



Photo: Allen Woodliffe

Nodding Pogonia (*Triphora trianthophora*) in Ontario

Ontario Recovery Strategy Series

Recovery strategy prepared under the *Endangered Species Act, 2007*

Natural. Valued. Protected.

About the Ontario Recovery Strategy Series

This series presents the collection of recovery strategies that are prepared or adopted as advice to the Province of Ontario on the recommended approach to recover species at risk. The Province ensures the preparation of recovery strategies to meet its commitments to recover species at risk under the Endangered Species Act (ESA) and the Accord for the Protection of Species at Risk in Canada.

What is recovery?

Recovery of species at risk is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a recovery strategy?

Under the ESA a recovery strategy provides the best available scientific knowledge on what is required to achieve recovery of a species. A recovery strategy outlines the habitat needs and the threats to the survival and recovery of the species. It also makes recommendations on the objectives for protection and recovery, the approaches to achieve those objectives, and the area that should be considered in the development of a habitat regulation. Sections 11 to 15 of the ESA outline the required content and timelines for developing recovery strategies published in this series.

Recovery strategies are required to be prepared for endangered and threatened species within one or two years respectively of the species being added to the Species at Risk in Ontario list. There is a transition period of five years (until June 30, 2013) to develop recovery strategies for those species listed as endangered or threatened in the schedules of the ESA. Recovery strategies are required to be prepared for extirpated species only if reintroduction is considered feasible.

What's next?

Nine months after the completion of a recovery strategy a government response statement will be published which summarizes the actions that the Government of Ontario intends to take in response to the strategy. The implementation of recovery strategies depends on the continued cooperation and actions of government agencies, individuals, communities, land users, and conservationists.

For more information

To learn more about species at risk recovery in Ontario, please visit the Ministry of Natural Resources Species at Risk webpage at: www.ontario.ca/speciesatrisk

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DECLARATION

The recovery strategy for Nodding Pogonia was developed in accordance with the requirements of the *Endangered Species Act, 2007* (ESA). This recovery strategy has been prepared as advice to the Government of Ontario, other responsible jurisdictions and the many different constituencies that may be involved in recovering the species.

The recovery strategy does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation, or the official positions of the organizations with which the individuals are associated.

The goals, objectives and recovery approaches identified in the strategy are based on the best available knowledge and are subject to revision as new information becomes available. Implementation of this strategy is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy.

RESPONSIBLE JURISDICTIONS

Ontario Ministry of Natural Resources
Environment Canada – Canadian Wildlife Service, Ontario

EXECUTIVE SUMMARY

Nodding Pogonia (*Triphora trianthophora*) is designated as endangered under Ontario's *Endangered Species Act, 2007* (ESA) and the federal *Species at Risk Act* (SARA). This species is a small orchid with a 5 to 31 cm purplish-green stalk, round leaves clasping the upper stem, and usually three greenish-white flowers. The plants acquire nutrients from a symbiotic fungus associated with its roots, and thus only appear above ground when conditions are favourable for flowering. They may be completely absent for a number of years, appearing dormant. However, the plants can be growing underground. The maximum period without flowering is not known.

In Canada, Nodding Pogonia is restricted to two locations in Ontario: Rondeau Provincial Park and Three Birds Woodlot (Essex County). At Rondeau more than 96 plants were present in 2011. Plants have not been seen at Three Birds Woodlot since 1987, but there have only been three partial surveys there in 26 years. The population is considered extant. Trend analysis is difficult due to large fluctuations in numbers of above-ground stems from year to year. In Ontario, the species grows in shady, moist beech-maple woods in small depressions with deep leaf litter and humus.

Current threats to Nodding Pogonia include: (1) disruptions of the mycorrhizal fungal association by earthworms, other invasive species such as Japanese Barberry (*Berberis thunbergii*) or Garlic Mustard (*Alliaria petiolata*), or potentially from air pollution; (2) degradation or loss of habitat from beech bark disease, forest management, or changes in drainage; and (3) grazing by White-tailed Deer, slugs or other animals. Potential threats and natural limitations are also discussed in the text.

The recovery goal is to maintain the extant populations of Nodding Pogonia in their current condition or better and to assist these populations over the long-term to become self-sustaining and viable. The recovery objectives are to:

- determine the current distribution and abundance of Nodding Pogonia populations in Ontario by 2022;
- assess threats to the species and its habitat by 2017 and address threats by 2019;
- fill knowledge gaps relating to the biology, ecology, habitat, and threats of Nodding Pogonia in Ontario by 2017;
- develop and implement a monitoring strategy to be used to help fulfill objectives 1 to 3 by 2015; and
- use a variety of tools to protect and maintain habitat of known populations by 2017.

It is recommended that the area to be considered for habitat regulation include:

- 1) all areas known to be occupied or formerly occupied by the species since 1950 unless they meet the criteria for lack of occupancy;
- 2) previously unknown areas where the species becomes discovered from 2012 onward; and

- 3) In deciduous forest habitat, a radial distance of 200 m around patches of Nodding Pogonia. If non-forested vegetation falls within the 200 m radius circle, it is recommended all of the forested area be included plus up to 30 m of unforested vegetation to a maximum distance of 200 m from the plants.

It is recommended that pre-existing human infrastructure such as roads, railway tracks, parking lots, agricultural crops, etc. should not be included in regulated habitat.

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1.0 BACKGROUND INFORMATION

1.1 Species Assessment and Classification

COMMON NAME: Nodding Pogonia

SCIENTIFIC NAME: *Triphora trianthophora*

SARO List Classification: Endangered

SARO List History: Endangered (2004)

COSEWIC Assessment History: Endangered (2010, 2000, 1999), Threatened (1988)

SARA Schedule 1: Endangered

CONSERVATION STATUS RANKINGS:

GRANK: G3G4

NRANK: N1

SRANK: S1

The glossary provides definitions for technical terms, including the abbreviations above.

1.2 Species Description and Biology

Species Description

Nodding Pogonia (*Triphora trianthophora*) is a small orchid that exists primarily underground and only produces flowering stems in favourable years. The roots of Nodding Pogonia are fleshy, and some have tuber-like swellings (called tuberoids or corms) used for nutrient storage. When present, the purplish-green above-ground stems range from 7 to 20 (30 maximum) cm in height (Romero-González et al 2002). Round leaves clasp the upper half of the stem, up to the base of the inflorescence (flower cluster). The number of leaves per plant may be one or several. Often the plant produces three flowers that are subtended by a leafy bract, but there may be as few as one or as many as seven flowers. The inner perianth (flower) consists of two top petals and a lower lip bearing three greenish crests. The three outer sepals are white and petal-like. The flowers sometimes have a distinctive magenta coloration. The fruit is an erect green capsule.

Species Biology

Nodding Pogonia is an inconspicuous species that only appears above ground in late summer just before it begins its brief flowering period. The plants are heterotrophic, meaning they require nitrogen and carbon for growth from a source other than photosynthesis. In Nodding Pogonia, nutrients are supplied by a mycorrhizal fungus in the cortex, or outer layer, of the roots (Carlswald and Stern 2009). This allows the species to survive underground and only occasionally appear above ground to flower and accomplish sexual reproduction.

If conditions in any particular year are not suitable for reproduction, few or no above ground stems may be produced, and the species may appear dormant. However, dormant does not mean an entirely inactive state since the plants are still able to grow and spread underground and to store nutrients in tuberoid corms, or swellings on the underground stem (Williams 1994). Periods of dormancy occur in a wide variety of plant species and have been shown to correspond to increased survival in periods of environmental stress and fluctuating resources (Shefferson et al. 2001, Gremer et al. 2012).

The maximum period this species may remain alive without appearing above ground (e.g., the dormancy period) is not known, but mark and recapture studies (which monitor the presence or absence of specific individuals) have shown a variety of dormancy periods for other orchid species. These range from 1 or 2 years for *Cypripedium* species (Shefferson et al. 2001, Kery and Gregg 2004), to up to 18 years in Helleborine (*Epipactis helleborine*) (Light and MacConaill 2006), to possibly as much as 20 years in some *Isotria* species (Correll 1950). However, Holsinger et al. (1996 cited in COSEWIC 2011) showed that after five years or more there is a 90% chance that plants of Small Whorled Pogonia (*Isotria medeoloides*) will not re-emerge.

