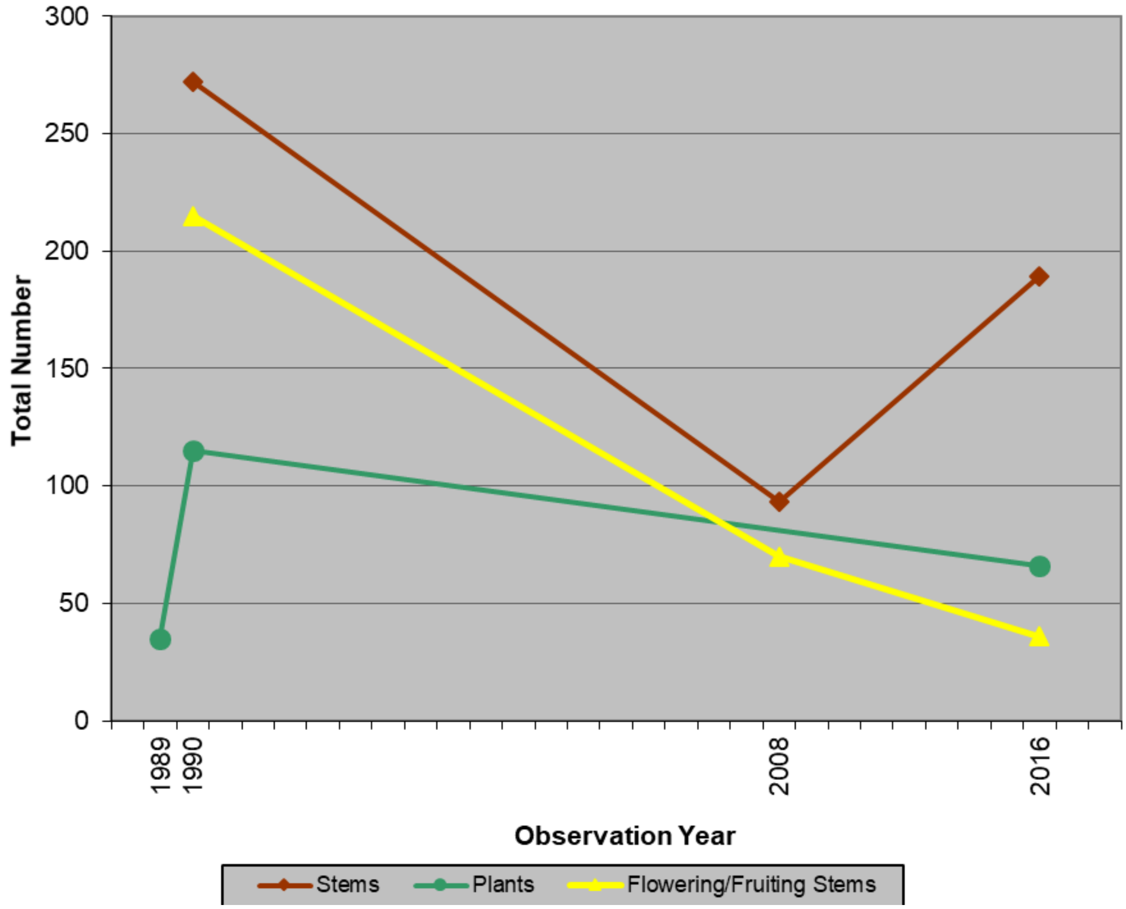

Figure 14. Downy Yellow False Foxglove count data, Normandale Fish Hatchery subpopulation, 1989-2016 (data source: NHIC 2016a).

Reasons for the large increase in numbers at the Shep's Subdivision are not known. It is possible that one of the two patches found at this site in 2016 was present in 1990 but missed, as the patches are some 50 m apart. McLeod's (1990) description of this subpopulation could refer to either of the extant patches, both of which contain many more plants than found in 1990. Habitat at this site may be benefiting from light selective logging, as suggested by McLeod (1990). The very open understorey at this site may result from heavy browse by deer wintering in this sheltered valley (Gartshore pers. obs. 2016).

Although the available information suggests that the overall abundance of Downy Yellow False Foxglove in Canada has been stable or even increased since 1990, four of the five extant sites have experienced substantial declines and no reversals of these trends have been observed, despite ongoing despite management action at a few sites.

Rescue Effect

It is unlikely that additional Yellow False Foxglove plants could become established through unassisted dispersal from populations outside of Canada as the species have no long-distance dispersal mechanism. The two perennial species are self-incompatible, which further decreases the probability of establishing new colonies. It is conceivable that plants could be dispersed through natural processes along the Lake Ontario or Lake Erie shorelines or across the Niagara or Detroit river systems. However, the probability of this occurring is extremely low given the limited availability of potentially suitable habitat along these shorelines in Canada and the small and scattered source populations in the proximal areas of the United States.

It is likely that plants from proximal sites in Michigan, Ohio, Pennsylvania, and New York, and sites elsewhere within the northern parts of the species' ranges, could survive in southern Ontario. In New York, the two perennial species are considered secure (S5), and Fern-leaved Yellow False Foxglove is apparently secure (S4) (NatureServe 2016b,c,d). The status of these species in the other adjacent states has not been ranked, except for Fern-leaved Yellow False Foxglove which is critically imperilled (S1) and endangered in Ohio (NatureServe 2016c).

THREATS AND LIMITING FACTORS

Threats

Direct threats to extant subpopulations were assessed for each species using the IUCN-CMP (World Conservation Union-Conservation Measures Partnership) unified threats classification system (Salafsky *et al.* 2008; Master *et al.* 2012). Threats are defined as the proximate activities or processes that directly and negatively affect the population. Results (impact, scope, severity, and timing of threats) are presented in tabular form in Appendices 4-6.

The overall threat impact was calculated to be very high to high for Smooth Yellow False Foxglove, and high for the other two species. The numbers associated with the threats listed below correspond to IUCN threat numbers and the threat calculator completed for this species.

Current and potential threats are discussed in order of threat impact score. The threats identified below apply to all three species of Yellow False Foxglove to varying degrees. Differences in the relative impact of the various threats on the three species reflect differences in biology, and in land ownership and management. A few sites support a high proportion of the remaining population of each species (Tables 1, 2, 3); threats at these sites had a large influence on the population-level threat scores.

This section draws primarily on threats observed during the 2016 fieldwork, with additional contributions from people familiar with specific sites. Information was not available on current or potential threats to the Smooth Yellow False Foxglove subpopulation on Walpole Island but savanna and prairie habitats on Walpole Island, in general, are being affected by a reduction in the traditional use of fire due to increased housing development (COSEWIC 2010).

Fire suppression (7.1), Impact MEDIUM for all three species

Over the past century, the absence and suppression of periodic wildfire has resulted in habitat degradation due to the succession and mesophication of oak ecosystems. Historically, the impact of fire suppression was particularly severe for the Black Oak savanna and woodland habitats. Other oak woodlands and forests are also impacted as the increase in mesophytic species results in decreased ground-level light levels and also drive other processes which are detrimental to Yellow False Foxgloves such as the build-up of moist leaf litter and an increase in available nitrogen (Nowacki and Abrams 2008; McEwan *et al.* 2011; Brose *et al.* 2014).

At several Yellow False Foxglove sites, controlled burning is being used to offset ongoing fire suppression and restore and maintain oak savanna and woodland habitats. Prescribed fire has been used as a habitat management tool at five extant Smooth Yellow False Foxglove sites (Ojibway Prairie PNR, Ojibway Park, Tallgrass Prairie Heritage Park, Walpole Island, Branchton Railway Knoll) and six former sites for this species (Spring Garden, Black Oak Heritage Park, Hardy Road Woods, Spooky Hollow, Barrie's Lake, and Altrieve Lake). Prescribed fire has been used at three extant Fern-leaved Yellow False Foxglove sites (Pinery Provincial Park, Turkey Point Provincial Park, and one patch at Cootes Paradise South Shore) and four former sites for this species (Blue Lake, Spring Garden, Paradise Grove, and High Park). Prescribed fire has not been used at any of the Downy Yellow False Foxglove sites.

The extent and frequency of prescribed burning efforts at the sites is quite variable.

This management strategy (combined with invasive species control) appears to be achieving its restoration objectives and maintaining the species at sites in large protected areas that have been burned repeatedly (Ojibway Prairie PNR, Pinery Provincial Park, Turkey Point Provincial Park). However, at some extant sites further management is needed before the habitat conditions are improved sufficiently, and at other sites, the management actions may have been initiated too late to recover the species.

Problematic native species 8.2, Impact MEDIUM for perennial species, LOW for Fern-leaved Yellow False Foxglove

Yellow False Foxgloves are heavily browsed by White-tailed Deer. Deer populations in southern Ontario occur at high densities as their diet is supplemented by agricultural crops, and they are protected from hunting in some parks and urban areas. Restricted hunts are used to control the deer population at Pinery Provincial Park.

High levels of browsing damage were observed at all Smooth Yellow False Foxglove sites, including two small subpopulations where all stems were browsed, and no flowers were present. Deer browse was also impacting reproduction at the majority of Downy Yellow False Foxgloves subpopulations, the exceptions being the Spencer Gorge and Clappison Escarpment Wood sites, which deer might be avoiding due to the proximity of heavily used recreational trails. The Fern-leaved Yellow False Foxglove population is also impacted by deer browse, but the impact on productivity was less noticeable for this species.

In contrast, winter deer browse may indirectly benefit Yellow False Foxglove habitat by controlling regeneration of woody species, as was observed at the Shep's Subdivision site, which supports the majority of the Downy Yellow False Foxglove population.

<u>Residential development (1.1), Impact MEDIUM for Fern-leaved Yellow False Foxglove</u>

Rural estate housing or subdivision developments could occur potentially occur on some of the privately owned Yellow False Foxglove sites, although none are currently zoned for development. Housing was considered an important threat for Fern-leaved Yellow False Foxglove because a substantial proportion of the population is on private lands adjacent to Pinery Provincial Park, and there is a significant risk that this area could be developed within the next 10 years. Residential development in proximity to Yellow False Foxglove patches was considered unlikely in the near future at other privately owned sites, including the Shep's Subdivision Downy Yellow False Foxglove site.

