Species at Risk Act
Management Plan Series

Management Plan for the Crooked-stem Aster (*Symphyotrichum prenanthoides*) in Canada

Crooked-stem Aster

2020

Government of Canada
Gouvernement du Canada
Canada

Recommended citation:

Environment and Climate Change Canada. 2020. Management Plan for the Crooked-stem Aster (*Symphyotrichum prenanthoides*) in Canada. *Species at Risk Act* Management Plan Series. Environment and Climate Change Canada, Ottawa. iv + 31 pp.

For copies of the management plan, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry[1].

Cover illustration: Allan Harris, Northern Bioscience. *This photo may not be reproduced separately from this document without permission of the photographer.*

Également disponible en français sous le titre
« Plan de gestion de l'aster fausse-prenanthe (*Symphyotrichum prenanthoides*) au Canada »

ISBN 978-0-660-32376-3
Catalogue no. En3-5/104-2019E-PDF

[1] https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed species of special concern and are required to report on progress within five years after the publication of the final document on the SAR Public Registry.

The Minister of Environment and Climate Change is the competent minister under SARA for the Crooked-stem Aster and has prepared this management plan, as per section 65 of SARA. To the extent possible, it has been prepared in cooperation with the Province of Ontario (Ontario Ministry of Natural Resources and Forestry), as per section 66(1) of SARA.

Success in the conservation 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 plan and will not be achieved by Environment and Climate Change Canada and Climate Change or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this plan for the benefit of the Crooked-stem Aster and Canadian society as a whole.

Implementation of this management plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

[2] www.canada.ca/en/environment-climate-change/services/species-risk-act-accord-funding.html#2

Acknowledgments

The initial draft of this management plan was completed by Judith Jones (Winter Spider Eco-Consulting). Subsequent drafts were developed by Elisabeth Shapiro (Environment and Climate Change Canada, Canadian Wildlife Service - Ontario (ECCC)) and Lauren Strybos (Formerly ECCC, Canadian Wildlife Service - Ontario). An earlier recovery strategy for this species was prepared by Jarmo Jalava in consultation with the Carolinian Woodlands Technical Committee. The following people are gratefully acknowledged for sharing information on this species: David J. Bradley and Eric Snyder (Ontario Ministry of Natural Resources and Forestry (OMNRF), Ron Gould (Ontario Parks), Allan Harris (Northern Bioscience), David Holmes (Long Point Region Conservation Authority), Daria Koscinski (Thames Talbot Land Trust), Will Van Hemessen (Private Consultant) and Mary Gartshore (Consulting Ecologist). This federal management plan benefited from input, review and suggestions from the following individuals and organizations: Burke Korol, Christina Rohe, Judith Girard, Ken Corcoran, Krista Holmes and Elizabeth Rezek (ECCC - Canadian Wildlife Service - Ontario) and Justine Mannion, Marie-Claude Archambault and Smeet Panchal (formerly ECCC - Canadian Wildlife Service - Ontario)

Acknowledgement and thanks are given to all other parties that provided advice and input used to help inform the development of this management plan. Those parties include various Indigenous organizations and individuals, landowners, citizens, and stakeholders who provided input and/or participated in consultation meetings.

Executive Summary

Crooked-stem Aster (*Symphyotrichum prenanthoides*) is listed as a species of Special Concern under Schedule 1 of the *Species at Risk Act* (SARA) and under the Ontario *Endangered Species Act 2007*. Crooked-stem Aster is a long-lived perennial herb with flexuous (zig-zagging) stems and pale blue ray florets. The species grows in colonies of upright stems arising from creeping rhizomes[3]. It has toothed leaves that vary from oval to lance-shaped and the bases of the upper leaves clasp the stem. In Canada, the species occurs in a wide range of habitats, including floodplains of creeks, at woodland edges, along the banks of rivers and streams, and along some roadsides. Flowering occurs from late August through to early October.

The range of Crooked-stem Aster includes the eastern and midwest United States. In Canada, the species is restricted to southwestern Ontario in a small area of Carolinian forest near the shore of Lake Erie. About 22 populations are known to occur in Elgin County (18 populations), Norfolk County (two populations) and Middlesex County (two populations). Another nine populations are considered historical in occurrence with their current status unknown, and three are considered extirpated. It is possible that the species may still be present at some historical sites.

The major threat to Crooked-stem Aster is habitat loss from invasive/non-native alien species, which occur at most of its sites. Additional threats include indirect impacts of Emerald Ash Borer road maintenance that uses herbicide or involves large machinery for major reconstruction, and trampling from inappropriate ATV use and off-trail hiking. Residential development, livestock grazing, and logging are occasional or localized threats. Browsing by White-tailed Deer and a lack of pollinators may also be potential threats.

The management objective is to maintain or increase the distribution and abundance of all populations in Canada, including any newly discovered populations, if biologically and technically feasible.

Broad strategies and conservation measures to meet this objective are presented in this management plan. Determining the status of historic populations, reducing indiscriminate ATV use, partnering with organizations to control invasive species and working with municipal and county agencies on other threats, are all high priority conservation measures.

[3] An underground stem that often sends out roots and shoots from its nodes.

Table of Contents

1. COSEWIC* Species Assessment Information

Date of Assessment: November 2012

Common Name (population): Crooked-stem Aster

Scientific Name: *Symphyotrichum prenanthoides*

COSEWIC Status: Special Concern

Reason for Designation: This perennial aster is restricted in Canada to a small area of the Carolinian forest near the shore of Lake Erie in Ontario. The species has experienced historic declines, but no recent losses have been documented and overall numbers appear to be stable. Invasive plants occur at a number of sites and have the potential to negatively impact the species in the future. Additional threats include indirect impacts of Emerald Ash Borer, and roadside maintenance. The species has a restricted distribution in Canada, and its persistence will likely require ongoing monitoring and management of invasive species.

Canadian Occurrence: Ontario

COSEWIC Status History: Designated Special Concern in April 1999. Status re-examined and designated Threatened in May 2002. Status re-examined and designated Special Concern in November 2012.

* COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

2. Species Status Information

In Canada, Crooked-stem Aster is listed as Special Concern[4] on Schedule 1 of the federal *Species at Risk Act* (SARA). In Ontario, Crooked-stem Aster is listed as Special Concern[5] under Ontario's *Endangered Species Act, 2007* (ESA).

In 1999, when Crooked-stem Aster (*Symphyotrichum prenanthoides*) was first designated Special Concern by COSEWIC, the quantitative criteria to define each risk category (endangered, threatened, etc.) had not yet been developed (Bennett pers. comm. 2015). When the first set of quantitative criteria were applied in 2002, Crooked-stem Aster was uplisted to Threatened (COSEWIC 2002). However, the discovery of 10 new sites between 2007 and 2017 (COSEWIC 2012; Gould pers. comm. 2016; Gartshore pers. comm. 2017; Koscinski pers. comm. 2017 and Van Hemessen pers. comm. 2017), means that it no longer meets COSEWIC's criteria for a Threatened species and has been re-designated to Special Concern (COSEWIC 2015).

The global conservation rank for Crooked-stem Aster is currently Secure to Apparently Secure[6] (G4G5) (NatureServe 2017). It is nationally ranked as Imperiled[7] in Canada (N2), and sub-nationally ranked as Imperiled in Ontario (S2) (NHIC 2015a). According to NatureServe (2017), the species occurs in 21 states, and is ranked S1 to S3 in six states, possibly extirpated (SH) in one, and not ranked (SNR) or status unknown (SU) in nine others (COSEWIC 2012; Appendix A).

3. Species Information

3.1. Species Description

Crooked-stem Aster is a perennial herb that forms colonies from rhizomes. The upright stems (20-90 cm tall) are usually bent at the nodes[8], especially in the upper part of the stem, hence the common name for this species. The upper stem leaves are lance-shaped with sharply toothed edges and clasping leaf bases, which lack petioles (a stalk that joins leaf to stem) (Figure 1). The lower stem leaves usually fall off before flowering time (Semple et al. 2002; Brouillet et al. 2006).