A report from South Carolina (Porcher 1977) reported a recurrence of Nodding Pogonia after an apparent absence of 125 years. However, this referred to an absence of reports on the South Carolina coastal plain, rather than from one particular site that had been consistently observed during that span of years. Thus, this report does not conclusively show that an individual Nodding Pogonia plant can reemerge after being dormant for that length of time. Still, the author noted that the orchids emerged in an area he had frequented for many years in which he had never seen them before. This would seem to indicate that the plants may have been dormant for at least the period of his use of the area, which could conceivably be 20 to 30 years or more.

The numbers of above ground stalks produced (if any) may vary greatly from one year to the next. In New Hampshire, an area of approximately one square mile (2.6 km²) was found to contain 20,000 stems of Nodding Pogonia during one year, less than 500 stems the next year, only 2 stems the third year, and none the fourth year. However, two years later, there were again about 20,000 stems present (Lownes 1926).

The conditions needed for flowering to occur in Nodding Pogonia are not known, but it has been observed that more flowering stems have appeared at Rondeau Provincial Park in cool, damp summers and that dry conditions may inhibit flowering (Woodliffe 1988, COSEWIC 2010). In addition, it is possible that other factors, such as corm size and amount of nutrient storage may also be involved (Williams 1994).

Some more visible Nodding Pogonia populations in Michigan have been known to persist for long periods of time (more than 30 years) in the same location (Case 1987) and may survive within suitable microhabitat even in semi-disturbed surroundings (Case 1987, Swink and Wilhelm 1994, Dister 2006).

In Ontario, flowers have been observed as early as July 30 and as late as September 27 (Woodliffe 1988). In favourable years, up to three stalks may grow, each with between one and seven flowers. An individual flower usually lasts only one day (Case 1987), during which time it is dependent on insect pollinators for seed set. Individual flowers develop to a specific stage and then remain at a stand-still until certain temperature requirements are met. Usually on the second morning after a significant drop in overnight temperature, all developed flowers open synchronously, a process which may increase the potential for cross-pollination. This process repeats itself with subsequent buds. Successful germination of the fine wind-dispersed seeds depends on contact with the correct associated fungus to nourish the developing embryo.

Pollinators of Nodding Pogonia are observed to be mainly Halictid bees. At Rondeau Provincial Park, sweat bees in the genus *Dialictus* were observed as pollinators (P.A. Woodliffe pers. comm. 2012). Medley (1979) reported nine species of bees, mainly in the family Halictidae, pollinating Nodding Pogonia in Michigan.

Artificial propagation of this species has had limited success. Anderson (1990) successfully germinated seeds of this species on an artificial medium and produced small corms in the laboratory, but attempts at reintroducing them in the wild were not successful. Material from Three Birds Woodlot was introduced to Rondeau Provincial Park in 1956, but the introduced plants apparently survived for only four years, and a similar attempt at John E. Pearce Provincial Park was apparently without success (Woodliffe 1988).

The corms of Nodding Pogonia are sometimes collected and cached by squirrels (Case 1987, P.A. Woodliffe pers. comm. 2009), and squirrels may inadvertently help Nodding Pogonia disperse to new locations since translocated corms are capable of producing above ground flowering stems or below ground growth. No specific work has been done on dispersal distances in Nodding Pogonia. However, a study of seed dispersal by Fox Squirrels (*Sciurus niger*) showed an inverse relationship between size of propagule and distance carried (Stapanian and Smith 1978). This study found that Black Walnut (*Juglans nigra*) seeds were carried a maximum distance of 108 m. In Illinois, Dow and Ashley (1996) found acorns of Bur Oak (*Quercus macrocarpa*) were dispersed a maximum of 165 m from parent trees, primarily by squirrels, although the mean distance was 22 m.

However, corms of Nodding Pogonia are smaller and lighter than walnuts or acorns and so might be carried farther, but they are probably not as valuable a food source and might be dropped sooner. These are generalizations that are not specific to orchid corms or to a particular species of squirrel. However, they serve to show that dispersal distances for Nodding Pogonia corms could be as much as 165 m or potentially greater.

Dispersal distances for Nodding Pogonia seeds are much larger than for the corms or for walnuts or acorns. While no specific distances are known for Nodding Pogonia, orchid seeds in general are tiny and dust-like and can remain airborne for long periods. Depending on the speed of the wind and other factors, they are capable of traveling

hundreds of metres from the parent plant (Murren and Ellison 1998, Arditti and Ghani 2000).

1.3 Distribution, Abundance and Population Trends

In Canada, Nodding Pogonia is restricted to two locations in Ontario: Rondeau Provincial Park in the Municipality of Chatham-Kent and Three Birds Woodlot, near Leamington in Essex County (Figure 1). Nodding Pogonia occurs throughout eastern North America (Figure 2) from New England to Texas, and south through Mexico, Guatemala, and Panama (NatureServe 2012). The species is globally ranked G3G4 or vulnerable to uncommon throughout its range, and the species is not ranked secure anywhere in North America (NatureServe 2012). Table 1 shows the conservation status of Nodding Pogonia in North America by state or province. In Canada and in Ontario, Nodding Pogonia is designated endangered. It is ranked N1 and S1 or critically imperiled both nationally and provincially.



Figure 1. Current distribution of Nodding Pogonia in Ontario.



Figure 2. North American distribution of Nodding Pogonia (Flora North America 2005). Red dot shows general location of Ontario populations. Distribution in Mexico, Guatemala, and Panama not shown.

Table 1. Conservation status of Nodding Pogonia in North America by state or province (NatureServe 2012).

Historic (SH)	Critically Imperiled (S1)	Imperiled (S2)	Imperiled to Vulnerable (S2S3)	Vulnerable (S3)	Not Ranked (SNR)
District of Columbia Pennsylvania	Connecticut Delaware Maine Maryland Massachusetts Michigan Nebraska New Jersey Ontario Vermont Virginia	Georgia Louisiana New Hampshire New York North Carolina Ohio South Carolina West Virginia Wisconsin	Mississippi Oklahoma	Florida Illinois Iowa	Alabama Arkansas Indiana Kansas, Kentucky Missouri Tennessee Texas

Rondeau Provincial Park

At Rondeau Provincial Park a colony with several clusters of 10 to 15 plants each was discovered in 1966. Annual monitoring of the Rondeau Provincial Park populations using permanent plots was begun in 1986. Numbers of above ground stems in both plot data and rough subpopulation counts vary greatly from year to year. For example, the plots contained 40 stems in 2005 but only 4 stems in 2007, and then 69 stems were

present in 2008 and 126 stems in 2009. Actual numbers for the total population are higher than plot totals because many plants occur outside of plots, but annual counts have not always been done for non-plot areas. Thus, it is impossible to determine what the annual total population maximums may have been in the past. In 2008, 1357 stems were counted in regular plots covering only a portion of the habitat and of the potential population (COSEWIC 2010). In 2011, 96 stems were counted: 13 in study plots and 83 in other areas, but only a portion of the total habitat was surveyed. The Rondeau population consists of four subpopulations within an area of approximately nine hectares (COSEWIC 2010).

It is possible that the Rondeau population originated from plants that were introduced into the park in 1956 from Three Birds Woodlot (Woodliffe 1988). By 1960, the introduced population had disappeared, but in 1966 the species was discovered at another location approximately one kilometre from the introduction site. It is not known whether the species was at the second location all along or whether these plants were the result of seed or corm dispersal from the introduced population. Still, regardless of the origin, the Rondeau population qualifies for recovery because it is within the natural range of the species, and because the propagules introduced came from a known native source (COSEWIC 2010).