<u>Invasive non-native species (8.1), Impact MEDIUM – LOW for Fern-leaved Yellow False Foxglove and Downy Yellow False Foxglove, LOW for Smooth Yellow False Foxglove</u>

Compared to most natural areas in southwestern Ontario, there were relatively few exotic invasive plant species at most of the extant Yellow False Foxglove sites. Often the sites with higher numbers of exotics had only small numbers of Yellow False Foxglove present (e.g., Branchton Prairie, Princess Point) so the population-level impact is low (or medium-low), even though the severity at these sites is significant. Extirpated sites such as Paradise Grove also had high numbers of invasives. This threat is pervasive and continuing even though invasive control has been carried out several sites. The number and extent of invasive species at Pinery Provincial Park continues to increase despite considerable mitigation efforts (Mackenzie pers. comm. 2016).

Emerging exotic forest pests may affect Yellow False Foxglove habitat in southern Ontario but the timing is uncertain and effects unknown. Oak wilt, caused by the fungal pathogen *Ceratocystis fagacearum*, is widespread in the Great Lakes region in the United States and is likely to spread into southern Ontario in the next decade. Oak wilt disease causes rapid death in Red Oak and Black Oak, whereas infected White Oaks can survive for several years.

Recreational activities (6.1), Impact MEDIUM – LOW for Smooth Yellow False Foxglove and Downy Yellow False Foxglove, LOW for Fern-leaved Yellow False Foxglove

Many of the extant Yellow False Foxglove patches are situated on or close to formal or informal recreational trails. Trampling of plants by recreational users and trail maintenance was observed at many sites in 2016. Overall only a small number of plants were directly impacted but some small subpopulations in heavily used areas are at serious risk of extirpation due to recreational activities, specifically the Spencer Gorge, Sixteen Mile Pond Island, and Longwoods Road Conservation Area subpopulations. Other sites where the occupied patches are in close proximity to heavily used hiking, biking or off-road vehicle trails include: Sixteen Mile Creek, London Riverbend East, Cootes Paradise South, Normandale Fish Hatchery, Clappison Escarpment Wood, and the St. Williams Conservation Reserve Turkey Point Tract. Fern-leaved Yellow False Foxglove sites in shoreline situations in Niagara, Hamilton, and Halton are also vulnerable to trampling as they can be accessed by canoes and other small watercraft. Trampling by rock climbers was identified as a significant factor in the recent extirpation of a Smooth Yellow False Foxglove subpopulation at Rattlesnake Point CA (Finney pers. comm. 2016).

Logging and wood harvesting (5.3), Impact MEDIUM – LOW for Downy Yellow False Foxglove

Periodic logging is expected to be an ongoing activity at the Shep's Subdivision and Spottiswood Lakes sites which support a large proportion of the Downy Yellow False Foxglove population. Trampling or disturbance could occur if equipment travels directly through the occupied patches. Logging practices which favour regeneration of maple would also be detrimental. Logging occurred at the Shep's Subdivision site between the 1990 and 2016 surveys but not in the immediate vicinity of the occupied patches.

Other threats

Several other threats were assessed but considered to have relatively minor or unknown impacts including

- Possible expansion of formal trail networks in some protected areas (with proper trail planning to minimize impacts)
- Periodic defoliation and increased oak mortality due to European Gypsy Moth, *Lymantria dispar*, outbreaks
- Nectar robbing by honeybees
- Declines in native bumble bee populations
- Herbivory by leaf- and seed-eating insects
- Infrastructure maintenance impacts on plants near existing roads and hydro corridors

- Habitat management to restore native ecosystems including prescribed burning and thinning of planted conifer is neutral or beneficial if properly planned and executed
- Nitrification favours competing species but airborne nitrogen inputs are presumably decreasing due to the closure of coal plants in southern Ontario.
- Climate change impacts are uncertain but increased drought and storm activity could be beneficial for these species by reducing competition and creating canopy gaps.

Limiting Factors

The availability of suitable habitat and microhabitat within the small geographic area with suitable climatic conditions is the primary factor limiting Yellow False Foxglove populations in Canada. The current distribution of the three populations corresponds closely to the distribution of remnant prairie and savanna vegetation in southern Ontario as mapped by Bakowsky and Riley (1994). Habitat conditions may be improving in some managed areas, but in general, habitat is declining in quality and quantity and is highly fragmented. The species have limited dispersal mechanisms and are therefore not able to readily disperse and colonize other habitat patches. Habitat patchiness may have been a barrier to dispersal of these species prior to European settlement, but habitat fragmentation within the Canadian range has been greatly exacerbated by agricultural conversion and development over the past two centuries.

Other aspects of their biology present further limiting factors. These three species are facultatively parasitic on oaks (and other species). The two perennial Yellow False Foxglove species are insect-pollinated and self-incompatible, whereas the Fern-leaved Yellow False Foxglove is insect-pollinated and self-compatible (Bell and Musselman 1982).

Number of Locations

Most of the known threats to these species relate to land use and habitat management practices such as fire management and recreational activities. As management activities are influenced primarily by land ownership, the number of locations may be determined by the number of sites (discrete land management parcels). Elevated deer populations also pose a significant threat that can rapidly affect all mature plants, particularly for the two perennial species, and this threat applies at the subpopulation scale. The number of extant locations is presented as a range (number of extant subpopulations - number of extant sites under separate management). Presumed extant (historical as defined in this report) subpopulations are counted as 0-1 locations.

There are seven to nine extant locations for Smooth Yellow False Foxglove (Table 1, Appendix 1). The three extant sites within the Ojibway Prairie Complex represent a single location in regard to the threat from high deer populations, or two locations based on differences in land management at the two sites owned by the City of Windsor versus the Provincial Nature Reserve site. The Walpole Island subpopulation is considered a single location as recent information is available for only one patch, and the four natural areas with known occurrences are all managed by the Walpole First Nation. The other five extant subpopulations each occur as single locations. The historical Dingman Creek subpopulation represents an additional possible location for this species as it is presumed extant. At least two to nine locations have become extirpated in the past 21 to 45 years.

There are six to ten extant locations for Fern-leaved Yellow False Foxglove (Table 2, Appendix 2). The Turkey Point and Pinery complexes each comprise one or two locations. The Cootes Paradise, Hendrie Valley, Fifteen Mile Pond, and Sixteen Mile Pond Island subpopulations are each considered a single location. The historical Forced Road Woods and Highbanks subpopulations each represent a possible location. No extirpations have been documented as occurring within the last 10 years but some of the seven locations extirpated within the past 40 years might have been lost within the past decade.

There are five to seven extant locations for Downy Yellow False Foxglove as the five extant and two historical subpopulations each occur at a single site (Table 3, Appendix 3). At least one location (Fifteen Mile – Sixteen Mile Creek Valley) has become extirpated in the past 21 to 45 years.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Currently, these species do not have any special legal protection in Canada, other than a measure of protection afforded where they occur within protected areas. Fern-leaved Yellow False Foxglove is listed as an Endangered species (two varieties recognized) in Ohio (Ohio Department of Natural Resources 2014), and a Threatened species in Minnesota (Minnesota Department of Natural Resources 2013). Downy Yellow False Foxglove is listed as an Endangered species in New Hampshire (New Hampshire Natural Heritage Bureau 2013).

Non-Legal Status and Ranks

All three species are ranked Secure globally (G5, last reviewed in 1984) NatureServe 2016b,c,d). Global rankings for two infraspecific taxa of Smooth Yellow False Foxglove consider *A. flava* var. *flava* as Secure (G5T5) and *A. flava* var. *macrantha* as Apparently Secure (G5T4T5) (NatureServe 2016b). Global rankings for the three infraspecific taxa of Fern-leaved Yellow False Foxglove reported from Canada include *A. pedicularia* var. *pedicularia* as Apparently Secure (G5T4), *A. pedicularia* var. *intercedens* as Apparently Secure (G5T4T5) and *A. pedicularia* var. *ambigens* as possibly Vulnerable (G5T3?) (NatureServe 2016c).

Smooth Yellow False Foxglove and Fern-leaved Yellow False Foxglove are both ranked as Imperilled? in Canada (N2?, NatureServe 2016bc), and Ontario (S2?, NHIC 2016c). These rankings were flagged as inexact or uncertain (as denoted by the ? qualifier) because the lack of recent survey effort at some historically documented sites made it unclear how many extant subpopulations remained at that time (status last reviewed 16 February 2015, NHIC 2016c). Downy Yellow False Foxglove is ranked as Critically Imperilled in Canada (N1, last reviewed 20 February 2012, NatureServe 2016d) and Ontario (S1, reviewed 15 February 2015, NHIC 2016c).

Smooth Yellow False Foxglove and Fern-leaved Yellow False Foxglove have not been assigned a national rank in the United States (NNR, NatureServe 2016b,c). Downy Yellow False Foxglove is ranked as Secure in the United States (N5) (NatureServe 2016d).

Sub-national NatureServe status rankings are available for only a few jurisdictions within the geographic ranges of the three species (Table 7) (NatureServe 2016b,c,d).

Fern-leaved Yellow False Foxglove has been assigned a non-legal status of Special Concern in Maine where it is considered Vulnerable (S3 ranking) (Maine Department of Agriculture, Conservation and Forestry 2015).

Table 7. Subnational status ranks and status designations for Smooth Yellow False Foxglove, Fern-leaved Yellow False Foxglove, and Downy Yellow False Foxglove in the United States.

Data sources: NatureServe 2016b,c,d; Maine Department of Agriculture, Conservation and Forestry 2015; Minnesota Department of Natural Resources 2013; New Hampshire Natural Heritage Bureau 2013; and Ohio Department of Natural Resources 2014.

Legend: SNR = Subnationally not ranked; S1= Critically imperilled; S2= Imperilled; S3 = Vulnerable; S4= Apparently Secure; S5= Secure.