Crooked-stem Aster blooms between late August and early October (COSEWIC 2012). As with all species in the aster family, what appears to be a flower is actually a head of many tiny flowers of two types: ray florets that appear as flat petals around the

[4] A wildlife species that may become a threatened or an endangered species, because of a combination of biological characteristics and identified threats.

[5] A species living in the wild in Ontario, which is not endangered or threatened, but may become threatened or endangered due to a combination of biological characteristics and identified threats.

[6] Common, widespread and abundant.

[7] At high risk of extinction or elimination due to very restricted range, very few populations, steep declines, or other factors.

[8] The stem of a vascular plant has nodes and internodes; nodes are attachment points of leaves or branches.

outside of the head, and tubular disc florets that make up the centre of the head. In Crooked-stem Aster each head may have 17-30 pale blue ray florets and 40-65 disc florets which are yellow initially and become purple or brown with age. The few to many flowering heads are in a panicle (a branched arrangement). The peduncles (stalks of the heads) are sparsely to densely covered with long, thin hairs. The single-seeded fruit has one rib on each side (Semple et al. 2002; Brouillet et al. 2006).

Crooked-stem Aster may be confused with other asters, as its heads may appear similar to those of other asters. However, the clasping leaf-bases attached to a flexuous (bent at the nodes) stem distinguish it from other asters.

Figure 1. The flexuous stem and clasping leaf-bases of Crooked-stem Aster[9].

3.2. Species Population and Distribution

In Canada, Crooked-stem Aster is known from Elgin, Norfolk and Middlesex counties in southwestern Ontario. It is considered historic in Oxford County. There are a total of 22 populations that are extant, four of these populations have not been reconfirmed within the last 20 years, but are currently presumed to be extant. An additional nine populations are historic with their status unknown and three are known to be extirpated. The majority of these populations occur on the floodplains of several creeks

[9] Photo by Allan Harris, used with permission. This photo may not be reproduced separately from this document without permission of the photographer.

which drain into the north shore of Lake Erie including: Kettle, Big Otter, Catfish, South Otter, Talbot, Silver and Dodd. Table 1 shows populations of Crooked-stem Aster and their status. The Canadian range of Crooked-stem Aster is shown in Figure 2.

Table 1. Populations of Crooked-stem Aster with last observation and status data. Lines separated by a dashed line are within 1 km of each other and may be considered parts of a single population. Site numbers correspond to numbering in Zhang et al. (1999) and COSEWIC (2012), population numbers 31-36 were found after 2012.

Population #	Population Name	# of stems (year last observed)	Last Obs.	Status	Land Tenure and Notes
Elgin County					
1	Taylor Pond, Aldborough Twp.		1980	Extirpated	Private land.
2	Big Otter Creek		1985	Historic--unknown	Unknown.
3	Little Otter Creek Valley		1986	Historic--unknown	Unknown. Not found 1997.
4	Vienna Pawpaw Woods	50 (1997)	1997	Extant	Suitable habitat observed in 2010. Probably private land.
5	Bayham Townline Woods		1986	Historic--unknown	Not reported in a 1993 site survey. Probably private land.
6	Little Jerry Creek	132 (1997)	1997	Extant	While not confirmed, this population is presumed extant. Private land.
7	Big Otter Creek, 2.7 km N of Calton	157 (2010)	2010	Extant	Private land.
8	Lake Erie shoreline near Wallacetown		1993	Historic--unknown	Not found in 2010 but suitable habitat observed in the area. Private land.
9	Springwater Dingman's Ponds		1941	Extirpated	Catfish Creek Conservation Authority.
10, 11, 14	Springwater Conservation Area; Malahide Township	229 (2010)	2010	Extant	Appear to be a single site. Catfish Creek Conservation Authority and municipal roadside.
12	4.8 km NE of St. Thomas		1952	Extirpated	Unknown.
13	Lower Silver Creek Valley	56 (1997)	1997	Extant	Suitable habitat observed in 2010. Private land.
15	Tyrconnell	420 (1997)	1997	Extant	Suitable habitat observed in 2010. Private land.
16	Kettle Creek, N of St. Thomas	34 (2010)	2010	Extant	Private land.
17	SW of Straffordville		1986	Historic--unknown	Insufficient location information for 2010 survey.
18	Yarmouth Natural Heritage Area includes NW of Port Bruce	180 (2010)	2010	Extant	Catfish Creek Conservation Authority (called Springwater Conservation Area south part in COSEWIC (2012)).
19	1.8 km NW of Straffordville	100 (2007)	2007	Extant	Private land.

Population #	Population Name	# of stems (year last observed)	Last Obs.	Status	Land Tenure and Notes
20	Catfish Creek Slope and Floodplain Forest ANSI		1986	Historic--unknown	Not reported in a 1988 site survey. Private land.
24	Talbot Creek		1986	Historic--unknown	Suitable habitat observed in the area in 2010. Private land.
25	Dan E. Patterson and Dalewood Conservation Areas	653 (2010)	2010	Extant	Kettle Creek Conservation Authority.
26	3.7 km NE of Richmond on Big Otter Creek	644 (2010)	2010	Extant	Private land.
27	East of Eden	12 (2007)	2007	Extant	Private and municipal road allowance.
28	Duttona Beach	200 (2007)	2007	Extant	Private land.
29	Dodd Creek		2011	Extant	Private land.
30	St. Thomas Waterworks Park		2012	Extant	City park. Listed as extirpated in 2002; observed in 2012.
32	Hawk Cliff Woods	15 (2016)	2016	Extant	Thames Talbot Land Trust.
35	Sparta Line	16 (2016)	2016	Extant	Private land.
36	Elgin Trail - Dodd Creek	~500 (2017)	2017	Extant	Private land.
Norfolk County					
21	Deer Creek	378 (2010)	2015	Extant	Long Point Region Conservation Authority.
31	Venison Creek		2017	Extant	Private land.
Middlesex County					
22	Mount Brydges, SW of Komoka		1992	Historic-unknown	Not found in 1997; not surveyed in 2010. Private and municipal road allowance.
33	Sharon Creek	~750-1000 (2017)	2017	Extant	Lower Thames Conservation Authority.
34	2 km north of Sharon Creek	36 (2017)	2017	Extant	Lower Thames Conservation Authority.
Oxford County					
23	Otterville Wetland		1992	Historic--unknown	Reported in a wetland evaluation, not surveyed in 2010. Land tenure unknown.

