COMMITTEE ON THE
STATUS OF ENDANGERED
WILDLIFE IN CANADA

OTTAWA, ONT. K1A 0H3
(819) 997-4991

COMITÉ SUR LE STATUT
DES ESPÈCES MENACÉES
DE DISPARITION AU
CANADA

OTTAWA (ONT.) K1A 0H3
(819) 997-4991

STATUS REPORT ON THE DROOPING TRILLIUM *TRILLIUM FLEXIPES* IN CANADA

BY

DAVID MCLEOD

STATUS ASSIGNED IN 1996
ENDANGERED

REASON: HIGHLY REDUCED NUMBER OF SITES WITH POPULATIONS LIMITED BY LOW SEED SET, LACK OF HABITAT FOR EXPANSION AND DISTURBANCE FROM RECREATIONAL ACTIVITIES.

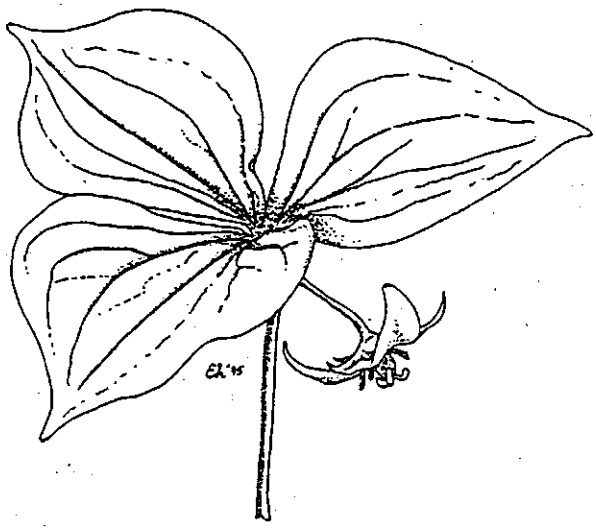
OCCURRENCE: ONTARIO

COSEWIC - A committee of representatives from federal, provincial and private agencies which assigns national status to species at risk in Canada.

CSEMDC - Un comité de représentants d'organismes fédéraux, provinciaux et privés qui attribue un statut national aux espèces canadiennes en péril.

STATUS REPORT ON ENDANGERED WILDLIFE IN CANADA

Drooping Trillium



COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA

COSEWIC

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JUNE 1994

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SPECIES:	"Species" means an indigenous species, subspecies, variety or geographically defined population of wild fauna and flora.
VULNERABLE: (V)	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
THREATENED: (T)	A species likely to become endangered if limiting factors are not reversed.
ENDANGERED: (E)	A species facing imminent extirpation or extinction.
EXTIRPATED: (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
EXTINCT: (X)	A species that no longer exists.
NOT AT RISK: (NAR)	A species that has been evaluated and found to be not at risk.
INDETERMINATE: (I)	A species for which there is insufficient scientific information to support status designation.

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STATUS REPORT ON THE DROOPING TRILLIUM
TRILLIUM FLEXIPES

IN CANADA

BY

DAVE MCLEOD
92 STROUD CRES., UNIT 48
LONDON, ONTARIO
N6E 1Y8

STATUS ASSIGNED IN 1996
ENDANGERED

COSEWIC Executive Summary

DESCRIPTION

- Scientific Name and Common Name:
  Trillium flexipes (Bent or Drooping Trillium)

- General Description and Size:
  The plant has an erect, sturdy stem from 15 to 60 cm in height topped by a whorl of three sessile, abruptly pointed leaves up to 20 cm long and broad. A single flower is borne on a straight peduncle originating from the middle of the leaf whorl that is 3 to 12 cm long and can be erect, horizontal or recurved relative to the general plane of the leaves. The three petals are obtuse, from 2 to 5 cm in length, and are normally white. A hybrid with T. erectum (Red Trillium) has maroon-coloured petals.

- Diagnostic Features:
  Within its range in Canada it can be confused with T. erectum (Red Trillium) (i.e. those with maroon-coloured petals) and T. cernuum (Nodding Trillium). It is best differentiated from the former by its white, ovoid, "bug-eyed" ovary with coarse, prominent stigmas, compared to the purple-black to maroon, subglobose ovary with smaller stigmas of erectum. The sessile to subsessile leaves, the only slightly declined to erect pedicel, the larger, spreading petals up to 5 cm in length, the similarly coloured anthers and filaments, and the long (up to 15 mm) anthers that are more than twice as long as the filaments, are diagnostic characteristics of flexipes that serve to separate it from cernuum with its petiolate leaves, abruptly declined pedicel, smaller (maximum of 2.5 cm in length) petals that are recurved between the sepals, and anthers that are often darker coloured than the filaments and relatively short (maximum of 8 mm in length), being only slightly longer than to about equalling the filaments.

DISTRIBUTION

- North American and Canadian Range:
  The main range of T. flexipes extends from western New York State, Pennsylvania, West Virginia, Virginia, North Carolina and northwestern Georgia through southwestern Ontario, southern Michigan, southern Wisconsin, Ohio, Indiana, Illinois, Kentucky, Tennessee, northern Alabama and northern Mississippi, to southeastern Minnesota, South Dakota, eastern Iowa, Missouri, Kansas and northeastern Arkansas. A disjunct population occurs in Delaware, Maryland and southeastern Pennsylvania on the eastern seaboard. In Canada the species

is confined to the western half of the Carolinian Floristic Zone from London in the east to western Essex County on the Detroit River in the west.

- Dispersal of Populations:
  The two extant populations are located 27 km apart at the Strathroy Conservation Area in the Town of Strathroy, Middlesex County and in Dunwich Township, Elgin County. Both fall within the larger area defined by the four historical populations. The six known populations occur within the watersheds of four major river systems: the Thames River (1 extant and 1 extirpated), the Sydenham River (1 extant), the Ausable River (Mud Creek) (1 historical) and the Detroit River (2 historical).

POPULATION SIZE AND TRENDS

- Number of Populations and Their Size:
  There are two extant populations. The one at Strathroy had over 500 flowering plants in 1994, covering approximately 3 ha (7.5 acres), while the smaller Dunwich Township population contained approximately 75 flowering plants in 1993 that occupied about 0.1 ha (0.25 acre). Both populations contain many sterile individuals that would range from one to nine years in age since it takes an average of ten years for a plant to reach maturity.

  There are four historical populations. The one at London is thought to be extirpated. The others, at Mud Creek, McGillivray Township, in Middlesex County, and at Amherstburg and on an island in the Detroit River in Essex County, have not been seen since the last century. Their precise locations and population sizes are thus unknown.

- Historical Growth and/or Decline in Size of Populations:
  The London population occurred in a location that has since undergone extensive development and so has probably been extirpated. The two extant populations have not been known and monitored long enough to detect any trends in their size.

HABITAT

- General Characteristics of Sites and Important Species Associates:
  T. flexipes grows in mesic, sandy loam, circumneutral soils of mature, deciduous woodlands that are usually associated with watercourses. Important associates of the Strathroy population include Silver, Sugar and Black Maple, White Ash and Basswood in the overstorey, while Ostrich Fern, Garlic Mustard and Wild Ginger are dominant ground cover associates. At the Dunwich Township site, Hackberry, White Elm, Blue Ash and Black Maple are the main canopy species.