Jurisdiction	Smooth Yellow False Foxglove	Fern-leaved Yellow False Foxglove	Downy Yellow False Foxglove
Alabama	SNR	SNR	SNR
Arkansas	SNR		
Connecticut	SNR	SNR	SNR
Delaware	S1	S1	S4
District of Columbia	SNR	SNR	SNR
Florida	SNR	SNR	SNR
Georgia	SNR	S1?	SNR
Illinois	SNR	SNR	
Indiana	SNR	SNR	SNR
Iowa		S1	
Kentucky	S5	S3?	S5
Louisiana	SNR	SNR	SNR
Maine	SNR	S3, Special Concern	
Maryland	S3	SNR	SNR
Massachusetts	SNR	SNR	SNR
Michigan	SNR	SNR	SNR
Minnesota		S2, Threatened	
Mississippi	SNR	SNR	SNR
Missouri	SNR	SNR	
New Hampshire	SNR	SNR	S1, Endangered
New Jersey	S4 (var. *flava*)	S4 (var. *pedicularia*)	S5
New York	S5 (var. *flava*) S1? (var. *macrantha*)	S4	S5
North Carolina	S3	S4	S5

Jurisdiction	Smooth Yellow False Foxglove	Fern-leaved Yellow False Foxglove	Downy Yellow False Foxglove
Ohio	SNR	S1, Endangered (var. *ambigens*) S1, Endangered (var. *pedicularia*)	SNR
Pennsylvania	SNR	SNR	SNR
Rhode Island	S2 (var. *flava*)	S2 (var. *pedicularia*)	S2
South Carolina	SNR	SNR	SNR
Tennessee	SNR	SNR	SNR
Texas	SNR		SNR
Vermont	S2	S1	S1
Virginia	S5	S4	S5
West Virginia	S4	S3	S5
Wisconsin	SNR	SNR	

Habitat Protection and Ownership

Ownership information for all known locales for each species is included in Appendices 1, 2, and 3.

The largest Smooth Yellow False Foxglove subpopulation is situated on public lands, including the Ojibway Prairie PNR and two adjacent natural area parks owned and managed by the City of Windsor. The second largest subpopulation (Venison Creek) is on lands recently purchased by the Nature Conservancy of Canada. Three other subpopulations are situated on public land including conservation lands along the Niagara Escarpment, and lands owned by the Town of Oakville. At the latter two sites, the extant patches are situated very close to the boundaries of the public lands. The other three subpopulations are on private lands including two under corporate ownership and one privately owned parcel.

Two of six extant Fern-leaved Yellow False Foxglove subpopulations are on lands managed by Royal Botanical Gardens. The large Pinery Complex subpopulation is partly in the provincial park and partly on adjacent private lands. Most of the large subpopulation in the Turkey Point Complex is within the provincial park, but some patches are in the adjacent St. Williams Conservation Reserve lands. The two small subpopulations in Niagara are believed to be privately owned.

Three of the five extant Downy Yellow False Foxglove subpopulations are on publicly owned lands including two properties owned by conservation authorities and one area on Provincial Crown Land. The largest subpopulation is owned by a private corporation and the fifth subpopulation is privately owned. Inventories and active management to protect the species has been carried out at the two conservation authority properties.

Many of the extant sites in public ownership, and some of the corporate and private lands, are being actively managed to conserve and restore natural heritage values. Many of these public lands, and some private lands, are also used for recreational purposes. Timber and firewood is being harvested on a few of the privately owned woodlots.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Audrey Heagy is a field biologist, technical writer and conservation practitioner with over 20 years' experience working for non-profit conservation organizations and as an independent consultant, primarily in southern Ontario. She has extensive experience with birds at risk and has been the lead writer for several bird status update reports, recovery strategies, and landbird conservation plans. In the 1990s, she coordinated a natural areas inventory of Hamilton-Wentworth Region. For the past 10 years, she has been involved with a community-based non-profit organization that is working with the provincial government to restore native oak savanna ecosystems at the St. Williams Conservation Reserve in Norfolk County, Ontario.

Mary E. Gartshore has over 40 years' experience as a field biologist, conservation biologist and ecological restoration practitioner in Ontario, Africa and elsewhere. She has extensive experience in all aspects of native plant production for ecological restoration projects in Ontario as principal of Pterophylla native plant nursery and the St. Williams Nursery and Ecology Centre. She has carried out extensive fieldwork in southwestern Ontario including the Haldimand-Norfolk Natural Areas Inventory 1986-1987, the Southern Ontario Woodlands Biodiversity Study 1994-1995, and St. Williams Crown Forest Life Science Inventory 2001.

COLLECTIONS EXAMINED

No collections were examined.

Appendix 1. Status of all reported Smooth Yellow False Foxglove sites in Canada, with information on land ownership, observations, status, and year last observed.

Legend: EO Number is Element Occurrence identifier assigned to site/subpopulation by NHIC. Shaded boxes indicate sites that are considered an extant site. Sites where plants were observed in 2016 are **bolded.** Heavy outline around boxes denotes sites grouped within a single subpopulation (complex). Brackets () indicate erroneous records. {} indicates record with imprecise locational information within 10 km of a site with more precise spatial information; thus, not considered a separate subpopulation or location. *Italics indicate negative search results.*

County/ Region	Site Name (EO Number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Brant	Hardy Road Woods (EO33982, EO65669)	Corporate	*2016, no plants found, G. Buck (Buck pers. comm. 2016)* *2006-2013, no plants found during monitoring following prescribed burns in 2006 and 2007 (NHIC 2016a)* 1990 sight record and specimen, *W.D. Ball* (NHIC 2016a)	Extirpated (1990)
Brant	*(Spottiswood Lakes)*	Private	*Presumed erroneous record as Aureolaria virginica but not A. flava was found at this site in 2016* 1990, 1 population of about 40 plants (Allen *et al.* 1990 in NHIC 2016a)	Erroneous (*A. virginica site*)
Essex	**Ojibway Prairie Provincial Nature Reserve**	Ontario Parks	**Part of Ojibway Prairie Complex** 2016, partial survey of ~ 3 ha of 65 ha site found 3+ patches: 3600 m^2 area with 82+ plants; ~ 200 m^2 area with 25+ plants; and ~200 m^2 area with 20+ plants. Estimated 250-1000 plants in 3 ha search area and +1000 plants for total site. Potentially ~10,000 m^2 occupied with 1000+ plants area for entire site. Present pre-2016, no details (Cedar pers. comm. 2016; Woodliffe pers. comm. 2016)	**Extant (2016)**
Essex	**Ojibway Park**	City of Windsor	**Part of Ojibway Prairie Complex** 2016, 300 m^2 area with 28 plants, additional patches may be present. Present pre-2016, no details (Cedar pers. comm. 2016)	**Extant (2016)**
Essex	**Tallgrass Prairie Heritage Park**	City of Windsor	**Part of Ojibway Prairie Complex** 2016, 3 patches, 4 m^2 area with 6 plants, 1 m^2 area with 1 plant, and 1 m^2 area with 1 plant Present pre-2016, no details (Cedar 2016)	**Extant (2016)**
Essex	*Spring Garden Natural Area (*EO 33978)	City of Windsor	**Part of Ojibway Prairie Complex** *2016, no plants found* 2011, Rare in 3 ELC polygons (Barcza pers. comm. 2016) 1994, sight record (NHIC 2016a) 1984, sight record (NHIC 2016a)	Extirpated (2011)

County/ Region	Site Name (EO Number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Essex	Black Oak Heritage Park	City of Windsor	**Part of Ojibway Prairie Complex** Not searched in 2016 (habitat degraded relative to other Ojibway sites, Cedar pers. comm. 2016) Present pre-2016, no details (Cedar 2016)	Historical (date unknown)
Essex	{Sandwich [Windsor]}	Unknown	General site, likely within the Ojibway Prairie subpopulation Not searched in 2016 1901 specimen, *Macoun* (Soper 1962, NHIC 2016a)	{1901}
Essex	Malden	Unknown	General site; not searched in 2016 Pre-1902, reported from Malden, *Maclagan* (Soper 1962; NHIC 2016a)	Presumed extirpated (pre-1902)
Essex	woods west of Leamington	Unknown	General site; not searched in 2016, very little potential habitat 1892 specimen, *Macoun* (Pennell 1928, 1935; Soper 1962, NHIC 2016a)	Extirpated (1892)
Haldimand	Cayuga	Unknown	General site, not searched in 2016 Pre-1902, reported from Cayuga, *Maclagan* (Soper 1962, NHIC 2016a)	Presumed extirpated (pre-1902)
Halton	**Sixteen Mile Creek north of Lions Park**	Town of Oakville	**Part of Sixteen Mile Creek Complex** 2016, 3 m^2 area with 7 plants 2012, few plants observed by Gartshore & O’Hara (Gartshore pers. comm. 2016; O’Hara pers. comm. 2016)	**Extant (2016)**
Halton	*Sixteen Mile Creek Red Pine Bluff*	Corporate (to be transferred to Town of Oakville)	**Part of Sixteen Mile Creek Complex** *2016, no plants found* 1998-1999, a half dozen plants observed (Goodban pers. comm. 2016). Likely same observation as 2003 Halton Natural Areas Inventory report in NHIC (2016a)	Extirpated (1998)
Halton	{Sixteen Mile Creek}	Multiple	These records could refer to either of above sites in Sixteen Mile Creek Complex 2003, sight record, *Varga* (Varga 2008) Pre-1994, position within site complex not specified (Geomatics 1993 in NHIC 2016a) Specimen records, 1976 to 1981 (McIlveen pers. comm. 2016)	{2003}