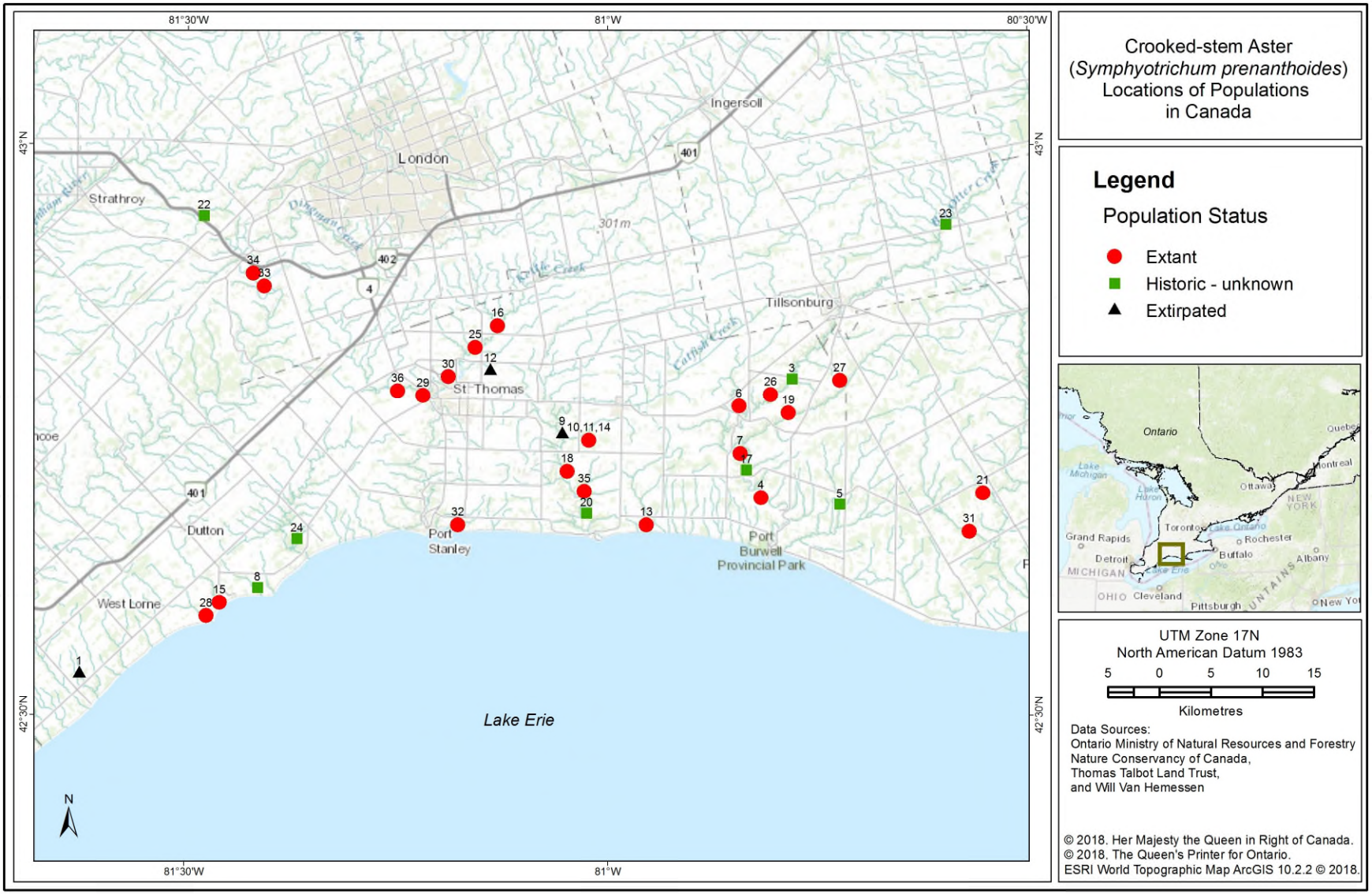

Figure 2. Canadian range of Crooked-stem Aster modified from COSEWIC (2012). This map displays the location of 22 extant, 8 historical and three extirpated populations. Population # 2 (status historic-unknown) not shown due to uncertainty in location information.

For the purpose of this management plan, the status of some populations in Table 1 and Figure 2 may differ from what is shown in the COSEWIC report (2012), and are based on the most recent information. COSEWIC (2012) lists site 22 as extirpated; however, the NHIC provides a ranking of historical for the same site. This population has not been surveyed since 1997, but given this discrepancy in rank this population will be considered historic with status unknown until its status is confirmed

In addition, COSEWIC (2012) lists population numbers 4, 6, 13 and 15, last confirmed in 1997, as unknown. However, populations that have been confirmed within the last 20 years are generally considered extant unless there is evidence to the contrary (NatureServe 2015). Therefore, for the purpose of this management plan, these four populations are considered extant.

Since the publication of the COSEWIC report in 2012, six new populations of Crooked-stem Aster have been confirmed; three in Elgin County, two in Middlesex County and one in Norfolk County. These populations were found in 2016 and 2017 and based on available stem counts for five of the six populations represent an estimated 1317-1567 stems. A survey conducted in September 2010 found approximately 2575 stems of Crooked-stem Aster among seven sites. These surveys along with ones completed in 1994, 1997 and 2007 provide a total estimated stem count of 4562-4812 stems for 19 of the 22 extant populations in Ontario. Numbers of flowering stems at sites visited varied from fewer than 20 to several hundred; however, due to the species' clonal nature the number of genetically distinct individuals is likely much lower (COSEWIC 2012).

In addition to the known locations listed above, it is possible that Crooked-stem Aster may be present in other areas. Aster species can be difficult to identify, and may have been overlooked or gone undetected during field surveys. This species is easiest to identify while flowering from late August through October, but most biological field work is completed earlier in the season, and therefore incidental sightings may not be as frequent.

In the eastern United States, Crooked-stem Aster is present from New Hampshire south to North Carolina and west to eastern Kentucky and Tennessee, with a second centre of distribution in Wisconsin, Minnesota, and Iowa (Kartesz 2015). It has been reported that Crooked-stem Aster is at the northern limits of its range in southwestern Ontario (COSEWIC 2012). However, the species occurs at higher latitudes in New York and Wisconsin (approximately 2-4^{o} further north) (Kartesz 2015). The North American Plant Atlas (Kartesz 2015) shows Crooked-stem Aster as being present in Alabama and Georgia while COSEWIC (2012) and NatureServe (2015) do not.

3.3. Needs of the Crooked-stem Aster

Biological Needs

A number of biological traits affect the needs of Crooked-stem Aster. Most asters cannot self-pollinate and must be pollinated by a genetically different individual (Jones 1978). This species grows in colonies forming groups or "clones" of connected, upright stems, originating from elongated rhizomes (Semple et al. 2002). In order for pollination to occur, pollen must come from flowers on a stem that belongs to a separate clone. Crooked-stem Aster is pollinated mainly by bees and butterflies (Zhang et al. 1999). Depending on the size of the clone and the spacing between clones, pollinators may be required to travel distances anywhere from a few centimetres to tens of metres or more between genetically different individuals. In Crooked-stem Aster, clones may grow as a dense cluster, with many stems in a few m^2, or they may grow with stems scattered over many m^2. Zhang et al. (1999) found Crooked-stem Aster clones ranged from fewer than 10 shoots in one or a few m^2, to 20-40 shoots in as much as 8 m^2, and one large clone had 50 shoots scattered along 20 m (linear measure) of ground. Some clones were noted as spaced 20 to 50 m apart. These growth traits may influence the size and shape of habitat requirements.

Fruits of Crooked-stem Aster are dispersed either by falling from the plants by gravity or by being blown off by wind. The fruits have bristles (collectively known as the pappus) which catch the wind and assist dispersal (Semple et al. 2002). No known dispersal studies have been conducted specifically on Crooked-stem Aster. Dispersal distances are hard to define as they relate to a number of changeable factors including wind speed, weather conditions and humidity, release height, and the height of the surrounding vegetation (Soons et al. 2004). These factors may differ on particular days and in different habitat types. In general, dispersal in the Aster Family is most favourable in fair weather with low humidity, as the bristles on the fruits are open and stiff, however wind speeds are usually low in such conditions (Sheldon and Burrows 1973). Sheldon and Burrows (1973) concluded that long distance dispersal in the Aster Family is typically prevented unless convection currents can carry fruits high up in the air, though this is unlikely to occur in the treed habitats, which Crooked-stem Asters prefer. Information suggests that fruits may also be dispersed by water (e.g., carried by currents in creeks and streams) and could be deposited downstream (COSEWIC 2012).

Most aster seeds are reportedly short-lived with viability times of one to one and a half years and up to four years reported (Jones 1978; Cullina 2000). It is not known whether Crooked-stem Aster may maintain a seed bank in the soil longer than 4 years.

Habitat Needs

In Canada, Crooked-stem Aster occurs in a wide range of habitats. In general, Crooked-stem Aster is found in the floodplains of streams and creeks flowing into Lake Erie, most commonly at the edge of woods or along creek banks through riparian forest, as well as in a few roadside and old field locations in that region.