Three Birds Woodlot

At Three Birds Woodlot, 12 Nodding Pogonia plants were discovered in 1950. Annual counts have only been done sporadically and only for parts of the population, but numbers have ranged from 188 in 1967 to 22 in 1985. No plants have been seen at Three Birds Woodlot since 1985, but the habitat has not been surveyed on a regular basis. The eastern part of the woodlot (where permission for access was granted) was searched in 1998, 2000 and 2008, but no Nodding Pogonia was found. With searches made in only 3 of the last 26 years and covering only part of the habitat, it remains possible that Nodding Pogonia may be present in the unsurveyed area or may have flowered in a year when no survey work was done. Three Birds Woodlot is approximately eight hectares (COSEWIC 2010).

It is impossible to determine trends for either population from abundance data due to inherent year to year fluctuations in numbers and due to inconsistent survey coverage. The Natural Heritage Information Centre (NHIC) assigns quality ranks to occurrences of natural features based on their predicted viability. Occurrences may be ranked as follows: A – Excellent, B – Good, C – Fair, D – Probably not viable; E – Verified extant, F – Failed to find, H – Historical, X – Extirpated. NHIC has ranked the Rondeau occurrence of Nodding Pogonia as C, while the Three Birds Woodlot occurrence is ranked H (NHIC 2012).

According to NatureServe (2012), a ranking of H is used to indicate that an occurrence has not been confirmed for 20 or more years although there may still be extant suitable habitat. It is also used for plant species with long-lived seed banks that may remain viable in the soil but absent for long periods of time. In such cases, an occurrence can be ranked H for up to 40 years without being considered extirpated. Often the H rank

may indicate a lack of field work (M.J. Oldham pers. comm. 2012). COSEWIC guidelines state that a population may be considered extirpated when (1) there is no remaining habitat for the species and the species has not been found in recent surveys; (2) 50 years have passed since the last credible record of the species despite surveys; or (3) there is information demonstrating that no individuals of the species remain alive (COSEWIC 2012). Therefore, the Three Birds Woodlot population is considered extant.

Nodding Pogonia was reported in 1960 from John Pearce Provincial Park as an introduced species (introduction date unknown), but a 1982 park inventory did not list the species as present (Woodliffe 1988). Morris and Eames (1929) mention Nodding Pogonia as formerly occurring at Komoka (Middlesex County), Ontario, but long extirpated. However, the location may have been reported incorrectly, and it is believed that the collection the report is based on probably came from somewhere in the Niagara region (Woodliffe 1988).

1.4 Habitat Needs

Nodding Pogonia grows in rich, moist deciduous beech-maple woodlands where there is deep leaf litter, an abundance of humus, and a well developed tree canopy. It is also sometimes found on rotten logs. Literature consulted from different time periods and from many different American states (c.f. Lownes 1920, Porcher 1977, Brackley 1985, Case 1987, Maine Dept. of Conservation 1998, Zika 2001) reported the species as growing in stands of pure American Beech (*Fagus grandifolia*) or where the canopy is predominantly beech with a component of Eastern Hemlock (*Tsuga canadensis*). In the United States, the species is known from rich woods along streams and on the edge of swamps and floodplain forests (Correll 1950), as well as on old beach ridges and in *Sphagnum* communities at the edges of bogs (Case 1987). In its broader North American range, Nodding Pogonia may occur in other habitats as well, such as sandy oak-mixed hardwood forests, seasonally wet, sandy flatwoods, Great Lakes dune forests, coniferous forests, tamarack swamps, rhododendron thickets, floodplain forests, wet muck in glacial lake bed forest, and in seasonally flooded sinkhole swamps (Romero-González et al. 2002).

According to P.A. Woodliffe (pers. comm. 2012), at Rondeau Provincial Park Nodding Pogonia is found in rich beech-maple forest with a few White Pine (*Pinus strobus*) in the canopy, along sandy ridges with acidic soil. The vegetation type has been classified as Fresh-Moist Sugar Maple-Hardwood Deciduous Forest (M. Cairns pers. comm. 2012) based on Lee et al. 1998. In drier years, the plants appear near the bottom of the low ridges (presumably the moist spots during dry years), but in wetter years, the plants appear a little higher up the side of the ridges, or even atop the ridges. At some Nodding Pogonia sites at Rondeau, the humus layer above the underlying sand is 10 to 15 cm deep, with leaf litter on top of that. In northern Michigan, it is reported that the tuberoid roots grow in contact with sand below a 7.5 to 10 cm layer of leaf mould (Van Arsdale 1982). However, many authors (see above) also reported the species growing in leaf-lined depressions and in leaf-mould without soil or sand.

Some typical associated species present in the habitat of Nodding Pogonia may include: Red Maple (*Acer rubrum*), Sugar Maple (*Acer saccharum*), Ironwood (*Ostrya virginiana*), Mayflower (*Maianthemum canadense*), Sarsaparilla (*Aralia nudicaulis*), among others, as well as other heterotrophic species such as Beechdrops (*Epifagus virginiana*), Indian Pipe (*Monotropa uniflora*) and Spotted Coral Root (*Corallorhiza maculata*) (Brackley 1985, Swink and Wilhelm 1997, Zika 2001).

1.5 Limiting Factors

Nodding Pogonia only grows above ground when conditions are favourable for the production of flowers and seeds. The species' reproductive biology is highly specialized and requires coinciding factors for successful reproduction. If one factor is lacking, successful reproduction will not occur because any of the links in the chain of events may be limiting. These include: suitable climatic and moisture conditions for the plant to produce flowers; insect pollinators to produce seed set; dispersal of seeds to suitable habitat; and contact of the seeds with a specific fungus species for successful germination and establishment.

A lack of pollinators may or may not be a limitation for Nodding Pogonia. The flowers of Nodding Pogonia bloom synchronously and are only fertile for one day, so if no pollinator is present on that day, reproduction is not possible. In a six-year study of Nodding Pogonia, Williams (1994) observed pollinators on only two occasions and reports that the short flowering period and lack of pollinators cause low capsule production. However, other workers have not had difficulty observing pollination in Nodding Pogonia (Medley 1979, Woodliffe 1988, Catling and Catling 1991). Furthermore, even low capsule production as a result of few pollinators may not be a limitation since each capsule contains thousands of seeds, which is more than in many species.

Because the two extant populations of Nodding Pogonia are isolated and small, loss of genetic diversity may be a concern especially if sexual reproduction is not successful for extremely long periods of times. The loss of genetic diversity could make the species incapable of responding to long-term changes in its habitat such as increased temperature or reduced moisture.

1.6 Threats to Survival and Recovery

Threats and factors that may be potential threats to Nodding Pogonia are presented in Table 2.

Table 2. Current, potential, and historical threats to Nodding Pogonia (Sources: COSEWIC 2010; Woodliffe 2011; H. Bickerton pers. comm. 2012).

Threat	THREE BIRDS WOODLOT	RONDEAU
1. Damage to mycorrhizal fungal association due to:		
Japanese Barberry		Current
Garlic Mustard	Current	
Earthworms	Current?	Current?
Air pollution	Potential	Potential
2. Habitat degradation or loss from:		
Beech bark disease	Current	
Forest clearing or forest management	Potential	
Changes in drainage	Potential	
Livestock grazing	Historical	
3. Herbivory		
White-tailed Deer	Potential	Current
Chipmunks, slugs	Potential	Potential
4. Other threats:		
Catastrophic events (floods, windstorms)	Potential	Potential

Disruption of or Damage to the Mycorrhizal Fungal Association

Anything that disrupts the connection of Nodding Pogonia plants with their fungal associates, or that reduces the presence of these fungi in the soil, could seriously impact the ability of the Nodding Pogonia to survive. Disruption of mycorrhizae is likely the most serious current threat to this species, but direct scientific proof of this still needs to be confirmed through field studies. However, indirect evidence of the seriousness of this threat is shown by studies of the effects of several invasive species on soil fungi and microorganisms.