County/ Region	Site Name (EO Number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Halton	Waterdown Escarpment Woods	Conservation Halton	*2016, no plants found* *2009, no plants found (NHIC 2016a)* *Not observed in surveys since 1989 (Finney pers. comm. 2016)* 1989, observed by B. Axon, position within site not specified (Finney pers. comm. 2016; NHIC 2016a)	Extirpated (1989)
Halton	(Ballinafad Pond)	Private	Not searched in 2016 *2003 observation record in NHIC database attributed to Halton Natural Areas Inventory is a data coding entry [species not listed on field datasheets (Finney pers. comm. 2016) and habitat is not suitable (Goodban pers. comm.2016).*	Erroneous (data coding error)
Halton	Crawford Lake-Rattlesnake Point Escarpment Woods	Conservation Halton	Not searched in 2016 *2008-2010, not found during extensive targeted searches, not observed since 1994, extirpated due to trampling during recreational activities (Finney pers. comm. 2016)*. 1994, 20 plants observed by S. Varga at Crawford Lake – Milton Outlier (Varga 1994 field notes provided by Finney pers. comm. 2016; Riley *et al.* 1996 in NHIC 2016a)	Extirpated (1994)
Halton	{Rattlesnake Point}	Conservation Halton	General site, potentially same as Crawford Lake – Rattlesnake Point site Not searched in 2016 1940, specimen from Rattlesnake Point, Cain (Soper 1962; NHIC 2016a)	{1940}
Hamilton	**Fifty Road Escarpment (Devil's Punch Bowl ESA)**	Hamilton Conservation Authority/ Private?	2016, 9 m^2 area with 31 plants 2002, observed by C. Rothfels (Goodban pers. comm. 2016; Hamilton CA 2016) Pre-1993, two patches shown on Varga *et al.* (1992) map (scan provided by Goodban) [possibly same as 1979 S. Varga specimen cited in Oldham 2010 for Niagara Region as close to regional boundary] 1989, observed by B. Lamond (Lamond pers. comm. 2016) Pre-1976, I. MacDonald record cited in Ecologistics 1976 ESA report, position within ESA not specified (McDonell pers. comm. 2016)	**Extant (2016)**

<table>
<tr><th>County/ Region</th><th>Site Name (EO Number)</th><th>Land Ownership</th><th colspan="2">OBSERVATIONS
Year, details (source)</th><th>STATUS (year last observed)</th></tr>
<tr><td>Hamilton</td><td>Cootes Paradise South (Sassafras Point)</td><td>Royal Botanical Gardens (NGO)</td><td colspan="2">2016, no A. flava found during search of Sassafras Point area for Aureolaria species

Present, no details (Smith 2003)

1956 and 1957, specimens from 3 areas on Sassafras Point (RBG 2016)</td><td>Extirpated (1957)</td></tr>
<tr><td>Hamilton</td><td>{Hamilton}</td><td>Unknown</td><td colspan="2">General site, potentially same as Cootes Paradise subpopulation

1890, specimen, Alexander (Soper 1962; NHIC 2016a)</td><td>{1890}</td></tr>
<tr><td>Hamilton</td><td>{Oaklands}</td><td>Unknown</td><td colspan="2">General site, potentially same as another Hamilton Region site

Pre-1902, reported by Crooks (Soper 1962; NHIC 2016a)</td><td>{pre-1902}</td></tr>
<tr><td>Middlesex</td><td>Longwoods Road Conservation Area</td><td>Lower Thames Conservation Authority</td><td colspan="2">2016, 1 plant. Not a viable subpopulation.

2005, ca. 20 plants (NHIC 2016a)</td><td>Extirpated (2016 non-viable; 2005 viable)</td></tr>
<tr><td>Middlesex</td><td>London Riverbend East
(EO 33981)</td><td>Corporate</td><td colspan="2">2016, 1 plant. Not a viable subpopulation.

1990, specimen, rare and local (NHIC 2016a)</td><td>Extirpated (2016 non-viable; 1990 viable)</td></tr>
<tr><td>Middlesex</td><td>Dingman Creek Northeast of Delaware
(EO 33980)</td><td>Private</td><td colspan="2">Coordinates available, not searched in 2016 (landowner permission not obtained), habitat likely intact.

1993, sight record (NHIC 2016a)</td><td>Historical (1993)</td></tr>
<tr><td>Middlesex</td><td>{London}</td><td>Unknown</td><td colspan="2">General site, potentially London Riverbend East site

1879, specimen, Burgess (Pennell 1928, 1935; Soper 1962; NHIC 2016a)</td><td>{1879}</td></tr>
<tr><td>Niagara</td><td>Fifteen Mile - Sixteen Mile Creek Valleys</td><td>Unknown</td><td rowspan="2">General site, very limited search for Aureolaria species in this vicinity in 2016 (Sixteen Mile Pond island and shoreline)

No recent records for Niagara Region (Oldham 2010)</td><td>1990s, not found during field in early 1990s (Varga 1995 in NHIC 2016a)

1980s, three species of Aureolaria observed by G. Myers (NHIC 2016a)</td><td>Extirpated (1980s)</td></tr>
<tr><td>Niagara</td><td>{Jordan Station, potentially same as above}</td><td>Unknown</td><td>1916, specimen, Aiton (Soper 1962; NHIC 2016a)</td><td>{1916}</td></tr>
<tr><td>Niagara</td><td>South of Queenston Power Plant</td><td>Unknown</td><td>General sites, potentially same as other Queenston or</td><td>1954, specimen, Soper & Dale (Soper 1962; NHIC 2016a)</td><td>Extirpated (1954)</td></tr>
</table>

County/ Region	Site Name (EO Number)	Land Ownership	OBSERVATIONS Year, details (source)		STATUS (year last observed)
	{Niagara Glen}	Niagara Parkway	Niagara Falls sites. Potential habitat in the vicinity mostly disturbed or degraded. *Limited search for Aureolaria species in 2016 at Queenston Heights.* *No recent records for Niagara Region (Oldham 2010)*	1939, specimen, *Hamilton NFO*. Erroneously reported as *A. virginica* in Oldham 2010 (Oldham pers.comm. 2017)	{1939}
	{Niagara Falls}	Unknown		1891, specimen, *Cameron* (Pennell 1928, 1935; Soper 1962; NHIC 2016a)	{1891}
	{Queenston}	Unknown		1877, specimen, *Macoun* (Soper 1962)	{1877}
Norfolk	**Venison Creek (Dedecker)**	Nature Conservancy of Canada (NGO)	2016, 3 patches, 20 m^2 area with 56, 70 m^2 area with 16 plants and 1 m^2 area with 2 plants 2012, one patch with 35, 16 and 8 “clumps” W.B. Draper (Draper 2016; NCC 2016)		**Extant (2016)**
Norfolk	{Near Simcoe}	Unknown	General site, potentially same as another Norfolk site Not searched in 2016 1949, specimen, *Montgomery & Landon* (Soper 1962; NHIC 2016a)		{1949}
Norfolk	Spooky Hollow [near Normandale]	Unknown	Not searched in 2016 but not reported during other botanical surveys of Spooky Hollow area 1949, specimen, *Landon* (Soper 1962; NHIC 2016a)		Extirpated (1949)
Norfolk	South of Bill’s Corners	Private	Not searched in 2016 1948, specimen, *Landon* (Soper 1962; NHIC 2016a)		Presumed extirpated (1948)
*Toronto	Swansea / Humber Plains [Toronto]	Unknown	General site, not searched in 2016 *Extirpated, species now gone from Toronto area (Varga 2008)* 1934, specimen, *Brown* (Soper 1962; NHIC 2016a) 1891-1932, four additional collections from Humber Plains vicinity cited by Varga (2008)		Extirpated (1934)

County/ Region	Site Name (EO Number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Walpole FN	Walpole Island **(**EO 33979) One subpopulation with four known areas that potentially should be considered as separate sites	First Nation	Not searched in 2016. No current information (Jacobs pers. comm. 2016). Habitat is likely intact but current condition unknown (Woodliffe pers. comm. 2017). 2008, sight record of about 50 plants in one patch (Buck pers. comm. 2017) 2004, sight record (NHIC 2016a) 1990, sight record (NHIC 2016a) 1985-1988, recorded in 4 natural areas during life science inventory including one area with "good numbers" (Woodliffe and Allen 1998; Woodliffe pers. comm. 2016) 1987, sight record (NHIC 2016a) 1984, sight record (NHIC 2016a) 1983, specimen (NHIC 2016a) 1958, specimen, *Gaiser* (Soper 1962, NHIC 2016a)	**Extant (2008)**
Waterloo	**Branchton Railway Oak Knoll**	Corporate	2016, 3 patches, ~ 5 m^2 area with 7 plants and two 1 m^2 area with 2 plants each 2015, 2 seed stalks (NHIC 2016a) 2007, 5 small plants (NHIC 2016a) 1978, two large colonies, specimen, *Lamb* (NHIC 2016a)	**Extant (2016)**
Waterloo	**Sudden Bog**	Private	2016, 5 plants, limited search, estimate 5-50 plants (Buck pers. comm. 2016) 1987, no details (NHIC 2016a)	**Extant (2016)**
Waterloo	Barrie's Lake	Private	*2016, no plants found* *2015, no plants found during 2 visits (NHIC 2016a)* 1976, specimen, *Lamb* (NHIC 2016a)	Extirpated (1976)
Waterloo	AltrieveLake	Corporate	*2016, no plants found during post-burn monitoring by G. Buck and A. Goodban (Buck pers. comm. 2016; Goodban pers. comm. 2016)* *2015, no plants found (NHIC 2016a)* 2006, a few stems observed by A. Goodban (Goodban pers. comm. 2016) 1975, single multi-stemmed plant, specimen, *Lamb* (NHIC 2016a)	Extirpated (2006)

County/ Region	Site Name (EO Number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Waterloo	{Galt}	Unknown	General site, potentially same as another known site in Waterloo Not searched in 2016 1910, specimen, *Herriot* (Soper 1962; NHIC 2016a)	{1910}
Waterloo	Veitch's Lake	Private	General site, potentially same as Galt site Not searched in 2016 1893, sight record (Montgomery 1944; incorrectly listed as *A. virginica* in NHIC 2016a)	Presumed extirpated (1893)
Wellington	Puslinch	Unknown	General site, not searched in 2016 1937, specimen, *Stroud* (Soper 1962; NHIC 2016a)	Presumed extirpated (1937)

Appendix 2. Status of all reported Fern-leaved Yellow False Foxglove sites in Canada with information on land ownership, observations, status, and year last observed.