White Baneberry, Garlic Mustard and Jack-in-the-pulpit are important ground cover species.

- Environmental and Physical Factors:

All known locations of this species in Canada fall within climatic regions that are characterized by very warm summer temperatures and relatively warm winters moderated by the adjacent Great Lakes. In Canada its habitat is characterized by mesic, bottomland or valley slopes on circumneutral, sandy loam soils with mature deciduous woodland adjacent to a watercourse. The common association of the various populations with watercourses suggests the need for fluvial processes in the creation and maintenance of suitable habitat.

GENERAL BIOLOGY

- Life Cycle:

T. flexipes is a perennial that takes an average of ten years to reach a reproductive flowering state. The flowers are perfect and reproduction is sexual, being mainly dependant on self-pollination. Seeds are the primary source of new plants.

- Reproductive Peculiarities:

This species has the potential to reproduce vegetatively but offshoots are rarely formed in large flowering individuals. Although flowers are usually self-pollinated, the long, exserted stamens and declining peduncle at flowering time have led some researchers to suggest that bumblebees and some butterflies could be potential cross-pollinators.

- Dormancy, Seed Set and Survival Rates:

The seed of T. flexipes undergoes a "double dormancy" in which only roots develop in the first year and it is not until the second year that the seed leaves emerge above ground. An average of only 34 percent of the ovules in a given flower are fertilized and set seed, being the second lowest rate of seven eastern North American pedicellate-flowered species, suggesting both a low self-compatibility and an inefficient cross-pollination system. However, most seeds germinate readily and seedlings have a better survival rate if dispersed by ants rather than germinating in clumps near the parent plant if no dispersal agent is available.

- Relationships with, or Dependence on Other Species:

Ants are effective short range seed dispersers. White-tailed Deer may effect long range dispersal if they browse the plants after maturation of the capsule but before the capsule has ejected the seeds or fallen to the ground beneath. The probability of this occurring may be remote, however, since it requires browsing within a short time frame and maintenance of seed viability after having passed through the digestive

tract, accompanied by deposition where optimum conditions for germination and growth prevail.

- Role it Plays in the Ecosystem:
  T. flexipes represents a component of the ground cover of the deciduous forest habitat in which it occurs. It thus contributes to the biodiversity of the site as well as to the control of soil erosion and to benefits that plants provide in general such as food, shelter, oxygen and reproductive sites for other organisms.

LIMITING FACTORS

- Specific Threats or Factors that Limit the Growth of the Populations:
  At both extant sites the amount of suitable adjacent habitat for population expansion is limited. Inefficient dispersal systems, both short and long range, may be contributing factors that hinder expansion beyond the existing areas. The relatively low rate of seed set, resulting from low self-compatibility and inefficient out-crossing mechanisms, could also be limiting the reproductive success and growth of the two populations.

- Reasons for the Decline or Increase in Populations:
  The historical population in the City of London is thought to have succumbed to habitat loss as a result of development of the area. This may likewise have happened to the two Essex County populations which also occur in densely populated areas and have not been seen now for almost 150 years. It is not yet known quantitatively if the existing populations are declining or increasing, but given the dearth of adjacent suitable habitat, especially at the Strathroy site, which is now surrounded by urban development, they are probably not increasing. The best that can safely be assumed is that they are just holding their own at both locations.

- Potential Threats:
  These include natural threats from herbivory and insect predation and disease organisms. Although no occurrences have been reported to date from either of the two extant populations, potential disease agents include the Botrytis fungus and mycoplasmas, while insect damage could result from Clepsis moth infestations. The degree of impact would depend on the severity and duration of an attack by a given organism, making the relatively small Dunwich Township population particularly vulnerable in this respect. Habitat destruction from urban development and uncontrolled recreational use at the Strathroy population, as well as transplantation from either population for horticultural use, are ever-present human threats.

PROTECTION

- Regulatory or Other Measures to Protect the Species:
  Although it is rated as **N1** in Canada and **S1** in Ontario according to the Natural Heritage Information Database, meaning that it is **critically imperiled because of extreme rarity** in both jurisdictions, there is currently no legal protection for T. flexipes in Canada under either federal or provincial law. Neither is it included in the list of Canadian flora protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to which Canada is a signatory. Some U.S. states such as New York and Maryland presently afford the species legal protection.

- Rehabilitation or Reintroduction Efforts & Research Programs:
  Reintroduction is not possible in this instance because there are currently no sites still in existence where the species was known to have occurred at one time but is now no longer present. Rehabilitation of the historical City of London site is not feasible because it has been permanently changed to other uses. No research programs have been undertaken specifically for any of the Canadian populations.

- Comments on Effectiveness:
  There can be no effective protection, recovery or research programs for T. flexipes until this species is given an appropriate status ranking and provided with legal protection.

CONCLUSIONS

- Comments on Status:
  Given the current rankings of **N1** in Canada and **S1** in Ontario for T. flexipes and the **critically imperiled** connotation because of its extreme rarity, the occurrence of only two populations within a very small geographical range in Ontario, the limited opportunity of both for future expansion because of the lack of adjacent suitable habitat, the relatively small size of the Dunwich Township population, together with the potential natural and human threats to both populations, it is proposed that this species be officially recognized as **Endangered** in Canada.

- Prognosis:
  With appropriate protective mechanisms in place along with the design and implementation of a management plan for each of the extant populations, it should be possible to at least maintain the species at its current population levels in both instances. If this does not happen, there will almost certainly be a gradual decline in numbers below that required for a viable population to exist because of human impacts

alone and extirpation will be inevitable. There is no guarantee, however, that uncontrollable natural causes will not produce the same negative result in any event.

Actions Necessary to Ensure Survival of Species or Increase Populations:

Ensurance of survival may not be possible without some attempt to establish new populations in suitable habitat within the range of known occurrences in Ontario. The feasibility of doing so should be explored, however, so that any possible negative ramifications will be adequately considered and addressed. It would be advisable to search for potential habitat along the same watercourses associated with both the extant and historical populations and if possible to use material from the same watershed for transplantation purposes.

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ABSTRACT

The bent or drooping trillium (Trillium flexipes) is a herbaceous, early spring ephemeral and perennial of rich, deciduous forests usually associated with watercourses. Except for a few small, disjunct populations in the states of New York, Delaware, Maryland, Virginia, North Carolina, Arkansas, Kansas and South Dakota on the periphery, the range of the species is confined within the eastern half of the United States between the Appalachian Mountains in the east and the Mississippi River states in the west, and from southeastern Minnesota, southern Michigan and southwestern Ontario in the north to northern Alabama and northwestern Georgia in the south. It occurs in 23 U.S. states and the province of Ontario in Canada.