At Rondeau Provincial Park, Nodding Pogonia is threatened by shrubs of the invasive Japanese Barberry (*Berberis thunbergii*). Japanese Barberry roots secrete the toxin berberidine (Schmeller et al. 1997) which is highly damaging to surrounding plants and soil microorganisms, resulting in changes in the structure and function of the soil (Ehrenfeld et al. 2001). In 2010 a successful effort was made to greatly reduce Japanese Barberry in the vicinity of the main Nodding Pogonia population, resulting in fewer barberry shrubs than have been present for at least two decades (P.A. Woodliffe pers. comm. 2012). The effort is not yet complete, and park staff are continuing to monitor and reduce barberry throughout the eastern half of the park, where it has been most problematic. Still, it remains a current threat to other Rondeau subpopulations and could recur as a threat to the main population if control activities are discontinued (COSEWIC 2010).

Garlic Mustard (*Alliaria petiolata*) is another exotic, invasive species that secretes chemicals into the soil, inhibiting the growth of nearby plants and mycorrhizal fungi. Garlic Mustard seedlings were observed at Three Birds Woodlot in 2008 (COSEWIC

2010). The species is present but not widespread in Rondeau Provincial Park (S. Taylor pers. comm. 2012).

Earthworms may be a current threat to Nodding Pogonia. Historically, earthworms were not naturally present in the forests of eastern North America and may be the cause of serious and widespread impacts to these ecosystems (Hale et al. 2006). It has been demonstrated that earthworms reduce duff and humus layers as well as fungal diversity (Baxter et al. 1999, Muratake 2003, Bohlen et al. 2004, Hale et al. 2006), all of which are necessary for the survival of Nodding Pogonia. Although earthworms have not been surveyed at either population, observations of the habitat at both populations in 2008 show shallow leaf litter and several patches of exposed bare soil at the location where the orchids have been seen in the past (Woodliffe 2011, H. Bickerton pers. comm. 2012). It is possible these changes in duff conditions are due to earthworms (COSEWIC 2010).

Nodding Pogonia occurs in a region with high levels of airborne pollutants. Air- and precipitation-borne nutrient loading (increases in available nitrogen) have been shown to reduce fungal diversity in Europe (Arnolds 1991), and are therefore possibly a threat to the mycorrhizal association required by Nodding Pogonia.

Habitat Loss or Degradation

Beech bark disease, which leads to mortality of American Beech trees, may threaten Nodding Pogonia by causing changes to soil moisture levels and affecting habitat conditions. American Beech is a significant component of the forest canopy in the Ontario habitat of Nodding Pogonia, and the loss of beech trees creates openings in the canopy which allow greater amounts of sunlight to reach the ground. This results in drier soil conditions which may be unsuitable for Nodding Pogonia. In addition, the roots of American Beech and large trees of other species bring moisture into the upper soil strata through hydraulic lift (Light and MacConaill 2006), so the loss of American Beech may affect soil moisture levels through this mechanism as well. It has also been speculated that Nodding Pogonia may receive nutrients from Beech trees via the mycorrhizal fungal association (Williams 1994). Beech bark disease was observed at Three Birds Woodlot in 2008 (COSEWIC 2010) but is not present at Rondeau Provincial Park (S. Taylor pers. comm. 2012).

Historically, clearing of land for agriculture and forest products may have been the primary cause of loss of Nodding Pogonia populations in Ontario, but the absence of historic data makes this purely speculative. Forest management creates gaps in the tree canopy (as discussed above), and the use of skidders and large machinery can damage soils, trample plants, or dislodge the underground corms. Changing drainage through irrigation or channeling of streams may also result in excessive drying of soils. Forest clearing and changing drainage are not current threats but could possibly occur on private land at Three Birds Woodlot although neither landowner has plans for these activities (H. Bickerton pers. comm. 2012).

In the past, portions of the Three Birds Woodlot were grazed by horses, but the population persisted and flowered for many years apparently unaffected by this. A population in Michigan is known to have persisted for more than 30 years despite grazing (Case 1987). Still, in the past grazing may have been involved in a decline in numbers of plants at Three Birds Woodlot. Livestock grazing can cause soil compaction, directly damage plants, and introduce exotic or invasive plant species. Grazing has been absent from Three Birds Woodlot now for more than 10 years and is not a current threat (COSEWIC 2010).

Herbivory

Browsing by White-tailed Deer continues to be a threat to Nodding Pogonia at Rondeau Provincial Park (M. Cairns pers. comm. 2012) and is a potential threat at Three Birds Woodlot. A herd reduction program at Rondeau Provincial Park in the 1990s reduced the severity of the threat for that population, but browsing continues to be observed. Browsing by deer, chipmunks, or slugs could damage plants during the critical, above-ground reproductive period.

In Massachusetts (Williams 1994), slugs are reported to be the most destructive herbivores of Nodding Pogonia, chewing into corms, stem, buds, and flowers. Slugs were also responsible for loss of capsules before ripening. It is not known whether slugs are a problem for Nodding Pogonia in Ontario. Plants of Nodding Pogonia are reportedly also eaten by Eastern Chipmunk (*Tamias striatus*) (Williams 1994).

Other Threats

With only two small, isolated, extant populations of Nodding Pogonia in Ontario, the species is at risk of extirpation due to catastrophic events such as storms or drought (COSEWIC 2010). Flooding could rot underground corms and damage mycorrhizae, and windstorms may cause an opening of the forest canopy and drying of the critical humus layer.

Many orchid species are threatened by trampling from visiting naturalists, and collecting of wild, native orchids by orchid enthusiasts is also a widespread practice that damages and removes plants. However, neither trampling nor collecting are serious threats at Rondeau Provincial Park as the species occurs in quite inaccessible areas away from trails. These problems are also not significant threats at Three Birds Woodlot, as the population is on private property and not accessible to the public (COSEWIC 2010).

1.7 Knowledge Gaps

Knowledge gaps may limit the successful recovery of the Nodding Pogonia. Further studies and a better understanding of the following are required:

- the current distribution and abundance of the Three Birds Woodlot population, and annual changes in trends at the Rondeau Provincial Park populations;

- whether other potential habitat areas support additional populations or are suitable as potential reintroduction sites;
- detailed, standardized Ecological Land Classification (ELC) documentation and mapping of the forest communities of the Three Birds Woodlot population;
- impacts of earthworms, slugs, and invasive plants on the species and its habitat.
- Specific mycorrhizal associations of Nodding Pogonia;
- conditions required for plants to produce above ground stems and other biological requirements for growth;
- impacts of air and water-borne nutrient loading on Nodding Pogonia;
- whether in fact there is an association with American Beech or mature trees of other deciduous species;
- details of species' biological and ecological needs relating to site management, stewardship;
- demographic studies to understand emergence periodicity, age structure of populations, and recruitment rates; and
- methods of propagation to be used in potential reintroduction efforts.

1.8 Recovery Actions Completed or Underway

The following recovery actions have been done and the following protective measures are already in place.

- Annual monitoring of plots at Rondeau Provincial Park tracks numbers and locations of plants as well as good bloom years.
- A significant amount of Japanese Barberry was removed from around the main population of Nodding Pogonia at Rondeau Provincial Park in 2010, and more removal work is planned.
- Deer reduction at Rondeau has had a beneficial effect on many features of the park and has somewhat reduced this potential threat to Nodding Pogonia.
- The privately owned Three Birds Woodlot is designated as an Environmentally Significant Area by the Essex Region Conservation Authority (ERCA 2012). As a result of this designation, an application to change the existing agricultural zoning to another land use or to sever part of the property would require an environmental impact assessment demonstrating no negative impact (D. Lebedyk pers. comm. 2012). As well, after June 30, 2012, the *Provincial Policy Statement* of the *Planning Act* (PPS) will prohibit development and site alteration in the habitat of Nodding Pogonia in applications for a change of land use.
- Nodding Pogonia is listed as endangered on the Species at Risk in Ontario (SARO) List of Ontario's *Endangered Species Act, 2007* (ESA). Under the Act, plants of Nodding Pogonia may not be harmed or killed. The habitat will be legally protected as of June 30, 2013.
- At Rondeau Provincial Park, Nodding Pogonia is protected by the *Provincial Parks and Conservation Reserve Act* (2007) under which it is illegal to disturb, cut, kill, remove or harm any plant in a provincial park without written authorization of the park superintendent. As well, the species occurs within a

nature reserve zone within the park in which some recreational activities are restricted.