<u>Legend:</u> EO Number is Element Occurrence identifier assigned to site/subpopulation by NHIC. Shaded boxes indicate sites that are considered an extant site. Sites where plants were observed in 2016 are **bolded.** Heavy outline around boxes denotes sites grouped within a single subpopulation (complex). Brackets () indicate erroneous records. {} indicates record with imprecise locational information within 10 km of a site with more precise spatial information; thus, not considered a separate subpopulation or location. *Italics indicate negative search results.*

County/ Region	Site Name (EO number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Brant	Forced Road Woods (EO33652)	Private/ Corporate	*2016, no plants found in small area checked (G. Buck, pers. comm. 2016). Additional suitable habitat not searched.* 1990, sight record, Ball (NHIC 2016a)	Historical (1990)
Brant	Blue Lake	Private	*2016, no plants found in small area checked* *2015, one immature rosette reported but likely misidentification (Buck pers. comm. 2016; NHIC 2016a)* *2008 no plants found during several years of post-burn monitoring (Buck pers. comm. 2016)* 1978, large colony, specimen, *Lamb* (NHIC 2016a) 1953 specimen, *Soper & Dale* (Soper 1962; NHIC 2016a)	Extirpated (1978)
Brant	Burford Plains	Unknown	General site, little habitat, not searched in 2016 Pre-1902, reported from Burford Plains, *Tate* (Soper 1962; NHIC 2016a)	Presumed extirpated (pre-1902)
Brant	Near St. George (EO60295)	Unknown	General site; not searched in 2016 1955 record, no details (NHIC 2016a)	Presumed extirpated (1955)
Essex	Spring Garden Natural Area (EO33653)	City of Windsor	*2016 no plants found* 1990 specimen (NHIC 2016a) 1986 record (NHIC 2016a) Known only from Spring Garden, not elsewhere at Ojibway Prairie Complex (Cedar pers. comm. 2016)	Extirpated (1990)
Essex	{Windsor}	Unknown	General site, potentially within 1 km of Spring Garden site Not searched in 2016 Pre-1914, reported from Windsor, *Cravin* (Soper 1962; NHIC 2016a)	{pre-1914}

County/ Region	Site Name (EO number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Halton	**Hendrie Valley (Grindstone Creek Valley)**	RBG (NGO)	2017, 2 patches: 195 mature plants (plus ~ 100 rosettes) in one patch, and 29 mature plants (~ 30 rosettes) in another patch (Gartshore pers. obs. 2017) 2016, 2 patches: 450 m^2 with 715 plants (plus 524 rosettes); 375 m^2 with 99 plants (plus 53 rosettes). Additional habitat not searched. 2012 specimen (RBG 2016) 2011, 2 plants flowering (NHIC 2016a) 1993, specimen (NHIC 2016a) 1957, specimen (RBG 2016)	**Extant (2016)**
Halton	{Hendrie Valley North}	Corporate or Private	Not considered a discrete site as the locational information may be incorrect. Not checked in 2016 Year unknown (post-1998), recorded during ELC mapping by RBG (RBG 2016). Coordinates of this record are considered uncertain as they are outside the RBG property boundary.	Uncertain {post-1998}
Hamilton	**Cootes Paradise South Shore**	RBG (NGO)	**Part of Cootes Paradise Complex** 2017, 2 patches: Sassafras Point - 1 patch with 28 plants and 307 rosettes. Princess Point - ~ 1 small plant, no rosettes (Gartshore per. obs. 2017). 2016, 2 patches: ~900 m^2 area with 130 plants at Sassafras Point; ~ 1 m^2 area with 2 plants at Princess Point. Additional habitat not searched. 2013, a few scattered plants at Princess Point (Goodban pers. comm. 2016) 2008, 1 clump at Princess Point (NHIC 2016a) 2001, >100 fruiting stems at Princess Point (NHIC 2016a) Year unknown (post-1998), recorded at Princess Point and two areas at Sassafras Point during ELC mapping (RBG 2016) 1998, specimen, Princess Point (RBG 2016) 1954-1956, 5 specimens from 3 areas on Cootes Paradise South (RBG 2016)	**Extant (2016)**

County/ Region	Site Name (EO number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Hamilton	Cootes Paradise McMaster Ravine	McMaster University & RBG (NGO)	**Part of Cootes Paradise Complex** *2016, no plants or habitat found in ravine west of McMaster campus*; ravine on east side McMaster not checked 1951, specimen, McMaster Ravine (NHIC 2016; RBG 2016) 1942, specimen, McMaster (RBG 2016)	Presumed extirpated (1951)
Hamilton	Cootes Paradise North Shore	RBG (NGO)	**Part of Cootes Paradise Complex** Cootes Paradise north shore areas were not checked in 2016 1955, 4 specimens from 3 areas on Cootes Paradise North (RBG 2016)	Presumed extirpated (1955)
Hamilton	{Cootes Paradise}	RBG (NGO)	**Part of Cootes Paradise Complex** Cootes Paradise general site 1957, specimen, RBG general site, (RBG 2016) 1890, specimen, Cootes Paradise general site (NHIC 2016a)	{1957}
Hamilton	{Hamilton (EO60293)}	Unknown	General site, potentially Cootes Paradise Not searched in 2016 1888, specimen, *Burgess* (Soper 1962; NHIC 2016a)	{1888}
Hamilton	{Oaklands near Hamilton (EO60296)}	Unknown	General site, potentially another site in Hamilton Not searched in 2016 1890, specimen, (NHIC 2016a)	{1890}
Hamilton	Waterdown Road	Unknown	General site; not searched in 2016 1859, reported by *Logie* (Soper 1962; NHIC 2016a)	Presumed extirpated (1859)
Lambton	**Pinery Provincial Park (EO60292)**	Ontario Parks	**Part of Pinery Complex** 2016, 5+ patches totalling +5000 m^2, 504+ plants from partial count. Additional habitat present and additional patches likely present (A. Mackenzie pers. comm. 2016). 1000+ estimate. 1977, no details (NHIC 2016a) 1936, specimen, *Sutton* (Soper 1962; NHIC 2016a)	**Extant (2016)**

County/ Region	Site Name (EO number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Lambton	**South of Pinery Park**	Private	**Part of Pinery Complex** 2017, fewer mature plants compared to 2016 (Gartshore per. obs. 2017) 2016, 35,000 m^2 area with 2055+ plants partial count, 2500+ estimate 2016-pre, similar numbers and extent in recent years (Stead pers. comm. 2016)	**Extant (2016)**
Lambton	Point Edward / Sarnia (EO60294)	Unknown	General site, not searched in 2016 1958, Blackwell, 3 miles east of Point Edward (NHIC 2016a) 1905, specimen, Point Edward east of pond (NHIC 2016a) 1901, specimen, Sarnia, *Macoun* (Soper 1962; NHIC 2016a) 1888, specimen, Point Edward (NHIC 2016a)	Presumed extirpated (1958)
Lambton	Ipperwash Beach	Unknown	Not searched in 2016. 1926, specimen, *Howitt* (Soper 1962; NHIC 2016a)	Presumed extirpated (1926)
Niagara	**Sixteen Mile Pond Island**	Unknown	2017, 17 mature stems and many rosettes (Jones pers. comm. 2017). 2016, 1 patch, 1250 m^2, with 42 plants 2010s, patch found on island (Staton pers. comm. 2016)	**Extant (2016)**
Niagara	**Fifteen Mile Pond**	Unknown	2016, 1 small patch with ~ 10 plants (O'Hara pers. comm. 2016)	**Extant (2016)**
Niagara	{Fifteen Mile - Sixteen Mile Creek Valleys}	Unknown	General site; not searched in 2016. Potentially same as Fifteen Mile Creek or Sixteen Mile Creek sites so presumed extant (rather than extirpated based on negative results of 1990 surveys) *1990s, not found during field in early 1990s (Varga 1995 in NHIC 2016a)* 1980s, three species of *Aureolaria* observed by G. Myers (NHIC 2016a)	{1980s}
Niagara	{Jordan Harbour}	Unknown	General site; not searched in 2016. Potentially refers to Fifteen Mile Creek or Sixteen Mile Creek sites. *1990s, not found during Niagara Natural Areas Inventory (Oldham 2010)* 1937, specimen, *Simon* (Soper 1962; NHIC 2016a)	{1937}

County/ Region	Site Name (EO number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
!Niagara	{West of St. Catharines}	Unknown	General site; not searched in 2016. Potentially refers to Fifteen Mile Creek or Sixteen Mile Creek sites. *1990s, not found during Niagara Natural Areas Inventory (Oldham 2010)* 1897, specimen, *McCalla* (Soper 1962; NHIC 2016a)	{1897}
Niagara	Paradise Grove (Oak Grove)	Niagara Parkway/ Parks Canada	*2016, no plants found* *Multiple recent negative searches (Allen pers. comm. 2016; Burant pers. comm. 2016)* Pre-1943, formerly abundant at Paradise Grove (Hamilton 1943 in Oldham 2010)	Extirpated (pre-1943)
Niagara	{south of Niagara-on-the-Lake}	Unknown	General site, potentially Paradise Grove site 1952, specimen, *Miller*, (Soper 1962; NHIC 2016a)	{1952}
Niagara	Queenston (EO60298)	Unknown	General site; limited search in 2016, limited habitat 1908, specimen, *Scott* (Soper 1962; NHIC 2016a) 1898, specimen (NHIC 2016a)	Presumed extirpated (1908)
Niagara	Niagara	Unknown	General site; not searched in 2016, limited habitat 1908, specimen, *Potter* (Soper 1962; NHIC 2016a)	Presumed extirpated (1908)
Norfolk	**Turkey Point Provincial Park (EO66159)**	Ontario Parks	**Part of Turkey Point Complex** 2017, ~10-fold reduction in number of mature plants (less than 200 flowering plants) at Patch A compared to 2016 (Heagy per. obs. 2017). 2016, 3 patches: Patch A 70,000 m^2 area with 2680+ plants, Patch B 200 m^2 with 55+ plants, and Patch C 1000 m^2 area with 144+ plants. Total population: >3000 estimate. 2015 Patch B ~ 100 plants within a 100 m^2 area (NHIC 2016a) 2011 Patch C, Specimen, (NHIC 2016a) 2008, Patch A 3 stems; Patch B: 40 stems; Patch C 30-50 stems (NHIC 2016a) 2005 TPPP general, no details (NHIC 2016a) 2003, Patch A, locally abundant (several 1000 plants) (NHIC 2016a) 2000 (or 2001), Patch C, dozens of plants (NHIC 2016a)	**Extant (2016)**