In 11 of the states its status is variously described by government agencies and the Nature Conservancy as rare, critically imperiled, endangered and extirpated and some states such as New York and Maryland provide legal protection for it. It is known from just six localities in Ontario, all of which are restricted to the western half of the Carolinian Life Zone in southwestern Ontario, and of which only two contain extant populations. One of the latter was discovered as recently as 1987 in Dunwich Township, Elgin County. The other at Strathroy, Middlesex County, was rediscovered in 1989 after a period of ninety-one years since it was originally and last reported from that site. Of the remaining four historical sites, the City of London population is believed to have been extirpated because of extensive development in the area, while the species has not been seen at any of the other three sites for more than 100 years now. Habitat destruction may have caused the demise of the two Essex County populations in the heavily populated area along the Detroit River.

Trillium flexipes is currently found at only two sites in Canada. The Elgin County site supports only a relatively small population on privately owned land, while the other, although larger and on land owned by the St. Clair Region Conservation Authority, is primarily in an urban area where it is potentially threatened, not only by the indirect impacts resulting from development on adjacent land, but also by the direct effects of increasing recreational use of the area and, because of easy access to the site, the potential loss from transplantation to private gardens or for the commercial nursery trade. For these reasons, as well as the small and ever-decreasing amount of specialized habitat required by the species within its very limited geographical range in Ontario, it is proposed that it be officially recognized at this time as **Endangered** in Canada.

I. SPECIES INFORMATION

1. CLASSIFICATION AND NOMENCLATURE

Scientific name: Trillium flexipes Rafinesque

Bibliographic citation: Rafinesque, C.S. 1840. Autikon Botanikon, 133. - U.S.A. (Kentucky; Tennessee).

Type specimen: Herbarium where type specimen is deposited was not determined. According to Index Herbariorum, important collections of Rafinesque, including many Autikon Botanikon types, are deposited at the William Darlington Herbarium of West Chester University (DWC) in West Chester, Penn., the Academy of Natural Sciences Herbarium (PH) in Philadelphia, Penn., and the University of Wisconsin Herbarium (WIS) in Madison, Wisconsin. Correspondents at each of these herbaria were contacted but none of them were able to locate the type and no one had any suggestions as to where it may be (Potvin at DWC, pers. comm. 1994; Schuyler at PH, pers. comm. 1994; Cochrane at WIS, pers. comm. 1994). Barnhart (1965) notes that many of Rafinesque's specimens are now at Angers, France. Two Angers' herbaria, ANG and ANGUC, are listed in Index Herbariorum, but neither includes Rafinesque under "important collections". Stafleu and Cowan (1983) suggest that "the P-DU (Paris-Durand) herbarium should always be checked for types where necessary", but they then go on to say that "the major part of the herbarium was thrown away by Elias Durand". Neither does Index Herbariorum list Rafinesque as a major contributor to P-DU. In this same vein, Overlease and Rofini (1987) state that "the lack of existing botanical specimens from C.S. Rafinesque's herbarium to support his many botanical writings has been of concern to botanists for many years", so it is possible that the type specimen of T. flexipes no longer exists.

Pertinent synonyms:

1. Trillium declinatum (Gray) Gleason. 1906. in Bull. Torr. Bot. Club 33:389. ; not Raf. 1840. in Autikon Botanikon, 135. - U.S.A. (Alabama; Florida).
2. T. gleasonii Fernald. 1932. in Rhodora 34:21,22.

Common names:

1. Bent Trillium (Patrick, 1986a).
2. Drooping Trillium (Patrick, 1987; Oldham et al., 1991).
3. White Trillium (Patrick, 1986a).
4. Declined Trillium (Patrick, 1986a).
5. Nodding Trillium (Mitchell, 1986; more commonly used in reference to T. cernuum).

French name: Trille courbe

Family name: Liliaceae
Trilliaceae (Patrick, 1985; Mitchell, 1989; as cited by Sawkins and McGough, 1993)

Common family name: Lily family
Trillium family (ibid.)

Major plant group: Angiosperm, monocotyledon

Current alternative taxonomic treatments:

There are no current alternative taxonomic treatments for this species which, even historically, has always been assigned to the very distinctive Trillium genus. Because of its distinctiveness, it has been suggested that this genus should be elevated to the rank of family (TRILLIACEAE) (Farr et al., 1979) and it is currently treated as such by some North American botanists who specialize in the genus, including Patrick (1985) and Mitchell (1989) (Sawkins and McGough, 1993). Thus, there has never been any problem taxonomically in assigning the taxon in question to this genus. There is also a consensus among botanists that this taxon represents a distinct species although this was not always the case (see next paragraph). However, Mohlenbrock (1970) states that "there is some question concerning the exact species meant by Rafinesque in his description of T. flexipes". This would suggest that perhaps Rafinesque's type specimen no longer exists and so cannot be examined to resolve the question. He then goes on to say that, for this reason, "those wishing to disregard his binomial use T. gleasonii". Some difficulty also still exists in assigning a given specimen to this species because of the great intra-specific variation and apparent ease with which hybridization occurs (Case, 1987). In addition to the two most commonly encountered synonyms mentioned above, three others have occurred in the literature according to the Gray Herbarium Index (1968). They are:

a) T. erectum L. var. declinatum Gray, as given on page 523 of Gray's Manual, Edition 5, in 1867, and prior to the subsequent recognition of the taxon as a species by Gleason in 1906 (i.e. T. declinatum),

b) T. cernuum var. declinatum (Gray) Farwell, as published in 1920 in the Report of the Michigan Academy of Science, Volume 21, page 363, and

c) T. erectum var. blandum Jennison (see also Kartesz and Kartesz, 1980; Mitchell, 1986).

Thus, neither Gray, Farwell nor Jennison considered this taxon to be a separate species, but they obviously disagreed as to which of the two closely related species it should be assigned. There does, however, appear to be some confusion in the literature about the application of the epithet declinatum at the varietal rank. Both Scoggan (1978) and Morton and Venn (1990) suggest that John Macoun incorrectly used Gray's terminology when they make reference to "T. erectum var. declinatum sensu John Macoun 1888, in large part, not Gray", as a synonym for T. cernuum var. cernuum. Neither of them lists this combination by Gray as an accepted taxon by itself, presumably because they do not accept it as occurring in either Canada or Ontario. Kartesz and Kartesz (1980), for some unknown reason, do not even mention such a combination. It is likely that Macoun would be familiar with a typical T. cernuum specimen and so would not be expected to call it something else. This would, therefore, lead one to believe that his choice of T. erectum var. declinatum, which is a synonym for T. flexipes, was intentional and used appropriately to indicate that he had in fact collected what was flexipes and not cernuum. We also know that Macoun had previous experience with flexipes, because he was named as an "other collector" for a specimen of that species collected in 1883 by T.J.W. Burgess at London, Ontario, and deposited at the McGill University herbarium in Montreal. However, none of the currently known herbarium specimens of T. flexipes from Canada were collected by Macoun. This could also mean, though, that there are as yet undiscovered Macoun specimens of true flexipes filed incorrectly under cernuum, especially when one considers that Scoggan and Morton and Venn were more concerned with a data compilation exercise than with verification of identifications. It is also puzzling that Scoggan (1978) makes no mention of T. flexipes or any of its synonyms (other than T. erectum var. declinatum which he disavows as being incorrectly used by Macoun in the sense intended by Gray) as occurring in Canada, even though there are several specimens filed under that name in major Canadian herbaria.