It is usually found in partial to full shade (Zhang et al. 1999; Semple et al. 2002; COSEWIC 2012). Figure 3 shows Crooked-stem Aster in a woodland roadside habitat. Soil conditions where Crooked-stem Aster occurs include rich sandy, loamy, or clayey soil (Zhang et al. 1999). In its greater global range, Crooked-stem Aster is found in moist or swampy grounds, woods, thickets, meadows, seeps, stream banks, and roadsides (Brouillet et al. 2006).

Figure 3. Crooked-stem Aster (pale flowers, bottom-centre, along path) in a woodland edge habitat growing with goldenrods and other asters. (Photo: Allan Harris, used with permission).

Crooked-stem Aster has been observed to tolerate moderate levels of disturbance and competition from weeds and taller plants, and is able to grow and reproduce in a broad range of light, canopy cover, and soil moisture conditions (Zhang et al. 1999; COSEWIC 2012; Harris pers. comm. 2015) (Figure 3). It is unknown whether Crooked-stem Aster requires disturbance to create suitable habitat patches, but if so, there may be a trade-off between a need for disturbance to occur and the occasional loss of individual plants when the disturbance happens. Disturbance activities would need to occur on a small scale and outside of the growing season with careful considerations of the seed bank.

Zhang et al. (1999) reported habitat data from their 1997 field work, as well as the habitat information listed on herbarium specimens of Crooked-stem Aster from Ontario. When these and other Canadian reports (COSEWIC 2012) are examined in detail, it is apparent that Crooked-stem Aster can be found in a variety of habitats, with different

associate species, a range of canopy cover if any, and different species making up the canopy. A generalized list of reported habitats includes:

- Creek and stream banks under forest canopy, at the edge of woods, or open;
- Open floodplains with no canopy;
- Floodplains in Black Maple Forest with Sycamore (*Platanus occidentalis*) and Black Walnut (*Juglans nigra*);
- Openings in forest of Sugar Maple (*Acer saccharum*), American Beech (*Fagus grandifolia*) and Eastern Hemlock (*Tsuga canadensis*);
- Open thickets on a slope in damp sandy loam;
- Wet-mesic thickets of Ninebark (*Physocarpus opulifolius*) and Diamond Willow (*Salix eriocephala*);
- Wet-mesic grove of White Cedar (*Thuja occidentalis*);
- Sandy moist soil, part shade;
- Roadside banks at the edge of woods or through woods;
- Gravelly soil of waste ground;
- In a small ditch mixed up with horsetail (*Equisetum* spp.);
- Moist seepage in road cut and ditch;
- Sandy embankment under ash trees;
- And a mix of conditions within one area: "along an old road paralleling a creek through lowland forest, but a few plants also extend up the valley slope into beech-hemlock forest" (COSEWIC 2012).

The main feature in common among most descriptions is mesic or moist conditions and soil that is at least somewhat sandy, although there are a few reports that appear to be somewhat drier (Zhang et al. 1999). The exact range of moisture levels tolerated by Crooked-stem Aster is not known, but soil that is at least mesic for some part of the growing season appears to be a requirement.

The forested habitat was classified by COSEWIC (2012) in the Ecological Land Classification of Southern Ontario (ELC) (Lee et al. 1998), as *Fresh-Moist Lowland Deciduous Forest* (Ecosite FOD7) often with Black Maple (*Acer saccharum* ssp. *nigrum*), ash (*Fraxinus* spp.), and/or White Elm (*Ulmus americana*) in the canopy. This ecosite is associated with soils that usually have a component of finer silt or clay that slows drainage (Lee 2008). However, this ecosite applies only to some habitats or parts of habitats. For example, thickets, cedar groves, and other kinds of wetlands have other ELC types, which have not been documented for Crooked-stem Aster. In addition, the disturbed edge of a forest or along a roadside, where Crooked-stem Aster can occur are not well typed by the current ELC.

Table 2. Canopy associates reported (Zhang et al. 1999; COSEWIC 2012) near Crooked-stem Aster include:

English Name	*Scientific Name*
Manitoba Maple	*Acer negundo*
Red Maple	*Acer rubrum*
Sugar Maple	*Acer saccharum*
Black Maple	*Acer saccharum ssp. nigrum*
Yellow Birch	*Betula alleghaniensis*
Paper Birch	*Betula papyrifera*
American Beech	*Fagus grandifolia*
Ash species	*Fraxinus spp.*
Black Walnut	*Juglans nigra*
Eastern White Pine	*Pinus strobus*
Sycamore	*Platanus occidentalis*
Poplar species	*Populus spp.*
Trembling Aspen	*Populus tremuloides*
Eastern White Cedar	*Thuja occidentalis*
Eastern Hemlock	*Tsuga canadensis*
Elm species	*Ulmus spp.*

The habitat needs of Crooked-stem Aster may be better understood by looking at the tolerances of its associates. A large number of associate species (Appendix B) have been reported (Zhang et al. 1999; COSEWIC 2012). Only about a quarter of those associate species are found mainly in forests. About a third have weedy growth habits (meaning they are able to grow in disturbed places or to spread over large areas) and another third are usually found in wet places (Reznicek et al. 2011). Photos taken by Allan Harris during field work in 2011 (COSEWIC 2012; Harris pers. comm. 2015) show Crooked-stem Aster growing with a variety of Eurasian weeds and native species of weedy habit, including European Colt's Foot (*Tussilago farfara*), Ox-eye Daisy (*Leucanthemum vulgare*), Canada Goldenrod (*Solidago canadensis*) and Common Plantain (*Plantago major*). In general, the ground flora found with Crooked-stem Aster is most often a dense layer of graminoids (grasses, sedges and rushes), goldenrods, and other asters (COSEWIC 2012).

Based on the above information, within the broad range of habitat situations, suitable habitat for Crooked-stem Aster will generally be found within or in proximity to creeks or streams, floodplains, seeps, or lowland forest; with mesic to wet soil conditions; often with sandy soil and somewhat shady sites.

Habitat Dynamics

It is possible that suitable habitat for Crooked-stem Aster may be dynamic or may be disturbance-based. Floodplains and creek banks are subject to periodic natural disturbance from inundation and fast currents during high water, which may clear off vegetation and expose soil for new establishment of this species. Forest openings may be the result of natural blow-down or human activities. Thickets may also be the result of disturbance in much wetter areas. Roadsides and forest edges are the result of human actions.

In floodplain forest, Ambrose and Aboud (1983) speculated that periodic openings in the forest may be needed for seedling establishment of mature trees that fruit infrequently, and that habitat dynamics that allow periodic creation of light gaps or prevent full canopy closure may be necessary to ensure tree seedling survival. If there is a natural cycle of disturbance occurring within lowland and floodplain forests, it is possible that other species in addition to trees are adapted to that cycle. However, field reports have not tied Crooked-stem Aster habitat to specific disturbance events, and populations remained extant between COSEWIC surveys of 1997 and 2010, and even between older records (e.g., 1985-1987) and 2010. Therefore, if habitat dynamics do play a role in creating or maintaining suitable habitat for Crooked-stem Aster, it is possible that the disturbance is needed only over long time periods, such as every 25 years or more.

4. Threats

Historically, loss of habitat was considered a major threat to Crooked-stem Aster and many other Carolinian species as most forest was converted to agricultural use. Present-day threats to the species may be compounded by the overall scarcity and fragmentation of forest habitat due to historical habitat loss. However, COSEWIC (2012) does not report limited habitat as a current threat to Crooked-stem Aster in Canada.

4.1. Threat Assessment

The Crooked-stem Aster threat assessment (Table 3) is based on the unified threats classification system of the International Union for Conservation of Nature (IUCN) and the World Conservation Union- Conservation Measures Partnership (CMP) (Salafsky et al. 2008). Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (global, national or subnational). Limiting factors are not considered during this assessment process. For purposes of threat assessment, only present and future threats are considered. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help in understanding the nature of the threats are presented in section 4.2 Description of Threats.