- Nodding Pogonia is included in the Carolinian Woodlands Ecosystem Recovery Strategy (Jalava, et al. 2009). Ecosystem-based recovery work is underway, coordinated by Carolinian Canada Coalition, a consortium of more than 40 governmental agencies and non-governmental organizations. Several conservation action plans (CAPs) have been developed, and a pilot project is now underway to implement the Essex Forests and Wetlands Natural Areas CAP (Carolinian Canada 2012) which covers the county where Three Birds Woodlot is located. A CAP will be developed for the Rondeau area in 2012, and Nodding Pogonia will be one of the target species.

2.0 RECOVERY

2.1 Recovery Goal

The recovery goal is to maintain the extant populations of Nodding Pogonia in their current condition or better, to assist these populations over the long-term to become self-sustaining and viable, and to fill knowledge gaps so that recovery activities at other locations may become possible in the future.

Rationale for Recovery Goal

The historical status of Nodding Pogonia in Ontario is unknown, raising questions as to what would constitute “recovery”. It is unclear whether Nodding Pogonia was once more common and widespread in the province or whether it has always been extremely rare, or whether the two current populations were recent establishments in the province at the time they first became known in the 1950s and 1960s. Therefore, it is suggested that restoration of a historic range or a historic population not be included in the recovery goal at this time.

In addition, successful propagation and reintroduction of Nodding Pogonia into the wild, which would allow establishment of new populations to be part of recovery, has not yet been achieved. Furthermore, very little interior, moist forest habitat remains in extreme southwestern Ontario where potential reintroductions could take place. Therefore, the focus of recovery should be on maintaining the existing populations and assisting them to become self-sustaining and viable by reducing threats and ensuring suitable growing conditions are maintained. Due to the lack of information about Nodding Pogonia, knowledge gaps must be filled before any broader goals can be defined.

2.2 Protection and Recovery Objectives

Table 3. Protection and recovery objectives

No.	Protection or Recovery Objective
1	Determine the current distribution and abundance of Nodding Pogonia populations in Ontario by 2022.
2	Assess threats to the species and its habitat by 2017 and address threats by 2019.
3	Fill knowledge gaps relating to the biology, ecology, habitat, and threats of Nodding Pogonia in Ontario by 2017.
4	Develop and implement a monitoring strategy to be used to help fulfill objectives 1 to 3 by 2015.
5	Use a variety of tools to protect and maintain habitat of known populations by 2017.

2.3 Approaches to Recovery

Specific approaches to address threats and accomplish recovery of Nodding Pogonia are presented in Table 4.

Table 4. Approaches to recovery of Nodding Pogonia in Ontario.

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
1. Determine the current distribution and abundance of Nodding Pogonia populations in Ontario by 2022.				
Critical	Short-term	Stewardship	1.1 Begin a respectful discussion with landowners of Three Birds Woodlot to see what recovery work can be planned with their collaboration.	<ul style="list-style-type: none"> Required before addressing threats and knowledge gaps will be possible at this site
Critical	Short-term	Inventory, Monitoring and Assessment	1.2 With permission of landowners, set up annual surveys of Three Birds Woodlot to determine the status of the population.	<ul style="list-style-type: none"> Gaps: distribution and abundance of Three Birds Woodlot population and biological requirements or threats
Critical	Short-term	Inventory, Monitoring and Assessment	1.3 Continue population counts at Rondeau Provincial Park, and expand monitoring area to include more habitat outside plots.	<ul style="list-style-type: none"> Gaps: distribution and abundance of Rondeau population and biological requirements or threats
Necessary	Short-term	Inventory, Monitoring and Assessment	1.4 Document ELC vegetation type for Three Birds Woodlot.	<ul style="list-style-type: none"> Gaps: biological requirements including suitable habitat conditions
2. Assess threats to the species and its habitat by 2017 and address threats by 2019.				
Critical	Short-term	Inventory, Monitoring and Assessment	2.1 Assess and document presence and severity of all threats at both populations	<ul style="list-style-type: none"> All threats
Critical	On-going	Management and Stewardship	2.2 Plan and implement actions to reduce presence of invasive species and address other threats from both populations.	<ul style="list-style-type: none"> All threats

Recovery Strategy for the Nodding Pogonia in Ontario

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Necessary	Short-term	Management	2.3 Working with the landowners, discuss potential for recovery work at Three Birds Woodlot.	<ul style="list-style-type: none"> All threats
Necessary	Long-term	Management	2.4 Continue deer population controls at Rondeau Provincial Park to keep threat from browsing low	<ul style="list-style-type: none"> Threat: herbivory by deer
Beneficial	Long-term	Management	2.5 After 3.5, evaluate the usefulness of augmenting the existing populations or establishing other populations of Nodding Pogonia within Rondeau Provincial Park and Three-Birds Woodlot.	<ul style="list-style-type: none"> Threats: catastrophic events; loss of genetic diversity
Beneficial	Long-term	Management	2.6 After 3.5, evaluate the feasibility of reintroducing the species to other suitable sites. Reintroduce if deemed feasible.	<ul style="list-style-type: none"> Threats: catastrophic events; enables withstanding other threats
3. Fill knowledge gaps relating to the biology, ecology, habitat, and threats of Nodding Pogonia in Ontario by 2017.				
Critical	Short-term	Research	3.1 Engage the academic community to participate in researching knowledge gaps.	<ul style="list-style-type: none"> Any or all threats
Critical	On-going	Research	3.2 Research impacts of earthworms and other invasive species on Nodding Pogonia and its habitat.	<ul style="list-style-type: none"> Threats: disruption of mycorrhizae by invasive species; habitat degradation.
Critical	On-going	Research	3.3 Research mycorrhizal relationships of the species.	<ul style="list-style-type: none"> Threat: disruption of mycorrhizae
Necessary	On-going	Research	3.4 Research the conditions required for producing above ground plants, and for flowering and fruiting.	<ul style="list-style-type: none"> Gaps: growing conditions and biological requirements
Necessary	On-going	Management	3.5 Investigate propagation and reintroduction protocols.	<ul style="list-style-type: none"> Gaps: propagation and biological requirements

Recovery Strategy for the Nodding Pogonia in Ontario

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Beneficial	On-going	Research	3.6 Investigate possible causes of suspected extirpation from sites where plants are presumed absent (e.g., Rondeau subpopulation 2).	<ul style="list-style-type: none"> Gap: biological requirements
Beneficial	On-going	Research	3.7 Discuss Nodding Pogonia with adjacent jurisdictions where the species occurs to share information and coordinate activities if possible.	<ul style="list-style-type: none"> Gaps: biological requirements; Threats: catastrophic events
Beneficial	Long-term	Management; Threats reduction	3.8 Investigate the appropriateness and feasibility of augmenting populations or reintroducing Nodding Pogonia to other suitable habitat.	<ul style="list-style-type: none"> Threats: catastrophic events; enables withstanding other threats
Beneficial	On-going	Inventory, Monitoring and Assessment	3.9 Identify and survey sites with potentially suitable habitat to search for new populations and to determine suitability for potential reintroductions if deemed feasible in 3.8.	<ul style="list-style-type: none"> Threat: loss or degradation of habitat by finding other less-impacted sites
Beneficial	Long-term	Research	3.10 Research the impacts of air pollution (e.g., NO ₂) on the species.	<ul style="list-style-type: none"> Gap: effects of air pollution
4. Develop and implement a monitoring strategy to be used to help fulfill objectives 1 to 3 by 2015.				
Critical	Short-term	Inventory, Monitoring and Assessment	4.1 Develop and apply monitoring protocol for Nodding Pogonia: <ul style="list-style-type: none"> - expand existing monitoring at Rondeau Provincial Park to include habitat outside plots; - apply protocol at Three Birds Woodlot after 1.1 and 2.3). 	<ul style="list-style-type: none"> Gaps: distribution and abundance; impacts of invasive species and other threats.
Necessary	On-going	Inventory, Monitoring, Assessment	4.2 Periodically check suitable habitat at John E. Pearce Provincial Park to see if Nodding Pogonia is still present from 1960s introductions.	<ul style="list-style-type: none"> Gaps: distribution and abundance.
5. Use a variety of tools to protect and maintain habitat of known populations by 2017.				