A colour form with red or maroon petals has been formally recognized which is currently referred to as T. flexipes forma walpolei (Farwell) Fernald. According to the Gray Herbarium Index (1968), it was originally published in 1920 in the Report of the Michigan Academy of Science, Volume 21, page 363, as T. cernuum var. declinatum f. Walpolei (Farwell). The type locality is Ypsilanti, Washtenaw County, Michigan (Voss, 1972). This taxon has been recognized historically in conjunction with the two specific synonyms mentioned above for T. flexipes as follows:

T. declinatum f. Walpolei (Farwell) Friesner

T. Gleasonii f. Walpolei (Farwell) Deam

Farwell also named another colour form of T. flexipes that has the typical white petals, but each with a dark reddish-brown blotch at the base, referring to it as forma billingtonii.

However, Case and Burrows (1962) established that these two forms occurred only where the ranges of T. flexipes and T. erectum overlapped, and then only where both species grew in proximity, thus enabling bees to cross-pollinate them. They concluded, therefore, that Farwell's so-called "forms" were not distinct taxa but were actually hybrids (Case and Case, 1993).

History of taxon in Canada:

All collection data prior to 1951 referred to below was taken from Patrick (1986b).

T. flexipes was first collected in Canada on May 11, 1848, by an unknown collector in woods near Amherstburg in Essex County, Ontario. The specimen is at the University of Edinburgh Herbarium (E 18480511). A second specimen mounted on the same sheet was collected from the same location on May 18, 1849. Earlier, on May 1, 1849, Maclagan made a collection from islands in the Detroit River that is also deposited at E (18490501). The proximity of the two locations, the overlap in the dates for the unknown collector's collections and the Maclagan collection, and deposition in the same herbarium, suggest that Maclagan may be the unknown collector.

The species was not collected again until May 30, 1881, in low woodland and rich woods along the north branch of the Thames River in London, Middlesex County, Ontario by T. Millman and T.J.W. Burgess. Each collector deposited a two-specimen sheet, including a June 21, 1881, collection from the same site, at the University of Toronto Herbarium (TRT 13957) and the McGill University Herbarium in Montreal (MTMG 40605) respectively. Two additional specimens were collected from the same site by Burgess in 1883 (with Macoun named as a co-collector) and again in 1884. These were likewise deposited at MTMG (24368 and 40668). Another MTMG collection of this species (Acc. # unknown) was made "near London" by W. Dearness. The only date given is "May" but it is assumed to be in the 1880's. The University of Western Ontario Herbarium contains a W.E. Saunders' collection (UWO 5070) of a cultivated plant of this species that had been taken from his garden in London on May 13, 1942.

A fourth site was discovered on May 23, 1892, on the "flats" of Mud Creek "near Parkhill", Middlesex County, Ontario by J. Dearness. A specimen was deposited in the

Department of Agriculture Herbarium in Ottawa (DAO 167807), followed by a second specimen from the same site on June 1, 1894 (DAO 167762).

Four years later, a fifth population was found on May 23, 1898, by L.H. Smith at Strathroy, Middlesex County, Ontario, and a specimen was deposited at DAO (167732).

On May 20, 1950, a collection purported to be this species was made by J.K. Shields and A.W. Miller in "rocky woods" of the Niagara Glen in Stamford Township of the Regional Municipality of Niagara (old Welland County), Ontario, and deposited at TRT (69198). The specimen was annotated by T.S. Patrick in 1980 as T. flexipes. However, he later expressed the opinion that it "is a questionable record because the specimen shows some evidence of past introgression with T. erectum", and that "the population probably no longer persists" (Patrick, 1987). Since it had been almost 90 years since the latest report of the species at Strathroy and it had not been seen at any of the other four locations over that same period of time, Patrick also concluded that the species was "possibly extirpated in Canada".

In 1989, D. Martin rediscovered the Strathroy population. Collections of both colour forms of T. flexipes were subsequently made at this location by M.J. Oldham and the author on May 15, 1990, and again on May 24, 1991, by Oldham. Duplicates of forma flexipes (Oldham #10732) have been deposited at CAN, MICH, TENN, UWO and WAT, while forma walpolei specimens have been deposited at MICH (Oldham #12563) and TENN (Oldham #10733), (Oldham, pers. comm. 1994). Additional specimens were collected from this site on May 18, 1990, by W. Stewart (#3556 with a duplicate, and #3557) and deposited at UWO (#41728, #42410 and #42002).

On June 7, 1993, while doing field work for this report, the author and M.J. Oldham visited a site in Dunwich Township of Elgin County, Ontario, from which a specimen had been collected on May 11, 1987, by W. Stewart (#3273), that was subsequently deposited at UWO (#40584) and determined to be T. cernuum. Another specimen was collected (Oldham #14853) and submitted to T. Patrick at the Georgia Department of Natural Resources for identification. It was determined to be good T. flexipes (Patrick, pers. comm. 1994), making this not only a new population for the species in Canada, but also one of only two extant ones.

2. DESCRIPTION

Plants are from 1.5 to 6 dm tall. The erect and sturdy stem is surmounted by a whorl of three sessile leaves that are

up to 2 dm long and broad, abruptly acuminate and narrowed from near the middle to the base. The peduncle is 3 to 12 cm long, straight, and can be erect, horizontal or recurved. Sepals are lanceolate and about equal in length to the petals. The petals are normally white but can be reddish or maroon in forma walpolei (Farw.) Fern., since shown to be a flexipes and erectum hybrid (Case and Case, 1993). They are usually obtuse, from 2 to 5 cm in length, and spreading but not usually recurved. Filaments are short and almost always 2 mm long, while anthers are from 6 to 15 mm in length, are 2 to 5 times as long as the filaments, and are white to creamy in colour. The ovary is white or pale to pink in colour, ovoid, sharply 6-angled or "bug-eyed", and broader at the base with prominent, coarse stigmas. It often has a stale or musty fragrance. Based on measurements given by Montgomery (1977) for the closely related species, T. erectum, seeds are 2.4 mm long by 1.7 mm wide with a large and prominent caruncle (elaiosome) attached. They are brown in colour while the surface is longitudinally rugose and transversely rugulose. For more detailed descriptions see Fernald (1950), Patrick (1986a, 1986b), Gleason and Cronquist (1991) and Young (1994).

Local field characters

The only similar plants with which T. flexipes might be confused are other Trillium species. Plants of the Elgin County population were previously misidentified as T. cernuum. The key characters for separating flexipes from cernuum are: the sessile to subsessile leaves, the occasionally slightly declined to the more often horizontal to erect pedicel, the larger (up to 5 cm long and 3.5 cm broad), spreading petals in approximately the same plane as the sepals, the similar colour of the anthers and filaments, and the relatively long (up to 15 mm) anthers, that are more than twice as long as the filaments, of flexipes, versus the petiolate leaves with the pedicel abruptly declined below them, the smaller (maximum of 2.5 cm long and 9 mm broad) petals that are recurved between the sepals, and the anthers that are often darker coloured than the filaments and relatively short (maximum of 8 mm in length), being only slightly longer than to about equalling the filaments, in the case of cernuum.