The predominant threats to Crooked-stem Aster are residential and commercial development, recreational activities and invasive non-native/alien species.

Table 3. Threat calculator assessment

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
1	**Residential & commercial development**					
1.1	Housing & urban areas	Low	Small	Serious	Moderate	Residential development, particularly cottage development poses a direct threat to some local populations by causing a loss of available habitat or altering the moisture regime.

2	**Agriculture & aquaculture**					
2.3	Livestock farming & ranching	Unknown	Restricted	Serious	Unknown	Plants may be consumed by grazing livestock in the short term and they may also trample ground, churn soil, add nutrients from manure and introduce invasive plant seeds.
4	**Transportation & service corridors**					
4.1	Roads & railroads	Medium	Restricted	Serious	Moderate	Road maintenance may involve cutting or herbicide treatment which may damage Crooked-stem Aster plants. Herbicide use may also change the species composition and structure of habitat.
5	**Biological resource use**					
5.3	Logging & wood harvesting	Low	Large	Slight	Moderate	Logging may degrade or destroy habitat by opening up the canopy enough to change the moisture and light regime. It may also cause an increase in tree seedling growth. However, light disturbance (e.g. from selective harvesting) can be beneficial.

6	**Human intrusions & disturbance**					
6.1	Recreational activities	Medium	Large	Moderate	High	ATVs and hiking may trample plants and degrade or destroy habitat. However, light disturbance may be beneficial.
8	**Invasive & other problematic species & genes**					
8.1	Invasive non-native/alien species	High	Pervasive	Serious	High	Many invasive plant species are present at Crooked-stem Aster sites. These species are able to colonize and take over Crooked-stem Aster habitat. Emerald Ash Borer, an invasive beetle may kill trees and open the canopy causing drier soil conditions.

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible: Not a Threat: when severity is scored as neutral or potential benefit.

[b] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71-100%; Large = 31-70%; Restricted = 11-30%; Small = 1-10%; Negligible <1%).

[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71-100%; Serious = 31-70%; Moderate = 11-30%; Slight = 1-10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

[d] **Timing** – The time frame over which the threat may occur or is occurring. High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

4.2. Description of Threats

Threats to the Crooked-stem Aster are described below in the order in which they appear in Table 3. The most serious threats to Crooked-stem Aster are habitat loss from invasive species and roadside maintenance using herbicide to reduce vegetation or using large machinery for major road reconstruction or improvement. Trampling from recreational activities, such as inappropriate all-terrain vehicle (ATV) use or off-trail hiking, is also a serious concern. Other threats also occur with somewhat lower impact.

1 Residential & commercial development

1.1 Housing & urban areas

Habitat for Crooked-stem Aster may be degraded or lost due to development. Most floodplain habitat is not suitable for development. However, cottage development was still noted as being a current threat at one site not on a floodplain (COSEWIC 2012). Although this threat is not likely to have a population-level effect on the species as a whole, it may lead to a significant loss of individuals at local population locations. Development may cause a direct loss of habitat by covering the ground with structures, lawns, or roadways. Even if all substrate is not covered up, development may also cause a change in the moisture regime. Crooked-stem Aster tolerates moderate disturbance, so it may be possible for disturbance to occur without damaging the species. However, it can be presumed that development would cause a loss of available habitat overall.

2 Agriculture & aquaculture

2.3 Livestock farming & ranching

Livestock grazing has been noted as a potential threat although there have been no observations of this threat occurring (COSEWIC 2012). However, this threat is likely to occur mainly on sites on private land, most of which have not been surveyed. Thus, the current impact of grazing is unknown. Livestock grazing may threaten Crooked-stem Aster in the short term due to consumption of the plants. It may also cause degradation of habitat over the long-term, or if large numbers of animals are present. Livestock grazing may cause trampling of ground, soil disturbance or compaction, increased nutrient inputs from manure, and introduction of non-native or invasive plant seeds, which can promote the spread of species that compete with Crooked-stem Aster (Scasta et al. 2015).

4 Transportation & service corridors

4.1 Roads & railroads

Three populations of Crooked-stem Aster occur along roadsides. Vegetation on some roadsides is regularly maintained with mowers or herbicides, both of which could damage Crooked-stem Aster plants. However, one roadside population which was regularly mowed actually increased in numbers (COSEWIC 2012). As long as mowing does not cut Crooked-stem Aster plants, periodic mowing (frequency not determined but probably not more than once or twice in a summer) appears not to be a threat. Conversely, the use of herbicide may directly harm Crooked-stem Aster and associated species and may change the species composition of habitat. Road improvement and construction may be a threat if ditches and roadsides are altered, or drainage and moisture levels changed.

5 Biological Resource Use

5.3 Logging & wood harvesting

Logging may degrade or destroy habitat if it opens the canopy enough to change the light and moisture regimes. It may also cause a rebound in growth of tree seedlings (Reader and Bricker 1992), which may compete with Crooked-stem Aster or take over areas used by the species. However, Crooked-stem Aster may withstand moderate levels of disturbance, so there may be a threshold below which logging would not be a threat. Threshold levels are unknown, but it is possible that small scale-selective cutting of trees could provide a benefit from increased light (Reader and Bricker 1992). Nevertheless, there could still be a cumulative effect from smaller operations over a number of years. There are currently active logging operations on some conservation authority lands, but silvicultural areas are surveyed prior to work commencing, and buffers are established to protect any species at risk present (Holmes pers. comm. 2015). Crooked-stem Aster has not been surveyed on most private land sites, so it is unknown whether logging may be a threat there.

6 Human intrusions & disturbance

6.1 Recreational Activities

The use of recreational vehicles (e.g., ATVs) occurs in some forests and along some roads and trails where Crooked-stem Aster is present (Harris pers. comm. 2015). Inappropriate ATV use is an on-going problem at many sites despite gates and other attempts to prevent access (Gagnon pers. comm. 2015; Holmes pers. comm. 2015). Inappropriate ATV use may damage plants and may degrade or destroy habitat if it causes rutting or compaction of soil, especially if it is moist. Despite this, a fairly large number of Crooked-stem Aster plants were observed along one forest ATV trail (Harris pers. comm. 2015), pointing to possible beneficial effects from light disturbance and a possible threshold for detrimental effects. Effects of trampling from foot traffic

along hiking trails may be similar to recreational vehicle use but may have a higher threshold before effects become detrimental.

8 Invasive non-native/alien species

8.1 Invasive non-native/alien species

Invasive species were found at almost all sites surveyed for Crooked-stem Aster in 2010 (COSEWIC 2012). These include: invasive Phragmites (*Phragmites australis australis*), Garlic Mustard (*Alliaria petiolata*), Glossy Buckthorn (*Frangula alnus*), Dame's Rocket (*Hesperis matronalis*), Honeysuckle (*Lonicera tatarica*), Spotted knapweed (*Centaurea stoebe* ssp. *micranthos*), Smooth Brome (*Bromus inermis*), as well as Reed Canary Grass (*Phalaris arundinacea*) which is a native species. All of these species are able to colonize and take over disturbed places (moist or otherwise), forest understory, and open areas. The presence of invasive species is a serious threat to native biodiversity (Environment Canada 2004). However, Crooked-stem Aster is a large, vigorous species able to compete with other colonial plants such as Canada Goldenrod, so the effects of invasive species may be less harmful to Crooked-stem Aster than to other species. Nevertheless, there may be potential impacts, including allelopathic[10] effects (Garlic Mustard), shading (Glossy Buckthorn, Honeysuckle), and altered soil moisture (Common Reed, Reed Canary Grass) (COSEWIC 2012). Finally, if invasive species do not greatly affect growth of Crooked-stem Aster, they may potentially affect seedling establishment if they cover most of the available ground. Habitat degradation due to invasive species is also considered a threat to populations in the United States, particularly in Minnesota and Ohio (COSEWIC 2012).