Recovery Strategy for the Nodding Pogonia in Ontario

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Critical	On-going	Management	5.1 Work with landowners on stewardship measures to ensure growing conditions are maintained.	<ul style="list-style-type: none"> • Threats; forest management, changes in drainage, grazing, and others
Necessary	On-going	Management	5.2 Review existing management plans for Rondeau Provincial Park to see if any changes or additions are needed for the protection and recovery of Nodding Pogonia.	<ul style="list-style-type: none"> • Any or all threats

Narrative to Support Approaches to Recovery

The first steps toward recovery are to ensure the two known populations persist at their current locations. Up-to-date information on population size and demographic structure, descriptions of habitat, and assessments of habitat condition and threats, is required for both populations in order to prioritize recovery activities.

On-going management measures to keep deer populations in check at Rondeau Provincial Park will continue to be needed to reduce or prevent any negative impacts to Nodding Pogonia. Currently, only one population is on private land. However, if additional populations are discovered at other locations, these may be priority sites for securement or conservation easements.

Recovery planning for Nodding Pogonia may be coordinated with implementation of a number of other initiatives: for example, the conservation action plans mentioned in Section 1.8 and the ecosystem approaches in the Recovery Strategy for Carolinian Woodlands and Associated Species at Risk (Jalava et al. 2009). As well, recovery activities may be coordinated with those for other species at risk that share the same habitat, such as American Chestnut (*Castanea dentata*).

This species produces copious, minute, wind-dispersed seeds, so natural colonization of new sites could be possible where suitable habitat conditions, including appropriate fungal species, are present. However, very little interior, moist forest habitat remains in extreme southwestern Ontario, and opportunities for natural establishment of new populations may be extremely limited.

Therefore, this recovery strategy recommends reintroduction be considered as a component of recovery of Nodding Pogonia. However, propagation of Nodding Pogonia has not been successful so far. Furthermore, research on propagation will need to take into consideration the feasibility of removing material from a source population, since Nodding Pogonia is critically imperiled or imperiled in Michigan, New York, and Ohio, the closest sources to Ontario. Periodic checks at John E. Pearce Provincial Park would be worthwhile. Given the extent of land conversion in the region of Ontario in which Nodding Pogonia occurs, opportunities for re-establishment of populations may be extremely limited.

2.4 Area for Consideration in Developing a Habitat Regulation

Under the ESA, a recovery strategy must include a recommendation to the Minister of Natural Resources on the area that should be considered in developing a habitat regulation. A habitat regulation is a legal instrument that prescribes an area that will be protected as the habitat of the species. The recommendation provided below by the authors will be one of many sources considered by the Minister when developing the habitat regulation for this species.

In establishing the area to be considered for regulation, it is recommended that several factors be taken into consideration.

1) Nodding Pogonia requires habitat that includes mesic forest dominated by deciduous trees, especially Sugar Maple and American Beech. A few scattered coniferous trees as well as some medium-sized to mature trees (DBH \geq 20 cm) of any species may also be present. Preferred ground conditions have deep leaf litter and humus layers. Therefore, the size of the protected habitat must be large enough to allow the functioning of ecological processes that produce and maintain required soil moisture, duff, and humus conditions. This means that the size of the area must be large enough to include sufficient trees to keep the ground well-shaded and moist and to provide the quantity of leaves needed to produce suitable leaf litter and humus. There is currently no scientific research on minimum sizes for these ecological functions as required by Nodding Pogonia, so it is recommended that specific sizes and distances to be considered be based on other parameters.

2) As a natural process in this ecosystem, squirrels sometimes move corms of Nodding Pogonia to new locations, and distances squirrels carry propagules may be large. Also, the dust-like seed may disperse a great distance (sometimes hundreds of metres or more) on the wind. Sufficient suitable habitat will be needed to allow space for dispersal of seeds and corms for establishment of new patches of Nodding Pogonia. As well, much of the suitable habitat at Rondeau Provincial Park has not been searched, and it is possible there are unknown colonies at some distance from known subpopulations. Therefore, to allow for dispersal and to protect potentially undetected dormant plants, a radial distance of at least 200 m is suggested around known locations of Nodding Pogonia, provided the area inside the circle is deciduous forest.

3) If the species is situated at a location near the edge of suitable deciduous forest habitat, it is recommended that a certain amount of vegetation outside the forest be included to protect the plants and the overall habitat conditions from negative impacts. For example, Nodding Pogonia requires moist, shaded ground with a rich humus component, so changes to drainage even in non-forested adjacent vegetation could negatively affect soil moisture at the location of Nodding Pogonia. A distance of 30 m was derived in the field as sufficient to protect Hill's Thistle (*Cirsium hillii*) from such impacts (Parks Canada Agency 2010). Therefore, it is recommended that a minimum distance of 30 m of non-forest vegetation, measured from the edge of the forest cover, be considered part of the habitat for regulation where necessary.

4) A maximum dormancy period has not been conclusively proven for this species, but 18 to 20 year periods have been shown to be possible for two other Canadian orchid species although it happens only infrequently. Even if only a few Nodding Pogonia plants actually achieve this length of dormancy, there is no way of knowing which dormant plants may be in the process of achieving it. Therefore, given anecdotal descriptions of long dormancy periods for Nodding Pogonia, it is recommended that the maximum dormancy period proven for other orchids in Canada (18 to 20 years at least) be assumed possible for Nodding Pogonia until further studies are done.

5) In order to adhere to the precautionary principle, habitat may need to be regulated even though occupancy by the species is not yet definitively known, either due to dormancy or because habitat has not been searched (e.g., parts of Rondeau Provincial Park) or not searched on a consistent basis (e.g., Three Birds Woodlot). Due to knowledge gaps with Nodding Pogonia, it may be necessary to prove a lack of occupancy rather than to prove occupancy. Therefore, criteria to define a lack of occupancy are needed. It is recommended that a lack of occupancy may be presumed when:

The entire area in question has been surveyed every year for 20 consecutive years, and in each year, brief surveys to determine presence/absence have been conducted once a week from August 1 to September 30. In none of these surveys has Nodding Pogonia been detected.

Therefore, it is recommended that the area to be considered for habitat regulation include:

- all areas known to be occupied or formerly occupied by the species since 1950 unless they meet the criteria for lack of occupancy (above);
- previously unknown areas where the species is discovered from 2012 onward;
- in suitable deciduous forest habitat as discussed above, a minimum radial distance of 200 m around recorded patches of Nodding Pogonia (even if the plants are not currently above ground). If non-forested vegetation falls within the 200 m radius circle, it is recommended all of the forested area be included plus up to 30 m of the non-forested vegetation (measured from the forest edge) to a maximum distance of 200 m from the Nodding Pogonia plants (Figure 3); and
- it is recommended that pre-existing human infrastructure such as roads, railway tracks, parking lots, buildings, septic beds, and active agricultural areas (e.g. crops) should not be included in regulated habitat.

Based on these criteria, it is expected that at Rondeau Provincial Park several large polygons will be formed of conjoined circles and that these polygons should be the areas to be considered for regulation. At Three Birds Woodlot, it is expected that the 200 m circles formed around the two subpopulation locations will cover most of the woodlot. Should any new populations be discovered, the above criteria may need to be applied to other sites. Figure 3 shows an example of how these criteria might be applied.