Plants of the Strathroy population of T. flexipes (especially those with maroon-coloured petals) are most likely to be confused with T. erectum which also occurs at this site. Vegetatively, these two species are more similar than in the case of T. cernuum as described above. Thus, floral characteristics, and particularly those of the ovary, provide a more reliable means of differentiating the two. While flexipes has a white, ovoid, "bug-eyed" ovary with coarse, prominent stigmas, that of erectum is purple-black to maroon, subglobose and has smaller stigmas (Patrick, 1986a and 1986b).

Illustrations

Figures 1 and 2 of this report depict the flowers and vegetative characteristics of T. flexipes from the Strathroy, Ontario, population. Line drawings are found in Britton and Brown (1913) under the synonym T. declinatum, Gleason (1952) under the synonym T. gleasoni (sic), Mohlenbrock (1970), Braun (1967) and Steyermark (erect form of flower) (1963) under T. flexipes. Colour plates of both white and maroon flowers are included in A Guide to the Wildflowers and Ferns of Kentucky (Wharton and Barbour, 1971). Colour photographs by Frederick W. Case, Jr. of several flexipes-erectum hybrids, are found in the Bulletin of the American Rock Garden Society, Volume 51, Number 3 (Summer 1993).

3. BIOLOGICAL AND ECONOMIC SIGNIFICANCE

T. flexipes is a floodplain/bottomland forest, spring ephemeral that has found a niche where the land is subject to the periodic disturbance of spring flooding and deposition of sediments. It can be a major, or even dominant, component of the ground cover as in the case of the Strathroy, Ontario, population. As a perennial, it becomes established as a permanent resident, thus providing a measure of stability to the erosion-prone soils of its preferred habitat. Trillium species in general are often grazed by white-tailed deer. The author has observed two occurrences of this feeding behaviour on T. grandiflorum in Middlesex County, Ontario, as well as the results of such grazing on several occasions on both grandiflorum and erectum. The terminal leaf whorl with its attached flower is usually stripped from the top of the stem with one bite, leaving only a patch of naked stems behind. Various species of Trillium have been shown to be myrmecochorous (Ohara and Higashi, 1987), meaning that their seeds are dispersed by ants who carry seeds to their nest where they feed on a juicy structure called an elaiosome, that is approximately twice as large as the seed to which it is attached. Since the seed itself is not eaten, it is discarded in the vicinity of the nest where it may eventually germinate. It has also been shown (ibid.) that some species of ground beetles (Coleoptera) will interfere with this type of seed dispersal if they get to a fallen seed before an ant and eat the elaiosome first. Ants will ignore these, resulting in clumping of seedlings near the parent plant and the ultimate survival of very few because of the increased competition. Davis (1981) reported infestations of the flowers of Trillium erectum in New Hampshire by the larvae of two species of Tortricid moths.

Trillium species have been used by humans for several purposes. The showy, colourful flowers are often used for horticultural purposes in wildflower gardens (Case, 1987; Case

FIGURE 1 Flowers of Trillium flexipes from population at Strathroy, Ontario (forma flexipes in centre and forma walpolei to the right; note also the invasive Alliaria petiolata)

FIGURE 2 Population of Trillium flexipes at Strathroy, Ontario

and Case, 1993). Bailey (1949) lists twelve species of Trillium known to be in cultivation. In addition, American Indians used the closely related T. erectum for several medicinal purposes. Tea made from the root, which contains steroids, was used for menstrual disorders, to induce childbirth, during menopause, as an aphrodisiac, and for coughs and bowel ailments. The entire plant was used for making poultices for tumors, inflammation, and ulcers. Physicians were also known to use the root tea internally for all the above as well as for hemorrhages, asthma, difficult breathing, and chronic lung disorders, and externally for snakebites, stings, and skin irritations (Foster and Duke, 1990).

4. DISTRIBUTION

Summary

The main range of T. flexipes runs west from western New York State, Pennsylvania, West Virginia, Virginia, North Carolina and the Cumberland Plateau of northwestern Georgia, through southwestern Ontario, southern Michigan, southern Wisconsin, Ohio, Indiana, Illinois, Kentucky, Tennessee, northern Alabama and northern Mississippi, to southeastern Minnesota, South Dakota, eastern Iowa, Missouri, Kansas and northeastern Arkansas. A disjunct population occurs in the Susquehanna River drainage of Delaware, Maryland and Pennsylvania on the eastern seaboard (Patrick, 1986a; Argus and Pryer, 1990). It is therefore, currently known to occur in the 23 states and one province listed above (Figure 3). It extends into Canada along the northeastern border of its range only within the Carolinian Zone of southwestern Ontario along the northern side of Lake Erie (Figure 4).

Locality citations

Precise locality data and land ownership, if known, is on file with COSEWIC and the appropriate provincial jurisdiction. This information is generally available unless the localities are considered to be publicity-sensitive.