County/ Region	Site Name (EO number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Norfolk	**St. Williams Conservation Reserve Turkey Point Tract (EO33655)**	MNRF Aylmer	**Part of Turkey Point Complex** 2017, similar number of mature plants compared to 2016 (Heagy per. obs. 2017). 2016, 2 patches: 21 m^2 with 36 plants (plus 29 rosettes), and 9 m^2 with 13 plants (plus 3 rosettes) *2015, no plants observed (Draper pers. comm. 2016)* 2008, 2 stems (Draper pers. comm. 2016) 2001, several plants present, (Draper pers. comm. 2016) 1987, no details (NHIC 2016a)	**Extant (2016)**
Norfolk	{Normandale Fish Hatchery}	MNRF Aylmer	**Part of Turkey Point Complex** Not accepted as a discrete site as uncertainty as validity. 2008 record has not been vetted by NHIC. Species not previously reported here even though near well-known *A. virginica* patch. *2017, no plants observed (Heagy pers. obs. 2017)* *2016, no plants found* 2008, 4 stems (NHIC 2016a)	Uncertain {2008}
Norfolk	{West of Normandale}	Unknown	General sites, not checked in 2016. Potentially part of the Turkey Point Complex subpopulation 1959, West of Normandale (NHIC 2016a) 1957, near Turkey Point, specimen, *Soper et al.* (Soper 1962; NHIC 2016a) 1953, southwest of Normandale (NHIC 2016a)	{1959}
Norfolk	{near Turkey Point}	Unknown		
	{Southwest of Normandale (EO60299)}	Ontario Parks		
Norfolk	Trout Creek Valley	Norfolk County	*2016, no plants found* 1985-1986, uncommon or rare at this site (Sutherland 1987)	Extirpated (1985-1986)
Norfolk	Hillcrest	Private	Not searched in 2016. Presumed extirpated as previously rare/uncommon, little potential habitat, and habitat conditions have likely deteriorated since 1986. 1985-1986, uncommon or rare at this site (Sutherland 1987)	Presumed extirpated (1986)

County/ Region	Site Name (EO number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Norfolk	Southwest of Bill's Corners	Private	Not searched in 2016. Presumed extirpated as previously rare/uncommon, little potential habitat, and habitat conditions have likely deteriorated since 1986. 1985-1986, uncommon or rare at this site (Sutherland 1987)	Presumed extirpated (1986)
Norfolk	Walsingham/ Silver Hill (EO60297)	Private	Not searched in 2016 *1985-1986 Silver Hill, no plants found (Sutherland 1987)* 1949, specimen, *Landon* (Soper 1962; Sutherland 1987; NHIC 2016a). Locality reported as Walsingham Lot 1, Concession VIII but Sutherland (1987) indicated probably collected at Silver Hill, Charlotteville Lot 1, Concession VIII	Extirpated (1949)
Norfolk	{Simcoe}	Unknown	General site, possibly Hillcrest or Bill's Corners sites, little habitat Not searched in 2016 Pre-1962, specimen, *Graham* (Soper 1962; NHIC 2016a)	{pre-1962}
Toronto	High Park (EO60300)	City of Toronto	Not searched in 2016 *Not found during extensive recent botanical surveys at this site (Varga 2008)* 1990s, up to 1990s there was a colony of up to 50 plants near Centre Road (Varga 2008) Formerly common, multiple specimens (Varga 2008) 1959, no details (NHIC 2016a) 1956, specimen, *Owens* (Soper 1962; NHIC 2016a)	Extirpated (1990s)
Walpole FN	Highbanks East Savannah, Walpole Island (EO33654)	Walpole Island First Nation	Not searched in 2016. No current information (Jacobs pers. comm. 2016). 1987, about 50 plants in one area (Woodliffe and Allen 1988; NHIC 2016a; Woodliffe pers. comm. 2017)	Historical (1987)
Waterloo	Little Turnbull Lake	Private	*2016, no plants found, partial search* *2015, no plants found during 2 searches (NHIC 2016a)* 1978, 5 plants, specimen (NHIC 2016a)	Extirpated (1978)
Waterloo	Veitch's Lake	Private	Not searched in 2016 1893, specimen, *Herriott* (Montgomery 1944; Soper 1962; NHIC 2016a)	Presumed extirpated (1893)

Appendix 3. Status of all reported Downy Yellow False Foxglove sites in Canada with information on land ownership, observations, status and year last observed.

Legend: EO Number is Element Occurrence identifier assigned to site/subpopulation by NHIC. Shaded boxes indicate sites that are considered an extant site. Sites where plants were observed in 2016 are **bolded**. Brackets () indicate erroneous records. {} indicates record with imprecise locational information within 10 km of a site with more precise spatial information; thus, not considered a separate subpopulation or location. *Italics indicate negative search results.*

County/ Region	Site Name (EO Number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Brant	**Spottiswood Lakes**	Private	2016, 2 patches, one 5 m^2 with 7 plants, one 1 m^2 with 2 plants. No buds, flowers or seed capsules 1990, 1 patch of about 40 plants (identified as *A. flava*) (NHIC 2016a)	**Extant (2016)**
Halton	**Clappison Escarpment Woods (EO2673)**	Conservation Halton	2016, ~ 400 m^2 patch with 14 plants, 57 stems, 31 reproductive stems 2015, 19 plants, 62 stems, 15 reproductive stems, Conservation Halton data (Finney pers. comm. 2016) 2009-2013, ~ 430 m^2 patch with 17 to 22 plants, 31 to 52 stems, 7 to 10 reproductive stems Conservation Halton data (Finney pers. comm. 2016) 2001, 150 stems Conservation Halton data (Finney pers. comm. 2016) 1997, few scraggly stems (Goodban pers. comm. 2016) 1994, 20 reproductive stems (Finney pers. comm. 2016) 1990, 150 m^2 area with 125 plants, 248 reproductive stems (McLeod 1990) 1988, 200 plants with 230 reproductive stems (in McLeod 1990)	**Extant (2016)**
Halton	(Waterdown Escarpment Woods)	Conservation Halton	1993 record in NHIC (2016) appears to be erroneous as only *A. flava* reported here 1990, Table 1 in McLeod (1990) incorrectly lists Waterdown Woods (should be Clappison Escarpment Woods)	Erroneous (*A. flava* site)

County/ Region	Site Name (EO Number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Hamilton	**Spencer Gorge (Tew's Falls) (EO2683)**	Hamilton Conservation	2016, 2 patches: ~ 8 m^2 area with 7 plants and 9 fruiting stems; 4 m^2 area with 5 plants and 10 fruiting stems 2015, 2 fruit stalks with seeds (NHIC 2016a) 2012, 13 plants, 3 fruiting stems, Hamilton Conservation Authority survey (McDonell pers. comm. 2016) 2002, 18 stems, 13 reproductive stems (NHIC 2016a) 2001, 24 plants observed, many flowering, Hamilton Conservation Authority (McDonell pers. comm. 2016; NHIC 2016a) 1990, 225 m^2 area with 23 plants, 44 stems, 6 reproductive stems (McLeod 1990 report)	**Extant (2016)**
Hamilton	Cootes Paradise North (EO2681)	Royal Botanical Gardens (NGO)	Not searched in 2016 *Previous negative searches and habitat reported to have been impacted by development (McLeod 1990)* 1957, specimen, *Tamsalu* (McLeod 1990; NHIC 2016a; RBG 2016)	Extirpated (1957)
Niagara	Fifteen - Sixteen Mile Creek Valleys (EO2672)	Unknown	General site; not searched in 2016 other than limited search for *A. pedicularia* *1990s, not found during fieldwork in early 1990s (Varga 1995 in NHIC 2016a)* 1980s, three species of *Aureolaria* observed by *G. Myers* (NHIC 2016a)	Extirpated (1980s)
Niagara	{St. Catharines}	Unknown	General site, potentially same as Fifteen and Sixteen Mile Creek Valleys site. Not searched in 2016 or 1990 Pre-1935, sight record *McCalla* (Soper 1962; NHIC 2016a)	{pre-1935}
Niagara	St. Davids (EO2676)	Unknown	General site; not searched in 2016 or 1990. Classed as extirpated in NHIC database (2016a) 1945, specimen, *Cody* (Soper 1962; Oldham 2010; NHIC 2016a)	Extirpated (1945)
Niagara	(Niagara Glen)	Niagara Parkway	Not searched in 2016 or 1990 1939, specimen of *A. flava Hamilton NFO 1939* determined as *A. flava* by McLeod 1990; erroneously reported as *A. virginica* in Oldham 2010 (Oldham pers. comm. 2017)	Erroneous (*A. flava* site)

County/ Region	Site Name (EO Number)	Land Ownership	OBSERVATIONS Year, details (source)	STATUS (year last observed)
Niagara	Queenston Heights/ Queen Victoria Niagara Falls Park	Niagara Parkway	Limited search in 2016 *1990, no plants found, considered extirpated (McLeod 1990)* Pre-1943, very common in woods between the School and Brock's Monument (Hamilton 1943 in Oldham 2010) 1901, specimens, *Macoun* (Soper 1962; McLeod 1990; NHIC 2016a) 1891, specimen, *Cameron* (McLeod 1990)	Extirpated (pre-1943)
Norfolk	**Normandale Fish Hatchery (EO2675)**	MNRF Aylmer	2016, 2 patches, 120 m^2 area with 47 plants and 55 m^2 area with 19 plants 2008, 93 stems, 70 of which had emerging flowers (NHIC 2016a) 1990, 2 patches, one 135 m^2 area with 53 plants with 129 stems, one 128 m^2 area with 62 plants with 143 stems (McLeod 1990; NHIC 2016a) 1989, 30 - 40 fruiting plants (NHIC 2016a) 1988, population discovered (McLeod 1990)	**Extant (2016)**
Norfolk	S of Walsingham (Walsingham Lot 12, Concession IV) (EO2679)	Private	Uncertainty as to locality (see Sutherland 1987) Not searched in 2016 or 1990 *1987, no plants found, considered extirpated (Sutherland 1987; McLeod 1990)* 1950s specimen, *Landon* (NHIC 2016a)	Extirpated (1950s)
Waterloo	**Shep's Subdivision (EO2674)**	Corporate	2016, 2 patches, 400 m^2 area with 238 plants, and 55 m^2 area with 49 mature plants 1990, 300 m^2 area with 19 plants (McLeod 1990) 1989,20 plants (McLeod1990) 1988, subpopulation discovered (McLeod 1990)	**Extant (2016)**
Waterloo	Sudden Bog (EO2682)	Private	*2016, no A. virginica found in small area searched (Buck, pers. comm. 2016)* *1990, part of site checked but not vicinity of 1977 record (McLeod 1990)* 1977, specimen, *Lamb* (NHIC 2016a)	Historical (1977)