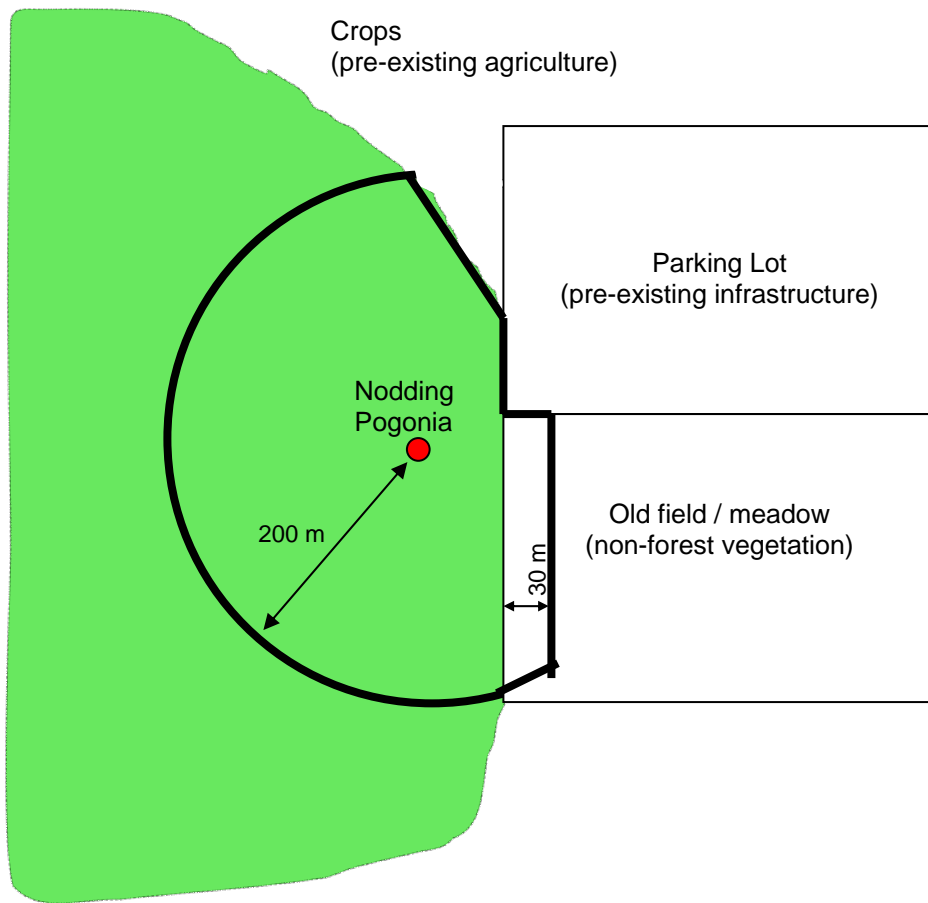


Figure 3. An example of an area to be considered for a habitat regulation for Nodding Pogonia using the parameters outlined above. Red dot is a patch of Nodding Pogonia. Left side of diagram shows 200 m radius circle in deciduous forest habitat. Right side shows up to 30 m of non-forested vegetation to be included (measured from the edge of the forest) and no area considered for regulation in the pre-existing parking lot or cropland.

GLOSSARY

Bract: A modified leaf that performs a function other than that of a typical leaf. For example, a small modified leaf is found below the flowers of Nodding Pogonia.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): The committee responsible for assessing and classifying species at risk in Canada.

Committee on the Status of Species at Risk in Ontario (COSSARO): The committee established under section 3 of the *Endangered Species Act, 2007* that is responsible for assessing and classifying species at risk in Ontario.

Conservation status rank: A rank assigned to a species or ecological community that primarily conveys the degree of rarity of the species or community at the global (G), national (N) or subnational (S) level. These ranks, termed G-rank, N-rank and S-rank, are not legal designations. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by the letter G, N or S reflecting the appropriate geographic scale of the assessment. The numbers mean the following:

- 1 = critically imperiled
- 2 = imperiled
- 3 = vulnerable
- 4 = apparently secure
- 5 = secure

Corm: A short, vertical, underground stem that is thickened as a food storage organ.

Cortex: The outer layer of tissue just inside the outer skin of a root or stem.

Duff: The top layers of material on the ground. It is mostly made up of un-decomposed leaves, needles, twigs, and woody material.

***Endangered Species Act, 2007* (ESA):** The provincial legislation that provides protection to species at risk in Ontario.

Heterotrophic: Gaining nutrition from alternate sources such as from parasitism or decomposition. Many orchids receive nutrition through a relationship with fungi in their roots and in the soil rather than from photosynthesis.

Humus: The organic layer above the mineral soil that results from decomposition of duff and other organic material.

Mesic: Moist; neither very wet nor very dry.

Mycorrhiza: a mutually beneficial relationship between a fungus and the roots of a plant.

Perianth: The structures that are found around the outside of the reproductive organs in a flower. Petals and sepals usually form the perianth.

Species at Risk Act (SARA): The federal legislation that provides protection to species at risk in Canada. This act establishes Schedule 1 as the legal list of wildlife species at risk to which the SARA provisions apply. Schedules 2 and 3 contain lists of species that at the time the Act came into force needed to be reassessed. After species on Schedule 2 and 3 are reassessed and found to be at risk, they undergo the SARA listing process to be included in Schedule 1.

Species at Risk in Ontario (SARO) List: The regulation made under section 7 of the *Endangered Species Act, 2007* that provides the official status classification of species at risk in Ontario. This list was first published in 2004 as a policy and became a regulation in 2008.

REFERENCES

- Anderson, A. B. 1990. Improved germination and growth of rare native Ontario orchid species, p. 65-73., *in*: G.M. Allen, P.F.J. Eagles & S.D. Price, *Conserving Carolinian Canada*. University of Waterloo Press, Waterloo.
- Arditti, J. and Ghani, A.K.A. 2000. Numerical and physical properties of orchid seeds and their biological implications. *Tansley Review No. 110, New Phytologist* 145: 367-421.
- Arnolds, E. 1991. Decline of ectomycorrhizal fungi in Europe. *Agriculture, ecosystems and environment*, 35: 209–244.
- Baxter, J.W., S.T.A. Pickett, M. M. Carreiro and J. Dighton. 1999. Ectomycorrhizal diversity and community structure in oak forest stands exposed to contrasting anthropogenic impacts. *Can. J. Bot.* 77: 771–782.
- Bickerton, H. 2012. Personal communication by telephone to J. Jones. Consultant and author of update COSEWIC status report on Nodding Pogonia.
- Bohlen, P.J., S. Scheu, C.M. Hale, M.A. McLean, S. Migge, P.M. Groffman and D. Parkinson. 2004. *Non-native invasive earthworms as agents of change in northern temperate forests*. *Frontiers in Ecology and the Environment* 2(8): 427-435.
- Brackley, F.E. 1985. The Orchids of New Hampshire. *Rhodora* 87(849): 51-52.
- Cairns, M. 2012. Personal communication by telephone and email to J. Jones. Zone ecologist, Ontario Parks, Southwest Zone, London, Ontario.
- Carlswald, B.S. and W.L. Stern 2009. Vegetative anatomy and systematics of Triphorinae (Orchidaceae). *Botanical Journal of the Linnean Society* 159: 203–210.
- Carolinian Canada, 2012. Essex Forests and Wetlands Conservation Action Plan. 64 pp. http://carolinian.org/Ecosystem_Recovery_EssexCAP_Pilot2009.htm
Accessed March 1, 2012.
- Case, F.W. 1987. *Orchids of the Western Great Lakes Region*, revised edition. Cranbrook Institute of Science, Bulletin 48, Bloomfield Hills, Michigan, USA.
- Catling, P.M. and V.R. Catling. 1991. A synopsis of breeding systems and pollination in North American orchids. *Lindleyana* 6:187-210.
- Correll, D.S., 1950. *Native Orchids of North American north of Mexico*. Chronica Botanica Co., Waltham, MA. 399 pp.