Extant populations currently or recently verified

Middlesex County, Ontario

1. Strathroy Conservation Area, Adelaide Township, Strathroy, verified May 16, 1994.

Elgin County, Ontario

2. Dunwich Township, verified June 7, 1993.

Extirpated populations

Middlesex County, Ontario

3. City of London, North Branch Thames River (T. Millman, TRT, May 30, 1881; W. Dearness, MTMG, May 1880's;

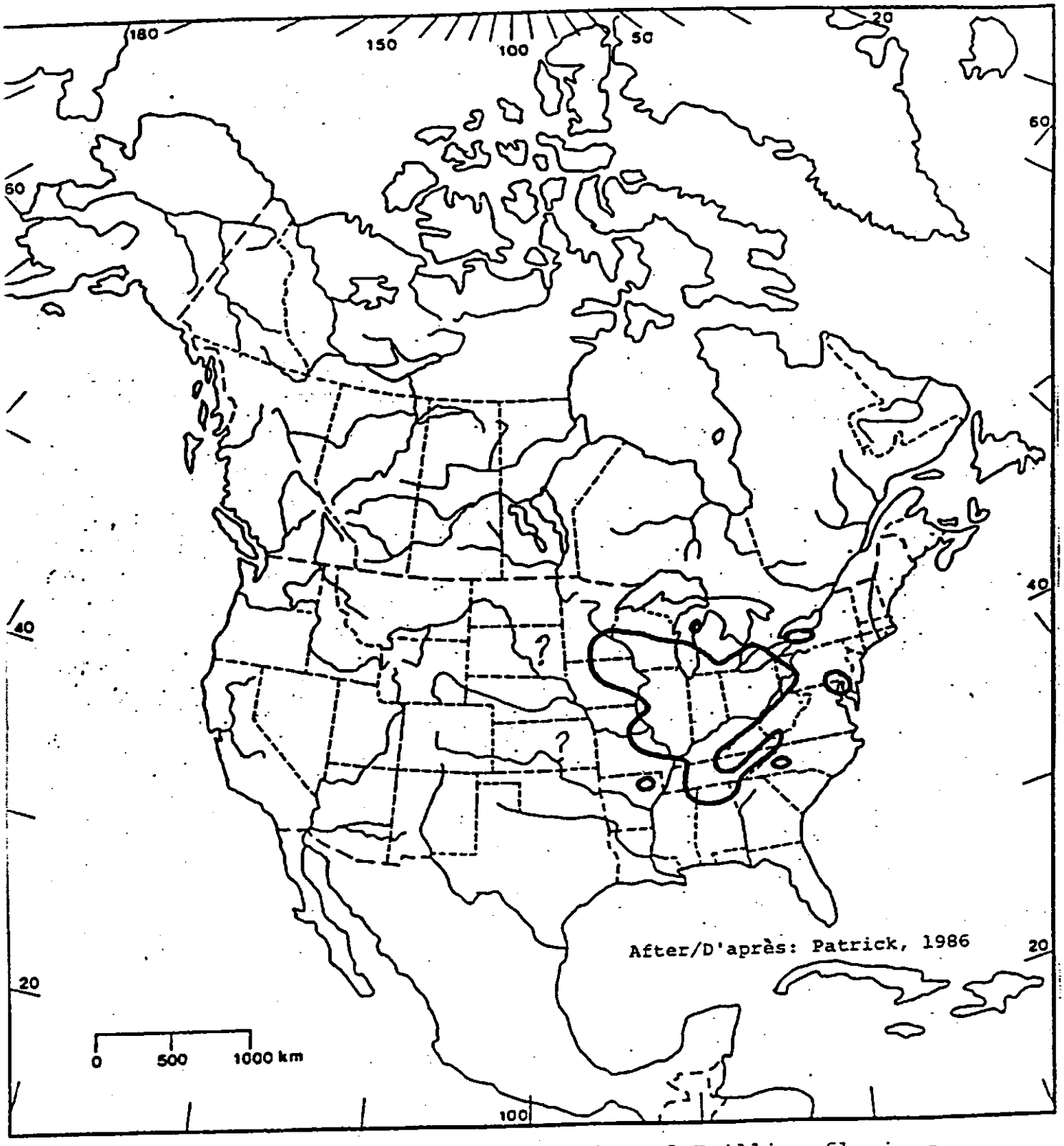

FIGURE 3 The Natural Distribution of Trillium flexipes in North America

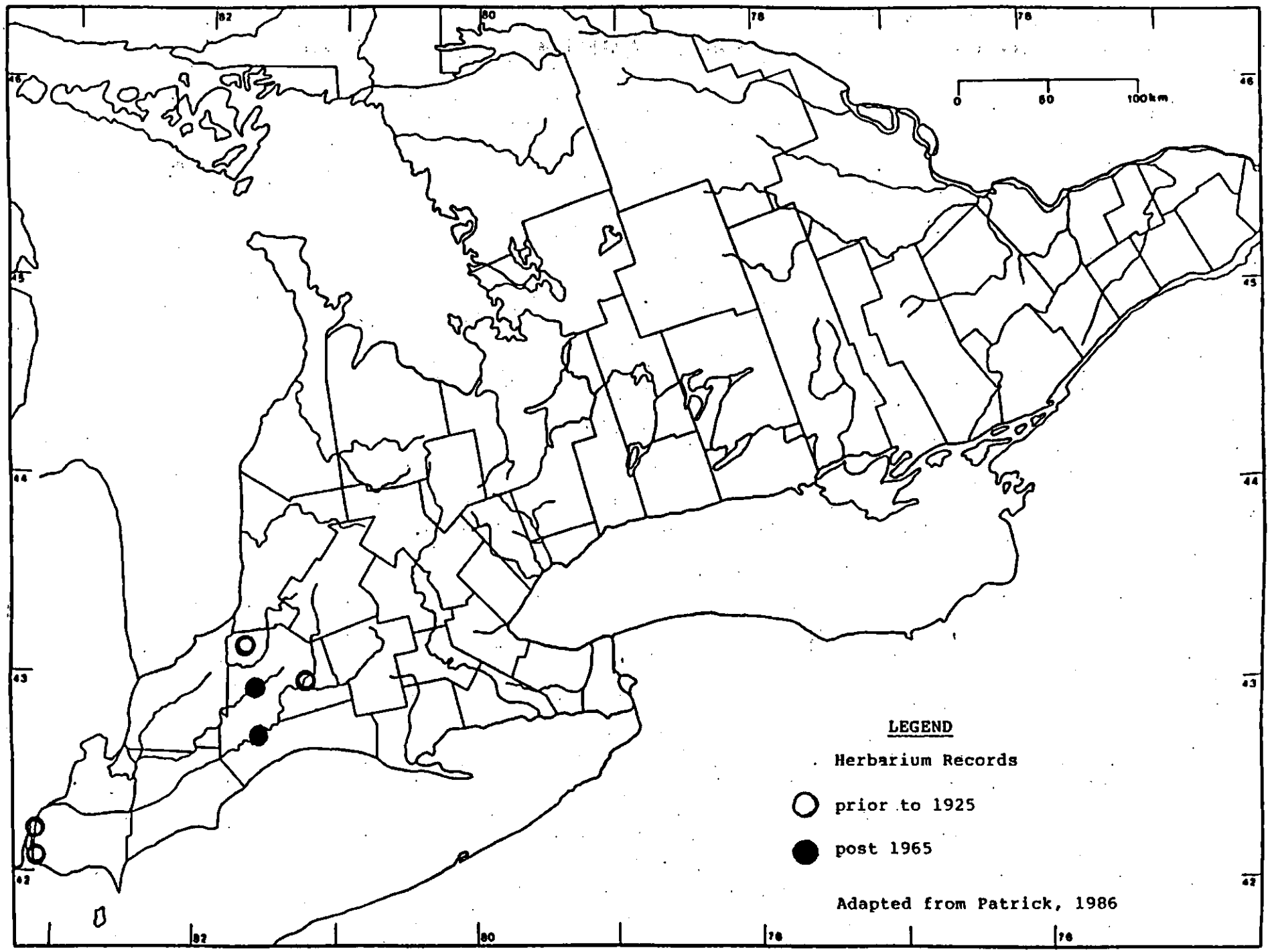

FIGURE 4 The Natural Distribution of Trillium flexipes

T.J.W. Burgess and J. Macoun, MTMG, Aug. 3, 1883; T.J.W. Burgess, MTMG, May 30, 1881, June 21, 1881, May 21, 1884). Although specific location information is lacking from all the specimen labels for the above listed collections, this stretch of the river has been intensively botanized within the past decade, often in conjunction with development proposals. A collection from this area on May 14, 1993, by M.J. Oldham, at first suspected of being this species, was subsequently determined to be T. cernuum (Patrick, pers. comm. 1994).

Historical populations of unknown status

Essex County, Ontario

4. Malden Township, near Amherstberg (unknown collector, E, May 11, 1848, May 18, 1849).

5. Islands in the Detroit River (Maclagan, E, May 1, 1849).

Middlesex County, Ontario

6. McGillivray Township, Mud Creek flats, near Parkhill (J. Dearness, DAO, May 23, 1892, June 1, 1894). Approximately a one kilometre stretch of Mud Creek about 2.5 km above the Parkhill Conservation Area reservoir was searched unsuccessfully on May 11, 1993, by the author and M.J. Oldham.

Potential sites for investigation

The three historical populations of unknown status listed above (i.e. numbers 4, 5 and 6) warrant further investigation.