County/ Region	**Site Name (EO Number)**	**Land Ownership**	**OBSERVATIONS** **Year, details (source)**	**STATUS (year last observed)**
Waterloo	Woods along railroad near Cambridge	Unknown	General site, potentially same locale as Galt or St. George Road site. Not searched in 2016 *1990, searched two potential areas but no plants found (McLeod 1990)* Late 1970s, specimen, *Reznicek* (McLeod 1990)	Historical (late 1970s)
Waterloo	{Galt} (EO2680)	Unknown	General site, potentially same locale as another Waterloo site Not searched in 2016 or 1990 1902, specimen, *Herriott* (Soper 1962; McLeod 1990; NHIC 2016a)	{1902}
Waterloo	{Woods along St. George Road}	Unknown	General site, potentially same locale as another Waterloo site Not searched in 2016 or 1990 1903, specimen, *Herriott* (Soper 1962; McLeod 1990; NHIC 2016a)	{1903}
Waterloo	(Veitch's Lake)	Private	Not searched in 2016 1893, sight record of *A. flava* (Montgomery 1944) was incorrectly attributed as *A. virginica* in NHIC database (2016a)	Erroneous (*A. flava* site)

Appendix 4. Threats calculator for Smooth Yellow False Foxglove.

Species or Ecosystem Scientific Name	Smooth Yellow False Foxglove (*Aureolaria flava*)			
Element ID		**Elcode**		
Date:	03-04-17			
Assessor(s):	Jenny Heron, Audrey Heagy, Alistair MacKenzie, Graham Buck, Vivian Brownell, Bruce Bennett, Del Meidinger, Jana Vamosi, Joanna James			
References:	DRAFT COSEWIC Report (December 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	2	1	
	D Low	0	1	
	Calculated Overall Threat Impact:	Very High	High	
	Assigned Overall Threat Impact:	**AB: Very High-High**		
	Impact Adjustment Reasons:			
	Overall Threat Comments	Nine of 24 (37.5%) of the known population is now extirpated. Reasons are not usually clear but habitat degradation due to lack of fire and natural succession are suspected to be a factor at many sites, along with reproductive failure due to excessive deer browse. Some sites along Niagara River may have been lost to hydroelectric or recreational development. Some sites may have been lost to mining and quarrying activities. This threats calculator assessment is based on the known extant population only. The proportion of each subpopulation (based on 2016 count data plus reports of incidental observation of 50 plants at Walpole Island in 2008 breaks down as follows: Ojibway Prairie Complex (47%), Venison Creek (22%), Walpole Island (15%), Fifty Road Escarpment (9%), Branchton Railway Knoll (3%), Sixteen Mile Creek (2%), Sudden Bog (1%), London Riverbend East (0%), and Longwoods Road (0%). Latter two subpopulations are considered nonviable as reduced to single plant each). Generation time 7-15 yrs (3 generations 21-45 yrs)		

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						
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						
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						
4	Transportation & service corridors						
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance	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
6.1	Recreational activities	CD	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	Trails observed impacting plants at Ojibway PNR, and Longwoods Road. Heavily used trails are within metres of the Thames Riverbend and Sixteen Mile Creek sites. Rattlesnake Point site extirpated due to trampling (rock climbing may have focused trampling in rim forest). Trampling from informal trails and canoe haul-out points may have been an issue at Cootes Paradise (Sassafras Point) site. The Ojibway PNR sites accounts for 44% of the Canadian population, however the number of individual plants at this site would be small. Four other sites are known to have trails, which has a range of negative impacts on this species.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	
7.1	Fire & fire suppression	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	Lack of periodic fire has resulted in mesophication and succession of oak woodland habitats. Some sites (Ojibway Prairie complex, Branchton Railway, Altrieve Lake, Hardy Road Woods) are being managed with prescribed burns but the results have been mixed (species extirpated at latter 2 sites, dense ground cover in parts of Branchton site, species doing well at Ojibway Prairie site). This threat category deals exclusively with the effects of fire suppression. Several sites are being managed with prescribed burns so this threat used to be more widespread historically. It now affects only a restricted proportion of the population (i.e. Venison Creek).
7.2	Dams & water management/use						
7.3	Other ecosystem modifications		Not a Threat	Large (31-70%)	Neutral or Potential Benefit	Moderate (Possibly in the short term, < 10 yrs)	Sixty-five percent of the population is actively managed with fire (Ojibway Prairie Complex, Walpole & Branchton Railway) in an effort to mitigate the effects of fire suppression.
8	Invasive & other problematic species & genes	B	High	Pervasive (71-100%)	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	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	Black Locust and *Phragmites* present at Ojibway Prairie PNR; species has not recolonized area where Black Locust was controlled. European buckthorn was identified as a problem at Branchton Railway site (has been controlled). Relatively few exotics (woody shrubs and cool-season grasses) noted at most sites. Gypsy moth outbreaks in past have caused elevated oak mortality and are likely to recur periodically in future; however, *Aureolaria* benefits from reduced canopy as long as its host species survives. Earthworms are not a serious concern as sites are too dry. Ojibway Prairie PNR (47% of population) and Walpole are considered relatively free of invasives. Black Locust and *Phragmites* are present adjacent to some patches, although it is unlikely that *Phragmites* will directly impact this species because it prefers wetter habitats. Invasive Gray Dogwood had a historical impact on the *A. flava* subpopulation at Branchton.
8.2	Problematic native species	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	High levels of browsing by White-tailed Deer (high populations in protected natural area remnants) noted at all subpopulations. Range of 20% to 100% of stems damaged by browsing. Sites with 100% browsing (i.e., Thames Riverbend East, Sudden Bog) had no flowering stems. Reduced productive output inferred at all sites. Excessive shading by Red Maple (generalist species benefiting from lack of fire or other disturbance) a problem at sites that are not being actively managed. The negative impact of deer browsing occurs across all sites to varying degrees. Deer browsing will not usually kill the individual plants, but will reduce productivity.
8.3	Introduced genetic material						
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.5	Air-borne pollutants		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	General nitrification favours competing species. This threat is likely decreasing due to the closing of coal plants. Although this threat does affect all subpopulations, it is difficult to assess the negative impacts on individual plants.
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Not a Threat	Pervasive (71-100%)	Neutral or Potential Benefit	Low (Possibly in the long term, >10 yrs)	
11.1	Habitat shifting & alteration						
11.2	Droughts		Not a Threat	Pervasive (71-100%)	Neutral or Potential Benefit	Low (Possibly in the long term, >10 yrs)	Species and habitat are adapted to dry conditions, deriving water and nutrients from the host tree. More information may be needed on how droughts would affect the host tree (oak). This threat is present across all sites.
11.3	Temperature extremes						
11.4	Storms & flooding						

Appendix 5. Threats calculator for Fern-leaved Yellow False Foxglove.

Species or Ecosystem Scientific Name	Fern-leaved Yellow False Foxglove (*Aureolaria pedicularia*)		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	03-04-17		
Assessor(s):	Jenny Heron, Audrey Heagy, Alistair MacKenzie, Graham Buck, Vivian Brownell, Bruce Bennett, Del Meidinger, Jana Vamosi, Joanna James		
References:	DRAFT COSEWIC Report (December 2016)		

Overall Threat Impact Calculation:

Threat Impact		Level 1 Threat Impact Counts: high range	low range
A	Very High	0	0
B	High	0	0
C	Medium	3	2
D	Low	1	2
	Calculated Overall Threat Impact:	High	High