The Emerald Ash Borer (*Agrilus planipennis* or EAB), a foreign, invasive beetle, has been documented as a threat to Carolinian forests that have a high component of ash trees (Environment Canada 2015). EAB is present in the Lake Erie region and is spreading throughout southern Ontario and Quebec (Canadian Food Inspection Agency 2015). In the Catfish Creek area, ash trees have been completely infested and all but the Blue Ash (*Fraxinus quadrangulata*) have died (Difazio pers. comm. 2015). Die-back of ash trees was not observed within Crooked-stem Aster habitat in 2010 (COSEWIC 2012), though die-back has occurred east and west of the species' range. As the species tolerates a variety of open canopy conditions, potential effects on Crooked-stem Aster are unknown. However, the loss of ash trees constitutes a major change in forests and could cause direct habitat changes such as opening up the canopy causing drier soil conditions, and indirect effects such as increases in invasive plant species (COSEWIC 2012).

[10] Allelopathic plants secrete toxins or other chemicals into the soil, affecting the growth of neighbouring species.

Other Potential Threats

A lack of pollinators may also be a potential threat. Crooked-stem Aster flowers from late August to early October and requires out-crossing[11] with pollen transfer by insects. Pollinators may be limited in the latest part of the bloom period. In addition, there may be a general decline in insect pollinators (bees especially) in Canada and globally, due to loss of habitat and food sources, diseases, pests, and pesticide exposure (Health Canada 2015). It is currently unknown what impact the decline in pollinator populations may have on Crooked-stem Aster. However, in the short-term, vegetative reproduction by rhizomes may compensate somewhat for reduced sexual reproduction.

Deer browse was not observed on Crooked-stem Aster during 2010 field work although deer were present (Harris pers. comm. 2015). Browse was not noted as a threat to this species by COSEWIC (2012), but other asters are often subject to browse. For example, monitoring in prairie restoration sites in Windsor found that deer preferentially ate Willowleaf Aster (*Symphyotrichum praeltum*), a threatened species, over other herbaceous plants (WEMG 2012; Jones 2013). Deer browse has also been noted as a threat to other species in Carolinian forests (Jones et al. 2013; Environment Canada 2015) but is currently not considered a threat to Crooked-stem Aster.

Any activity that changes the soil moisture regime or prevents flooding could pose a potential threat. Some examples might include construction of permanent structures to prevent high water levels, changes to agricultural drainages, replacing natural creek banks with cement or riprap, etc. However, no specific activities are observed as current threats to the species.

5. Management Objective

The management objective for the Crooked-stem Aster in Canada is:

- Maintain or increase (if determined to be biologically and technically feasible), the distribution and abundance of all populations, including any newly discovered populations.

Crooked-stem Aster has experienced historic declines mainly due to habitat loss; however, current numbers suggest that populations are fairly stable and no recent losses have occurred (COSEWIC 2012). The number of mature individuals is unknown, but likely in the thousands. There are an estimated total of 4562-4812 stems at 19 of the 22 extant populations. However, the abundance of total individual plants remains uncertain (COSEWIC 2012). This uncertainty includes a lack of recent information about a number of populations with a historic-unknown status (Table 1). As such, quantitative abundance objectives have not been set at this time. Efforts to increase the abundance and distribution of populations of Crooked-stem Aster in Canada will be carried out as

[11] Out-crossing refers to the pollination of a plant with pollen from a different plant of the same species.

opportunities arise (e.g., through ongoing and future restoration work by Conservation Authorities and stewardship groups, best management practices, and threat mitigation). The priority will be to focus on existing locations with small extant and historic populations or new locations within the native range where sufficiently large areas of suitable habitat (forest edges or in sunny openings within river floodplains or forests) are available or can be made available through restoration (e.g. to mitigate threats of invasive species) to support long-term persistence of the population.

Maintaining and/or increasing current populations will likely require the reduction or elimination of threats, particularly the encroachment of invasive species. Habitat management and use of best management practices along with increased outreach and communication with landowners to inform and raise awareness of the species and its threats may assist in achieving these recovery objectives and allow for a natural increase of plants within extant and presumed extant populations. In addition to measuring progress towards the management objectives, a regular assessment of threats will be important in evaluating the management of this species.

6. Broad Strategies and Conservation Measures

6.1. Actions Already Completed or Currently Underway

On lands owned by the Long Point Region Conservation Authority, Crooked-stem Aster is located in managed forested areas with active logging operations. These areas are surveyed prior to work commencing and BMP's are followed (Holmes pers. comm. 2015). One such guidance document is the Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales (OMNR 2010), which seeks to contribute to the conservation of biodiversity through sustainable forestry management practices. Additionally, BMP's have been developed by the OMNRF and Ontario Invasive Plant Council for several invasive species that impact Crooked-stem Aster including: Phragmites, Garlic Mustard, Glossy Buckthorn, Honeysuckle, and Spotted Knapweed, as well as native Reed Canary Grass.
The federal Habitat Stewardship Program (HSP) offers incentives to projects that target the conservation of species at risk. The Carolinian Canada Coalition undertook several projects from 2009-2013 which included the development of regional Conservation Action Plans to target specific, coordinated actions to conserve species at risk in Carolinian Canada. Crooked-stem Aster is included in Carolinian Canada Coalition's (CCC) Elgin Greenway Conservation Action Plan (Jalava et al. 2012), along with 64 other species at risk. The document lays out conservation targets for the habitat of each species and suggests actions for habitat protection.

6.2. Broad Strategies

The broad strategies of this management plan are described below. They are not identified in order of priority. The priority is identified in relation to the conservation measures (see section 6.3 Conservation Measures).

1. Conduct surveys to gather data on presence, abundance, and threats to guide future conservation efforts;
2. Engage key stakeholders in Crooked-stem Aster conservation and stewardship;
3. Conduct outreach and education to promote awareness of Crooked-stem Aster and its habitats;
4. Address knowledge gaps on the biological and habitat requirements of Crooked-stem Aster

6.3. Conservation Measures

Table 4. Conservation Measures and Implementation Schedule

Broad Strategy	Conservation Measure	Priority[a]	Threats or Concerns Addressed	Timeline
1. Conduct surveys to gather data on presence, abundance, and threats to guide future conservation efforts	Survey historic-unknown populations for population status, abundance and threats.	High	All threats	2023
	Assess current threats at extant and presumed extant populations, and develop and implement a mitigation plan where appropriate.	High	All threats	2023
	Develop and implement a long-term monitoring protocol.	High	All threats	2023
2. Engage key stakeholders in Crooked-stem Aster conservation and stewardship	Place signage and barriers to control hiker access to populations and to curtail off-trail recreational activities and development of unauthorized trails, promote the use of marked trails only. Support enforcement of unauthorized trails.	High	ATV use; Trampling along hiking trails	2023
	Ensure that woodlot management best management practices (BMPs) are followed (e.g. Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales) (OMNR 2010),	Medium	Logging and wood harvesting	2028
	Where appropriate, implement BMPs to reduce the impacts of invasive species on Crooked-Stem Aster.	High	Invasive species	2028
	Collaborate and support organizations and individuals undertaking planning and /or conservation actions to protect or restore Carolinian forest and floodplain habitats where Crooked-stem Aster occur.	High	Residential development; Other potential threats (e.g., changes to moisture regime).	2023
	Ensure county and municipal authorities are aware of locations of all Crooked-stem Aster populations and all relevant threats.	Low	Residential development; Road maintenance; Other potential threats (e.g., changes to moisture regime).	2023