Erroneous reports

Regional Municipality of Niagara, Ontario

7. Stamford Township (Welland Geographical County), Niagara Glen (J.K. Shields and Miller, TRT, May 20, 1950). Although this population was mapped by Patrick in the "Atlas of the Rare Vascular Plants of Ontario" in 1987, he notes that it "is a questionable record because the specimen shows some evidence of past introgression with T. erectum; the population probably no longer persists". However, this occurrence is included on Riley's 1989 list of vascular plants for the Central Region of Ontario, but without comment on Patrick's conclusion.

Status and location of presently cultivated material

There are no known locations in Canada where T. flexipes is being cultivated. However, it is currently under cultivation in a woodland garden at the home of Frederick and Roberta Case near Saginaw, Michigan (Case and Case, 1993).

Biogeographical and phylogenetic history of the species

The genus Trillium is distributed globally in three major centres. These are in the temperate regions of eastern Asia including Japan, western North America and eastern North America. Of the 46 species of Trillium, 10 are endemic to eastern Asia, 7 to western North America and 29 to the east, one of which is T. flexipes. Those plant genera with similar disjunct populations in Asia and North America and with endemic species in each area, are remnants of the Arcto-Tertiary flora of mixed and deciduous forests which at one time circled the globe in the temperate zone (Reznicek, 1988). Like many other species that found refuge during the last ice age in more southerly climes, T. flexipes extended its range northward across the Canadian border in post-glacial times as the climate to the north moderated (Gleason, 1952). This migration into Canada appears to have occurred through either the Niagara Peninsula from northwestern New York State, or from southern Michigan at the western end of Lake Erie, or both, given the presently known distribution of the species. It would have begun at the eastern end approximately 8000 years ago after the retreat of the Ontario Lobe of the Wisconsin Ice Cap and the fall of Lake Warren opened the land bridge between the Ontario basin and New York State (Zumberge, 1958; Chapman and Putnam, 1984).

The currently accepted taxonomic relationship of the species expresses its phylogenetic history probably as accurately as any other means, given the vagaries of phylogenetic interpretation and the extent to which it is even possible for a classification system to be purely phylogenetic or purely phenetic. This account thus assumes that Gleason's 1952 taxonomic treatment of Trillium provides a reasonably close approximation of its phylogenetic origins. Derivation from higher classification ranks follows Benson (1979).

The Lily family (Liliaceae) is derived from the Spermatophyta division of the vascular plant subkingdom. It is a member of the Angiospermae class, Monocotyledoneae subclass, and Liliales order. The Trillium genus is derived within the Lily family through the Subfamily Trilliaceae (now considered by some botanists such as Patrick (1985) to be a distinct family), characterized by an erect stem with a terminal whorl of three large leaves subtending a single sessile or peduncled flower. There are eleven other subfamilies within the Lily family. Trilliaceae is mono-generic, containing only the genus Trillium. It is further differentiated within the genus into two subgenera consisting of the pedicellate- and sessile-flowered species. The pedicellate-flowered species can be divided still further into two additional groups based on whether the peduncle is erect or declinate (nodding). T. flexipes is a member of the latter group of declinate-flowered species (Ohara and Utech, 1988).

5. GENERAL ENVIRONMENT AND HABITAT CHARACTERISTICS

Summary

The two extant Canadian stations of T. flexipes occur within the Lake Erie Counties climatic region. The two historical populations in the Detroit River area are within the Kent and Essex region, while the old London and Parkhill sites fall within the South Slopes climatic region (Brown et al., 1980). These regions are characterized by very warm summer temperatures and relatively warm winters moderated by the adjacent Great Lakes. In Canada the species prefers the mesic to wet-mesic forested bottomland sites or wooded valley slopes adjacent to a watercourse on circumneutral, sandy loam soils. It is able to tolerate, or even possibly benefit from some periodic disturbance of a site caused by annual flooding and sediment deposition within the floodplain of a watercourse.

Climate

The extant Strathroy and Elgin County populations, as well as the historic ones at London and Parkhill are located within the Lake Erie Counties climatic region. The mean daily temperature for the year is 8.3°C. In January the mean daily temperature is -5°C, but is 21.7°C for July. The mean annual frost free period is 151 days, extending from May 10 to October 8. Mean annual precipitation is 87 cm.

The historic Detroit River area populations fall within the Kent and Essex climatic region where the mean daily temperature for the year is 8.9°C. The mean daily temperature varies from -3.9°C for the month of January, to over 22°C for July. The mean annual frost free period is about 173 days, from April 20 to October 20. The mean annual precipitation is approximately 75 cm. Southern Ontario receives about 2,000 hours of bright sunshine in an average year (Brown et al., 1980).

The extant populations receive slightly more annual rainfall than the old Detroit River populations, and would experience a colder climate were it not for the moderating influence of local microclimatic effects because of their occurrence in the more sheltered forested slopes and floodplain bottomlands of the Sydenham and Thames river valleys.

Air and/or water quality requirements

No information available.

Physiographic, edaphic and topographic characteristics

The old London and the extant Strathroy populations are located in spillway and sand plain areas within the Caradoc Sand Plains and London Annex physiographic region. The extant

Dunwich Township population occurs in a narrow strip of sand plain that connects the Caradoc Sand Plains to the Bothwell Sand Plains via the Thames River corridor (Chapman and Putnam, 1984).

The historical Parkhill population on Mud Creek occurs within a bevelled till plain area of the Huron Slope physiographic region, while the Detroit River and Amherstburg historical populations are most likely within the clay plain portion of the St. Clair Clay Plains region (ibid.).

Edaphic and topographic characteristics are presented here for the two extant sites. The Strathroy site contains essentially one large continuous population growing in sandy loam of a relatively flat to undulating floodplain of bottomland forest along the Sydenham River. T. flexipes favors the slightly higher elevations of better drained sites characterized by mesic conditions except during the spring flood. As the floodplain soils change to muck upstream of the population, where higher rates of seepage from the river valley slopes prevail, flexipes disappears entirely and is replaced by erectum. Patrick (pers. comm., 1994) notes that flexipes prefers the better drained, circumneutral soils. This observation agrees well with both the Strathroy and Dunwich Township sites. In the latter case, the population occurs in loamy sand of a relatively steep (30° to 45°), northeasterly-facing slope along the south side of the Thames River. By contrast, this population is not subject to annual spring flooding, although it would otherwise appear to experience a similar mesic moisture regime since the plants occur above the zone of permanent groundwater seepage near the base of the slope.

Dependence on dynamic factors

In Ontario, this species is usually associated with watercourses. Only the historical Amherstburg record makes no mention of an adjacent watercourse, although there may well be one even in that case. This would strongly suggest that fluvial processes are responsible for creating and maintaining a suitable combination of abiotic factors necessary for its survival. Establishment of slightly elevated floodplain terraces and erosion of slopes above the local groundwater seepage zone where better drainage prevails and circumneutral loam soils with some sand content exist, are apparently needed. These are also the topographic features within a riverine system that have the greatest potential for long-term stability, and thus for the establishment of the forest community required by T. flexipes. The warmer climate prevailing within the Carolinian Zone, augmented by warmer, site-specific microclimates, appears to be a requirement as well.