- COSEWIC. 2010. COSEWIC assessment and status report on the Nodding Pogonia *Triphora trianthophoros* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 22 pp. www.sararegistry.gc.ca/status/status_e.cfm
- COSEWIC. 2011. COSEWIC status appraisal summary on the Small Whorled Pogonia *Isotria medeoloides* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi pp. www.sararegistry.gc.ca/status/status_e.cfm.
- COSEWIC 2012. Species assessment criteria, Table 5. Committee on the Status of Endangered Wildlife in Canada, accessed February 22, 2012. http://www.cosewic.gc.ca/eng/sct0/assessment_process_e.cfm#tbl5
- Cronquist, A. 1991. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*, 2nd ed. New York Botanical Garden, 910 pp.
- Dister, D.C. 2006. Characterization of a new population maximum for *Triphora trianthophora* (Swartz) Rydberg in Ohio. *Castanea* 71(4): 321-324
- Dow, B.D. and M.V. Ashley, 1996. Microsatellite analysis of seed dispersal and parentage of saplings in bur oak, *Quercus macrocarpa*. *Molecular Ecology* 5: 615-627.
- Ehrenfeld, J.G., P. Kourtev, and W. Huang. 2001. Changes in soil functions following invasions of exotic understory plants in deciduous forests. *Ecological Applications* 11:1287–1300.
- ERCA 2012 Natural Areas Map of the Essex Region; http://www.erca.org/downloads/natural_areas_map.pdf accessed February 21, 2012.
- Flora North America. 2005. Distribution of *Triphora trianthophora* in North America. http://efloras.org/object_page.aspx?object_id=8981&flora_id=1, accessed March 1, 2012.
- Gremer, J.G., E.E. Crone, and P. Lesica 2012. Are dormant plants hedging their bets? Consequences of Prolonged Dormancy in Variable Environments. *The American Naturalist* 179(3): 315-327.
- Hale, C. M., L. E. Frelich, P. B. Reich. 2006. Changes in cold-temperate hardwood forest understory plant communities in response to invasion by European earthworms. *Ecology* 87(7): 1637-1649.
- Holsinger, K.E., P. Vitt, S.C. Gawler, A. Dibble, T. Vining, W.A. Wright, and C.S. Campbell 1996. "Reproductive patterns and the cost of reproduction in an endangered orchid *Isotria medeoloides*: A ten year retrospective," *Ecological Society of America*, Providence, Rhode Island, 8-11-96 to 8-14-96 (presented by

- P. Vitt). Cited in W. Brumback, C. Fyler, and J. Korecki. 2008. Monitoring and Habitat Management of *Isotria medeoloides* at E. Alton, New Hampshire.
- Jalava, J.V., J.D. Ambrose and N. S. May. 2009 (In Prep.). National Recovery Strategy for Carolinian Woodlands and Associated Species at Risk, Phase I. Draft 10 – March 31, 2009. Carolinian Canada Coalition and Ontario Ministry of Natural Resources, London. Viii + 75 pp.
- Kery, M. and K.B. Gregg 2004. Dormancy and survival in the terrestrial orchid *Cypripedium reginae*. *J. of Ecology* 92: 686-695.
- Lebedyk, D. 2012. Personal communication by email. Conservation Biologist, Essex Region Conservation Authority, Essex, Ontario.
- Lee, H.T., W.D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig, and S. McMurray. 1998. Ecological Land Classification for Southern Ontario: First Approximation and Its Application. Ontario Ministry of Natural Resources, Southcentral Sciences Section, Science Development and Transfer Branch. SCSS Field Guide FG-02.
- Light, M. H. S. and M. MacConaill. 2006. Appearance and disappearance of a weedy orchid, *Epipactis helleborine*. *Folia Geobotanica* 41: 77-93.
- Lownes, A.E. 1920. Notes on *Pogonia trianthophora*. *Rhodora* 22: 53-55.
- Lownes, A.E. 1926. *Triphora trianthophora* native of Eastern North America. *Addisonia* 11: 61-62.
- Maine Department of Conservation, 1998. *Triphora trianthophora* (Nodding Pogonia) rare plant fact sheet. <http://www.maine.gov/doc/nrimc/mnap/features/tritri.htm> Accessed February 20, 2012.
- Medley, M. E. 1979. Some Aspects of the Life History of *Triphora trianthophora* (Sw.) Rydb. (Three Birds Orchid) with Special Reference to Its Pollination. M.A. thesis. Andrews University.
- Morris, F. and E.A. Eames. 1929. Our Wild Orchids. Charles Scribner's Sons, New York. 464 pp.
- Muratake, S. 2003. Effects of Exotic Earthworms on Northern Hardwood Forests in North America. *Restoration and Reclamation Review*. 8 (8.1): 1-11.
- Murren, C.J. and A.M. Ellison 1998. Seed dispersal characteristics of *Brassavola nodosa* (Orchidaceae). *Am. J. Bot.* 85 (5): 675-680.

- NHIC (Natural Heritage Information Centre) 2012. On-line databases. Ontario Ministry of Natural Resources, Peterborough, Ontario. http://nhic.mnr.gov.on.ca/nhic_.cfm accessed February 22, 2012.
- NatureServe 2012. Explorer: online encyclopedia of plants, animals, and ecosystems of the U.S. and Canada. <http://www.natureserve.org/> accessed March 2, 2012.
- Oldham, M.J. 2012. Personal communications to J. Jones by email. Botanist and herpetologist, Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough.
- Porcher, R.D. 1977. The rediscovery of *Triphora trianthophora*, Three Birds Orchid, in the coastal plain of South Carolina. *Castanea* 42:108-111.
- Schmeller, T., B. Latz-Bruning, and M. Wink 1997. Biochemical activities of berberine, palmatine and sanguinarine mediating chemical defence against microorganisms and herbivores. *Phytochemistry* 44(2): 257-266.
- Shefferson, R.P., B.K. Sandercock, J. Proper, and S. Beissinger, 2001. Estimating dormancy and survival of a rare herbaceous perennial using mark–recapture models. *Ecology* 82(1):145–156.
- Stapanian, M. and C.C. Smith 1978. A model of seed scatterhoarding: coevolution of Fox Squirrels and Black Walnuts. *Ecology* 59 (5): 884-896.
- Swink, F. and G. Wilhelm, 1994. *Plants of the Chicago Region*, 4th ed. Indiana Academy of Science, Indianapolis. 391 pp.
- Taylor, S. 2012. Personal communication to J. Jones by telephone and email. Acting ecologist, Rondeau Provincial Park.
- Van Arsdale, J.M. 1982. A new northern station for *Triphora trianthophora*. *Michigan Botanist* 21: 93-94.
- White, D. J. 1999. Updated COSEWIC Status Report on the Nodding Pogonia, *Triphora trianthophora*. Committee on the Status of Endangered Wildlife in Canada. 5 pp.
- Williams, S. 1994. Observations on reproduction in *Triphora trianthophora* (Orchidaceae). *Rhodora* 96(885): 30-43.
- Woodliffe, P. A. 1988. Status Report on the Nodding Pogonia, *Triphora trianthophora*, in Canada. Committee on the Status of Endangered Wildlife in Canada. 42 pp.
- Woodliffe, P. A. 1997. Summary of Nodding Pogonia (*Triphora trianthophora*) data from 50m sq. plots at Site 1, Rondeau Provincial Park, 1986-1996 (annotated with 1997 data). Unpublished report, 1p.

- Woodliffe, P.A., 2011. Facts, figures and the unfolding status of Nodding Pogonia (*Triphora trianthophora*), unpublished report to Rondeau Provincial Park, Ontario. 6pp.
- Woodliffe, P.A., 2012. Results of Nodding Pogonia (*Triphora trianthophora*) monitoring, unpublished report to Rondeau Provincial Park, Ontario. 6pp.
- Woodliffe, P.A. 2009-2012, personal communication. Ontario Ministry of Natural Resources, District Ecologist, Aylmer, Ontario (retired January, 2012).
- Zavitz, C.H. 1956. Notes on *Triphora trianthophora* in Ontario. *Rhodora* 58(686): 31-35.
- Zika, P.F. 2001. New England Note: *Triphora trianthophora* in Massachusetts and Vermont. *Rhodora* 85: 123-124.