3. Conduct outreach and education to promote awareness of Crooked-stem Aster and its habitats	Promote responsible recreational vehicle use including staying on trails, and information on identifying and avoiding species at risk.	Medium	ATV use	2023
	Communicate with owners of all private lands supporting Crooked-stem Aster to build awareness and encourage stewardship. Provide information about protecting the species and relevant threats.	Medium	Logging; Livestock Grazing; Changes to moisture regime.	2028
4. Address knowledge gaps on the biological and habitat requirements of the Crooked-stem Aster	Study the effects of habitat disturbance, including the Emerald Ash Borer, on the Crooked-Stem Aster.	Low	Disturbance, Other potential threats (e.g., Emerald Ash Borer; lack of pollinators)	2033
	Monitor local populations for damage from deer browse. Where necessary implement measures to protect plants from deer browse.	Low	Disturbance, Other potential threats (e.g., Emerald Ash Borer, lack of pollinators)	2033
	Determine pollination needs of Crooked-stem Aster.	Low	Disturbance, Other potential threats (e.g. Emerald Ash Borer; lack of pollinators)	2033

[a] *"Priority" reflects the degree to which the measure contributes directly to the conservation of the species or is an essential precursor to a measure that contributes to the conservation of the species. High priority measures are considered those most likely to have an immediate and/or direct influence on attaining the management objective for the species. Medium priority measures may have a less immediate or less direct influence on reaching the management objective, but are still important for the management of the population. Low priority conservation measures will likely have an indirect or gradual influence on reaching the management objective, but are considered important contributions to the knowledge base and/or public involvement and acceptance of the species.*

6.4. Narrative to Support Conservation Measures and Implementation Schedule

In order to plan effective conservation measures, better information is needed on the current status of many populations. The development and establishment of long-term protocols is important in monitoring abundance at all Crooked-stem Aster populations. There are 12 populations on privately-owned land that have not been reconfirmed since the 1990's or earlier. Communication with private landowners where the species occurs would be beneficial to promote awareness, encourage stewardship and reduce threats. In addition, other landscape-wide actions, such as supporting efforts to protect Carolinian habitats in the regions where Crooked-stem Aster occurs, will be beneficial. A long-term monitoring protocol would allow the status of populations to be tracked and would allow a timely response if threat levels increase.

Developing approaches to reduce destructive or inappropriate types of ATV will be important, as efforts to maintain gates and prevent unauthorized access have not been very successful at some sites (Holmes pers. comm. 2015), and enforcement may be difficult. Increased on-the-ground presence of land management staff or of conservation-minded local people may be beneficial in deterring this threat. A landscape-wide effort to encourage environmentally-responsible ATV riding would benefit Crooked-stem Aster as well as and many other species and habitats.

Controlling invasive species in the habitat of Crooked-stem Aster will likely require a long-term commitment if it is to be effective. At current levels, invasives may be only a moderate-level threat for Crooked-stem Aster because it may tolerate some competition from weedy species. However, controlling invasive species will be beneficial to the habitat as a whole, and may prevent more serious or future problems for Crooked-stem Aster.

7. Measuring Progress

The performance indicators presented below provide a way to measure progress towards achieving the management objectives and monitoring the implementation of the management plan.

- The abundance and distribution of current and confirmed Crooked-stem Aster populations are maintained or increased.

8. References

Ambrose, J.D. and S.W. Aboud 1983. COSEWIC status report on the Blue Ash *Fraxinus quadrangulata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON**.** 27 pp.

Bennett, B. 2015. Personal communication to Judith Jones by email on December 4, 2015. Co-chair, COSEWIC Vascular Plant Subcommittee, Ottawa, ON.

Brouillet, L, J.C. Semple, G.A. Allen, K.L. Chambers, and S.D. Sundberg 2006. *Symphyotrichum* in Flora of North America, V. 20. Oxford University Press, New York, p. 521.

Canadian Food Inspection Agency 2015. Emerald Ash Borer. http://www.inspection.gc.ca/plants/plant-protection/insects/emerald-ash-borer/eng/1337273882117/1337273975030 [accessed December 3, 2015].

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002. COSEWIC assessment of the Crooked-stem Aster *Symphyotrichum prenanthoides* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. http://www.cosewic.gc.ca/eng/sct1/searchdetail_e.cfm?id=571&StartRow=1&boxStatus=All&boxTaxonomic=All&location=All&change=All&board=All&commonName=Crooked-stem%20Aster&scienceName=&returnFlag=0&Page=1 [accessed December 31, 2015].

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2012. COSEWIC assessment and status report on the Crooked-stem Aster *Symphyotrichum prenanthoides* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 33 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2015. COSEWIC Assessment Process, Categories and Guidelines Committee on the Status of Endangered Wildlife in Canada. Ottawa. http://www.cosewic.gc.ca/eng/sct0/assessment_process_e.cfm [accessed December 31, 2015].

Difazio, T. 2015. Personal communication to Judith Jones by telephone on December 3, 2015. Resource Planning Coordinator, Catfish Creek Conservation Authority, Aylmer, Ontario.

Environment Canada 2004. Invasive alien species strategy for Canada. 40 pp. http://publications.gc.ca/site/eng/462217/publication.html [accessed December 3, 2015].

Environment Canada 2015. Management Plan for the Blue Ash (*Fraxinus quadrangulata*) in Canada [Proposed]. *Species at Risk Act* Management Plan Series. Environment Canada, Ottawa. iv + 25 pp.

Gagnon, P. 2015. Personal communication to Judith Jones by telephone on December 3, 2015. Lands and Waters Supervisor, Long Point Region Conservation Authority, Tilsonberg, Ontario.

Gartshore, M. 2017. Personal communication to Elisabeth Shapiro by email on November 30, 2017. Biologist Consultant, Walsingham, Ontario.

Gould, R. 2016. Personal communication to Judith Jones by email on January 4, 2016. Protected Areas Specialist, Ontario Ministry of Natural Resources and Forestry, London, Ontario.

Harris, A. 2015. Personal communication to Judith Jones by email on November 30, December 1 and 3, 2015. Biologist-consultant, Northern Bioscience, Thunder Bay, Ontario.

Health Canada 2015. Pollinator Health and Pesticides. Website: http://www.hc-sc.gc.ca/cps-spc/pest/agri-commerce/pollinators-pollinisateurs/index-eng.php [accessed December 31, 2015].

Holmes, D. 2015. Personal communication to Judith Jones by telephone on December 8, 2015. Field superintendent, Long Point Region Conservation Authority, Tilsonberg, Ontario.

Jalava, J.V., S. Caveney, M. Carabetta, D. Koscinski, R. Donley and the Elgin Greenway CAP Development Team 2012. Elgin Greenway Conservation Action Plan. Carolinian Canada Coalition, London, Ontario. 53 pp.

Jones A.G. 1978. Observation on reproduction and phenology in some perennial asters. Amer. Mid. Nat. 99: 184-197.

Jones, J. 2013. Recovery strategy for the Willowleaf Aster (Symphyotrichum praealtum) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. vi + 29 pp.

Jones, J., J.V. Jalava, and J. Ambrose 2013. Recovery Strategy for the Nodding Pogonia (*Triphora trianthophora*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. v + 29 pp.

Kartesz, J.T. 2015. *Symphyotrichum prenanthoides* in The Biota of North America Program (BONAP). North American Plant Atlas. http://bonap.net/napa. Chapel Hill, N.C. [accessed November 30, 2015].

Koscinski, D. 2017. Personal communication to Elisabeth Shapiro on November 29, 2017. Conservation Property Manager, Thames Talbot Land Trust. London, Ontario.

Lee, H.T. 2008. Southern Ontario Ecosystem Table. Conservation Ontario, http://www.conservationontario.ca/events_workshops/ELC_portal/index.html [accessed December 1, 2015].

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 Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02.

NatureServe 2017. *Symphyotrichum prenanthoides* in NatureServe Explorer: An online encyclopedia of life, NatureServe, Arlington, Virginia. http://explorer.natureserve.org [Accessed November 30, 2017].