Assigned Overall Threat Impact:	**B = High**
Impact Adjustment Reasons:	
Overall Threat Comments	10 of 25 (40%) of the known population is now extirpated. Habitat loss due to development may have been a factor at some sites but habitat degradation due to lack of fire, shading from planted conifers, and natural succession is suspected to be main factor at many extirpated sites (e.g.,Trout Creek, Spring Garden, Paradise Grove). Generation time: 2 years; timing scale for threats assessment: 10 years.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	C	Medium	Restricted (11-30%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs)	
1.1	Housing & urban areas	C	Medium	Restricted (11-30%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs)	The Fifteen Mile Pond site is located on the shoreline in a residential subdivision. Pinery is at risk of residential development if the land is rezoned.
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%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs)	Expansion of camping at Turkey Point or Pinery sites could have serious direct or indirect impacts. Increase in formal trails at these sites, Cootes Paradise, or Hendrie Valley could also have detrimental impact. Camping and recreation won't be expanded at Pinery because it is already at capacity. Less is known about Turkey Point, but the situation there is likely similar to Pinery. Further development is possible at Cootes Paradise and Hendrie Valley because both are currently at 14% capacity; however care is usually taken to avoid species at risk.
2	Agriculture & aquaculture						Site conditions not conducive to agriculture
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						
4	Transportation & service corridors		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	
4.1	Roads & railroads		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	Some plants at Pinery and Turkey Point populations are on road margins, potentially impacted by traffic or road maintenance but negligible numbers. Pinery Point is scheduled for road resurfacing but footprint should not change.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.2	Utility & service lines		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	Moderate (Possibly in the short term, < 10 yrs)	One patch at Turkey Point is confined to local hydro corridor, some plants impacted by corridor management but overall benefits as habitat is maintained in an open condition. Ongoing removal of trees in hydro corridor could benefit this species.
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
6.1	Recreational activities	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Some plants close to authorized trails at Pinery Park and Cootes Paradise (Princess Point) and close to campground at Turkey Point PP but little direct impact. Serious direct impact from informal trails and campfire sites at Sixteen Mile Creek Island site (42 plants). Serious impact from unauthorized ATV/dirtbike use at St Williams CR site (49 plants). Slight to moderate impact of informal trails and canoe haul-outs at Cootes Paradise and Hendrie Valley sites. At Pinery this species only occurs in areas inaccessible to the public. Few plants are found near campsites at Turkey Point, although the extirpation of a limited number of plants is possible.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.1	Fire & fire suppression	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	Fire suppression and past planting of conifers has degraded oak savanna habitats. Some sites (Pinery PP, Turkey Point PP, Princess Point) are being actively managed with prescribed burns to restore open conditions but frequent ongoing management is required to maintain this habitat. Fire suppression is occurring at Turkey Point, Cootes Paradise, Pinery, and Ojibway, but 60% of the population is being actively managed.
7.2	Dams & water management/use						
7.3	Other ecosystem modifications		Not a Threat	Large (31-70%)	Neutral or Potential Benefit	Moderate (Possibly in the short term, < 10 yrs)	Ingrown and degraded oak savanna habitats at Pinery and Turkey Point are being restored through thinning of planted conifers and prescribed burns. Recent plantation thinning (for habitat restoration purposes) close to patches in St William Conservation Reserve, but there is no impact on plants and no change in light conditions. Sixty percent of the population is managed with prescribed burns to mitigate the effects of fire suppression. Habitat management also occurs in the form of non-commercial forest thinning.
8	Invasive & other problematic species & genes	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	
8.1	Invasive non-native/alien species	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	Buckthorn and other exotic shrubs and trees cause excess shading, and an increase in duff layer at Princess Point sites. Several patches of periwinkle groundcover at Turkey Point PP large patch. Some exotics and planted conifers at other sites as well but not dense numbers. There is active management of invasive plants in Ontario provincial parks (Pinery & Turkey Point), although the situation continues to worsen despite best efforts.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Some browsing by White-tailed Deer (high populations in protected natural area remnants) noted but does not appear to be having serious impact on productivity. Browsing can help maintain open conditions. Shading by Red Maple (generalist species) is less of problem in these very dry habitats but build up of duff layer could prevent germination. Management of the deer population at Pinery to below the park's carrying capacity to 50-75 individuals has reduced browsing pressure on *A. pedicularia* (therefore Pinery is not included in the scope of this threat). There is no deer management at Turkey Point so there is higher browsing pressure at this location, although it should be noted that this is not affect the ability of this plant to reproduce. Wild Turkeys have recently become very successful and widespread. It is possible they may have an impact on this species by disturbing leaf litter, but the extent and effect of this impact is unknown at this time.
8.3	Introduced genetic material						
9	Pollution		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	General nitrification favours competing species. This threat is likely decreasing due to the closing of coal plants. Although this threat does affect all subpopulations, it is difficult to assess the negative impacts on individual plants.
9.6	Excess energy						
10	Geological events						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Not a Threat	Large (31-70%)	Neutral or Potential Benefit	Low (Possibly in the long term, >10 yrs)	
11.1	Habitat shifting & alteration						
11.2	Droughts		Not a Threat	Large (31-70%)	Neutral or Potential Benefit	Low (Possibly in the long term, >10 yrs)	Species and habitat are adapted to dry conditions, derive water and nutrients from its host tree. More information may be needed on how droughts would affect the host tree (oak). This threat is present across all sites.
11.3	Temperature extremes						
11.4	Storms & flooding						

Appendix 6. Threats calculator for Downy Yellow False Foxglove.

Species or Ecosystem Scientific Name	Downy Yellow False Foxglove (*Aureolaria virginica*)		
Element ID		**Elcode**	
Date:	03-04-17		
Assessor(s):	Jenny Heron, Audrey Heagy, Alistair MacKenzie, Graham Buck, Vivian Brownell, Bruce Bennett, Del Meidinger, Jana Vamosi, Joanna James		
References:	DRAFT COSEWIC Report (December 2016)		

Overall Threat Impact Calculation:

Threat Impact		**Level 1 Threat Impact Counts: high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	4	2
D	Low	0	2
	Calculated Overall Threat Impact:	High	High

Assigned Overall Threat Impact:	**B = High**
Impact Adjustment Reasons:	
Overall Threat Comments	This threats calculator assessment is based on the known extant population only. The proportion of each subpopulation breaks down as follows: Shep's Subdivision (74%), Normandale Fish Hatchery (17%), Clappisons Woods (4%), Spencer Gorge (3%), Spottiswood Lakes (2%). Generation time 7-15 yrs (3 generations 21-45 yrs)

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	
1.1	Housing & urban areas		Not calculated (unknown timing)	Pervasive (71-100%)	Extreme (71-100%)	Unknown	There is a possibility that 100 acres of woodlot could be developed for housing but timing is unknown (but unlikely to occur within the next 10 years).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas						
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						
4	Transportation & service corridors						
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	CD	Medium - Low	Pervasive - Large (31-100%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.3	Logging & wood harvesting	CD	Medium - Low	Pervasive - Large (31-100%)	Moderate - Slight (1-30%)	High (Continuing)	Loss of Walsingham subpopulation may have been related to logging activity. Recent/ongoing logging in vicinity of Shep's Subdivision and Spottiswood Lakes subpopulations and adjacent to Normandale Fish Hatchery but not close to extant patches (no direct impacts observed, increases in exotics and Red Maple are a potential threat). Sudden Bog site could also be affected by logging. Two sites (76% of the population) are currently experiencing selective logging: Shep's Subdivision and Spottiswood Lakes. Logging is likely occurring on a 10-year cycle, and is not likely to occur in the vicinity of where this species occurs. Logging can sometimes be considered beneficial when opening gaps in the forest canopy; however it can also encourage growth of maple, a negative impact on *A. virginica*. The Shep's site has been logged in the past 10 years, but not to the extent to create gaps in the forest canopy; however it is not known what logging practices will occur in the future. Logging is not expected at Normandale (17% of the population) within the next 10 years.
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance	CD	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	
6.1	Recreational activities	CD	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	Heavily use trails observed impacting plants at Spencer Gorge. Mountain bike/hiking trails close to Clappison and Normandale Fish Hatchery subpopulations. Informal trail/deer trail runs through both patches at Shep's Subdivision. This threat applies to 20% of the population at sites where there is active recreation. There is evidence of heavily used trails impacting plants in some areas, with the potential to extirpate the subpopulation at Spencer Gorge. The site at Shep's is not included here because the only trails present are those used by deer.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	C	Medium	Restricted (11-30%)	Extreme - Serious (31-100%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.1	Fire & fire suppression	C	Medium	Restricted (11-30%)	Extreme - Serious (31-100%)	High (Continuing)	Lack of periodic fire has resulted in mesophication and succession of oak woodland habitats at sites other than at Shep's Subdivision subpopulation where grazing is maintaining open understorey. Minor habitat management (trimming of maple and exotic saplings/shrubs) has occurred at Spencer Gorge and Clappison sites. Fire suppression is not problematic at all sites (specifically Shep's, which accounts for 74% of the total population) because deer are preventing Red Maple regeneration, which would otherwise negatively impact *A. virginica*. There is evidence of decline at the other sites where fire suppression has resulted in the growth of Red Maple, although two of the four sites are being managed for Red Maple.
7.2	Dams & water management/use						
7.3	Other ecosystem modifications						Mesophication impacts are covered under 7.1. General nitrification impacts are covered under 9.5.
8	Invasive & other problematic species & genes	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	
8.1	Invasive non-native/alien species	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	Several exotic invasives (e.g., Glossy Buckthorn, Sycamore Maple, Dog-strangling Vine) present at Spencer Gorge and Clappison Woods subpopulations. Relatively few exotics are known at other subpopulations. Gypsy Moth outbreaks have caused elevated oak mortality and are likely to recur periodically in future; however, *Aureolaria* benefits from reduced canopy as long as host species survives. Glossy Buckthorn is present at two sites. Dog-strangling Vine is present in the vicinity of two other sites. Major declines have been observed at four sites due to a combination of Red Maple regeneration, exotic invasives and recreational activities, but it is difficult to assign the decline to any one of these causes. Subpopulation increases for this species are occurring at two sites that are being actively managed. There are no known invasive species at the Normandy site.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	High levels of browsing by White-tailed Deer (high populations in natural area remnants) noted at several subpopulations (Sheps 33 to 56% of stems browsed; Normandale 21 and 23% browsed, Spottiswood 30% browsed). Sites with heavy browsing had fewer flowering stems (4-8% at Sheps; 17-23% at Normandale, 0% at Spottiswood). Little (0-9%) browsing at Spencer Gorge and Clapisson sites. Excessive shading by Red Maple (generalist species benefiting from lack of fire or other disturbance) a problem at all sites except Shep's Subdivision where deer are controlling regeneration. Some benefits to deer browsing as they keep the habitat open and allow for more light; but this needs to be balanced against the negative impact on productivity due to loss of plant material and reduced reproduction. The timing of deer browsing is an important factor - browsing in the winter on woody material can create openings in the forest canopy which is a benefit to this species, for example browsing is occurring in the winter at Shep's, which is causing an increase in individuals over time. However, deer browsing in the summer will negatively impact the individuals of this species by causing a decline in vigour but is unlikely to cause extirpation at any one site. Biggest impact of browsing is in 26% of population.
8.3	Introduced genetic material						
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	General nitrification favours competing species. Severity hard to estimate. This threat is likely decreasing due to the closing of coal plants. Although this threat does affect all subpopulations, it is difficult to assess the negative impacts on individual plants.
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Not a Threat	Pervasive (71-100%)	Neutral or Potential Benefit	Low (Possibly in the long term, >10 yrs)	
11.1	Habitat shifting & alteration						
11.2	Droughts		Not a Threat	Pervasive (71-100%)	Neutral or Potential Benefit	Low (Possibly in the long term, >10 yrs)	Species and habitat are adapted to dry conditions; they derive water and nutrients from the host tree. More information may be needed on how droughts would affect the preferred host tree (oak). This threat is present across all sites.
11.3	Temperature extremes						
11.4	Storms & flooding						