NatureServe 2015. Conservation status overview NatureServe, Arlington, Virginia. http://www.natureserve.org/conservation-tools/conservation-status-assessment [Accessed December 31, 2015].

NHIC 2015a. On-line database of Ontario tracked species. Natural Heritage Information Centre, Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario. http://www.ontario.ca/page/get-natural-heritage-information [accessed December 31, 2015].

NHIC 2015b. Natural heritage methodology. Natural Heritage Information Centre, Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario. http://www.ontario.ca/page/natural-heritage-methodology [accessed December 31, 2015].

OMNR, 2010. Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales. Ontario Ministry of Natural Resources, Government of Ontario, Toronto, Ontario. 211pp.

Reader, R.J. and B.D. Bricker 1992. Response of five deciduous forest herbs to partial canopy removal and patch size. American Midland Naturalist 27(1): 149-157.

Reznicek, A.A., E.G. Voss and B.S. Walters 2011. Michigan Flora Online. University of Michigan Herbarium. http://michiganflora.net/home.aspx [Accessed November 30, 2015].

Salafsky, N.D., D. Salzer, A.J. Stattersfield, C. Hilton-Taylor, R. Neugarten, S.H.M Butchart, B. Collen, N. Cox, L.L. Master, S. O'Connor, and D. Wilkie. 2008. A standard lexicon for biodiversity conservation: unified classifications of threats and actions. Conservation Biology 22:897-911. Classification online at: http://conservationmeasures.org/CMP/IUCN/browse.cfm?TaxID=DirectThreats

Scasta, J.D., D.M. Engle, S.D. Fuhlendorf, D.D. Redfearn and T.D. Bidwell. 2015. Meta-analysis of exotic forages as invasive plants in complex multi-functioning landscapes. Invasive Plant Science and Management 8(3):292-306.

Semple, J.C., S.B. Heard and L. Brouillet 2002. Cultivated and native asters of Ontario (Compositae: Astereae). University of Waterloo Biology Series 41: 1-134.

Sheldon, J.C. and F.M. Burrows 1973. The dispersal effectiveness of the achene-pappus units of selected compositae in steady winds with convection. New Phytologist 72: 665-675.

Soons, M.B., G.W. Heil, R. Nathan, and G.G. Katul 2004. Determinants of long-distance seed dispersal by wind in grasslands. Ecology 85(11) 3056-3068.

Tackenberg, O., P. Poschlod, and S. Bonn 2003. Assessment of wind dispersal potential in plant species. Ecological Monographs 73(2) 191-205.

Van Hemessen, W. 2017. Personal communication to Elisabeth Shapiro on November 22, 2017. Botanist. London, Ontario.

WEMG (Windsor-Essex Mobility Group). 2012. Willowleaf Aster (*Symphyotrichum praealtum*) 2011 Annual monitoring report for the Windsor-Essex Parkway. Windsor-Essex Mobility Group and Parkway Infrastructure Constructors document no. PIC-83-225-0224.

Zhang, J.J., D.E. Stephenson, J.C. Semple and M.J. Oldham. 1999. COSEWIC status report on the crooked-stem aster *Symphyotrichum prenanthoides* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-16 pp.

Appendix A: Conservation ranks of Crooked-stem Aster in Canada and the United States

Global (G) Rank	National (N) Ranks	Sub-national (S) Ranks
G4G5	Canada: N2	Ontario (S2)
	United States: N4N5	Connecticut (SH), Delaware (S1), Florida (SNA), Illinois (SU), Indiana (SNR), Iowa (S3), Kentucky (S5), Maryland (SNR), Massachusetts (S2), Michigan (SNR), Minnesota (SNR), Mississippi (SNR), New Jersey (S2), New York (S5), North Carolina (S3?), Ohio (SNR), Pennsylvania (SNR), Tennessee (SNR), Vermont (S1), Virginia (S4S5), West Virginia (S4), Wisconsin (SNR)

Rank Definitions (Master et al. 2012)

S1: Critically Imperilled: At very high risk of extirpation in the jurisdiction due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors.

S2: Imperilled: At high risk of extirpation in the jurisdiction due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.

N3/S3: Vulnerable: At moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.

S4: Apparently Secure: At a fairly low risk of extirpation in the jurisdiction due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.

S5: Secure/Apparently Secure: At no risk to fairly low risk of extirpation in the jurisdiction due to an extensive to very extensive range, abundant populations or occurrences, with little to some concern as a result of local recent declines, threats or other factors.

G5/N5/S5: Secure: At very low risk of extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.

SNR: Unranked: Conservation status not yes assessed.

U: Unrankable: Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.

?: Inexact numeric rank: The addition of a ? qualifier to a 1-5 conservation status rank denotes that the assigned rank is imprecise.

Appendix B: Plant Species Found in the Habitat of Crooked-stem Aster

Latin Name	English Common Name
Ambrosia artemisiifolia	Ragweed
Asclepias syriaca	Common Milkweed
Bidens spp.	Beggar's Ticks
Carex stricta	Tussock Sedge
Cornus alternifolia	Alternate-leaved Dogwood
Daucus carota	Wild Carrot
Equisetum arvense	Field Horsetail
Equisetum hyemale	Scouring Rush
Erigeron strigosus	Rough Fleabane
Eupatorium spp.	Joe-pye-weed/Boneset
Eurybia macrophylla	Big-leaf Aster
Geranium spp.	Crane's Bill/Herb-Robert
Geum spp.	Avens
Heliopsis helianthoides	False Sunflower
Impatiens capensis	Touch-me-not
Leucanthemum vulgare	Ox-eye Daisy
Lobelia spp.	Lobelia
Oenothera spp.	Evening-primrose
Physocarpus opulifolius	Ninebark
Plantago lanceolata	English Plantain
Plantago major	Common Plantain
Prenanthes spp.	White Lettuce
Rhus typhina	Staghorn Sumac
Rubus spp.	Raspberries
Rudbeckia triloba	Brown-eyed Susan
Salix eriocephala	Diamond Willow
Salix spp.	Willows
Sambucus spp.	Elderberries
Smilacina racemosa	Spikenard
Smilacina stellata	Starry False Solomon's Seal
Solidago canadensis	Canada Goldenrod
Solidago caesia	Blue-stemmed Goldenrod
Solidago flexicaulis	Zigzag Goldenrod
Solidago gigantea	Giant Goldenrod
Solidago patula	Spreading Goldenrod
Symphyotrichum cordifolium	Heart-leaved Aster
Symphyotrichum lanceolatum	White Panicled Aster
Symphyotrichum lateriflorum	Calico Aster
Symphyotrichum novae-angliae	New England Aster
Symphyotrichum puniceum	Purple-stemmed Aster
Symphyotrichum urophyllum	Arrow-leaved Aster
Tussilago farfara	Coltsfoot

Appendix C: Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[12]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[13] (FSDS) goals and targets.

Conservation planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that implementation of management plans may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the management plan itself but are also summarized below in this statement.

Most conservation measures suggested for Crooked-stem Aster, such as controlling impacts from invasive species, reducing indiscriminate ATV use, working with private landowners to promote species' awareness, and sharing information with planning authorities will be beneficial to other species that use similar habitat. Surveys to fill knowledge gaps on population status, and research on the biological needs and limitations of Crooked-stem Aster are also not expected to have any negative effects.. Crooked-stem Aster has some tolerance for disturbance, and may tolerate some human activities that might harm other species, for example moderate logging. However, disturbance is not required to promote recovery of the Crooked-stem Aster. Therefore, recovery of Crooked-stem Aster is not expected to have any negative environmental effects.

[12] www.canada.ca/en/environmental-assessment-agency/programs/strategic-environmental-assessment/cabinet-directive-environmental-assessment-policy-plan-program-proposals.html
[13] www.fsds-sfdd.ca/index.html#/en/goals/