Biological characteristics

In Canada Trillium flexipes is an understorey, perennial herb of forested, mesic floodplain terraces and slopes adjacent to rivers or other watercourses. In Canada, all reported occurrences are restricted to the Niagara Section of the Deciduous Forest Region (Rowe, 1972). This area is almost identical to that defined by Fox and Soper (1954) which they referred to as the Carolinian Floristic Zone in Canada, an area inhabited by plant species whose ranges are centred in the eastern United States to the south. Such species, of which T. flexipes is an example, are usually referred to as Carolinian.

It is a spring ephemeral, dependent upon the vernal, open canopy state of a deciduous forest for early growth and flowering. The specific conditions prevailing at the two extant sites are given below:

Strathroy Conservation Area: May 15, 1990, May 11, 1993 (M.J. Oldham and D. McLeod) and May 16, 1994 (D. McLeod)

Overstorey: - mature deciduous forest with 80 to 100% canopy closure when fully leafed out.
- associates, in order of dominance, are Acer saccharinum, Acer negundo, Acer saccharum, Fraxinus americana, Tilia americana, Carpinus caroliniana, Prunus serotina, Fagus grandifolia, Populus deltoides, Betula alleghaniensis and Quercus rubra.

Shrub Layer: - this stratum varies from a rather open situation with only a few scattered shrubs and saplings to areas where more densely concentrated patches occur.
- species associated with this population include Cornus foemina, Hamamelis virginiana, Prunus virginiana, Lindera benzoin, Vitis riparia, Cornus amomum, Rubus idaeus, Ribes americanum, Corylus americana, Sambucus canadensis and Spiraea alba.

Ground Cover: - dominant associates are Matteuccia struthiopteris, Alliaria petiolata, and Asarum canadense.
- other associates, including low shrubs and herbs, are: Actaea pachypoda, Allium canadense, Allium tricoccum, Arisaema triphyllum, Athyrium filix-femina, Carex blanda, Carex gracillima, Carex hirtifolia, Carex pedunculata, Carex radiata, Carex rosea, Caulophyllum thalictroides, Circaea lutetiana, Claytonia virginica, Dicentra canadensis, Equisetum arvense, Erythronium americanum, Euonymus

obovata, Galium triflorum, Geranium maculatum, Geum canadense, Glyceria striata, Hepatica acutiloba, Hydrophyllum virginianum, Impatiens capensis, Hystrix patula, Laportea canadensis, Lilium michiganense, Lonicera dioica, Lysimachia ciliata, Maianthemum racemosum, Maianthemum stellatum, Mitella diphylla, Onoclea sensibilis, Oryzopsis asperifolia, Parthenocissus inserta, Poa alsodes, Podophyllum peltatum, Polygonatum pubescens, Polygonum virginianum, Prenanthes sp., Ranunculus abortivus, Ranunculus hispidus, Rhus radicans, Rudbeckia laciniata, Sanguinaria canadensis, Smilax herbacea, Solidago altissima, Solidago caesia, Solidago flexicaulus, Thalictrum dioicum, Thalictrum pubescens, Tiarella cordifolia, Trillium erectum, Trillium grandiflorum, Uvularia grandiflora, Viola pubescens, Viola rostrata and Viola sororia.

Dunwich Township: June 7, 1993 (D. McLeod, M.J. Oldham, F. Simpson and L. Spicer)

Overstorey: - a somewhat open, mature deciduous forest canopy with approximately 75% closure when in full leaf.
- associates, in order of dominance, are Celtis occidentalis, Ulmus americana, Fraxinus quadrangulata, Acer nigrum, Ulmus rubra and Fraxinus americana.

Shrub Layer: - rather sparse with a relatively open understorey composed mainly of sapling regeneration of the canopy species.

Ground Cover: - associates are Actaea pachypoda, Alliaria petiolata, Arisaema triphyllum, Impatiens capensis, Maianthemum racemosum, Podophyllum peltatum and Solidago caesia.

The two extant populations described above, exhibit variable dominance within their respective communities. At Strathroy the population consists of more than 500 flowering plants plus an even greater but undetermined number of sterile plants along both sides of an approximately 300-metre stretch of the Sydenham River, with most plants occurring on the south side of the river in a fairly wide floodplain forest. The species occurs as scattered, individual plants near the edges of the population where it can not be considered a dominant or even co-dominant component of the ground cover, as well as in

more concentrated patches in the more central portion of the population where it is at least a co-dominant. The densest concentrations of plants and those showing the greatest vigour occur adjacent to a hiking trail through the floodplain forest.

The Dunwich Township population, however, consists of approximately 75 flowering plants randomly scattered along a 100-metre stretch of the forested valley slope on the southern side of the Thames River. T. flexipes is a co-dominant of the ground cover at this location.

The open spring and more closed summer canopy conditions at both sites indicate that the species is dependent upon a fairly high light intensity during the early stages of growth and the flowering period. However, this requirement appears to diminish as the canopy leafs out since fruit maturation and photosynthesis continues well into mid-summer. The increased concentration of more robust plants near the trail at the Strathroy site suggests that more optimum conditions for growth are found where the canopy is a little more open, compared to the remainder of the site where a higher degree of closure prevails. Natural tree falls, forest fire or canopy defoliation caused by indigenous insect species or pathogens, may also occur occasionally and so ensure a continual supply of habitat with more optimum light conditions.

Three provincially rare plant species are associated with the Trillium flexipes populations (Argus et al., 1982 - 1987). Arisaema dracontium (green dragon) and Carex trichocarpa (hairy-fruited sedge) are present at Strathroy, while Fraxinus quadrangulata (blue ash) occurs at the Dunwich Township site. Blue ash is also officially recognized as a threatened species in Ontario (OMNR, 1994) and in Canada (Ambrose and Aboud, 1982). No endangered plant species were recorded as associates.

6. POPULATION BIOLOGY

Summary

Only two populations of Trillium flexipes are presently known to exist in Canada, both of which occur in southwestern Ontario. The Strathroy, Middlesex County population, consisting of over 500 flowering plants, was originally found in 1898 but was only recently rediscovered in 1989. The smaller Dunwich Township, Elgin County population was discovered as recently as 1987 and contained approximately 75 flowering plants in 1993. The maximum distance between these two locations is 27 km, while all six confirmed locations, including historical sites, are separated by a maximum of 190 km between London in the northeast and Amherstburg to the

southwest. The recent discovery in 1987 of the previously unknown population in Dunwich Township has just kept pace with the probable extirpation of the species at the old London location. There has been neither adequate time nor rigorous enough monitoring of either extant population since their recent discovery (or rediscovery) to determine if they are in expansion or decline. Clearing and alteration of woodlands for development and recreational purposes is the probable cause for the loss of the former London population. It is also possible that the two Essex County populations have met a similar fate, since there has been a high level of on-going development in that area during the past 150 years. However, the lack of specific location information for these two sites makes it difficult to draw any hard conclusions. The Mud Creek population may have fared better since there appears to have been little, if any, alteration of the main valley of the creek for some distance upstream of the Parkhill Conservation Area reservoir.

Demography

There is one recently discovered (Dunwich Township) and one recently rediscovered (Strathroy) population of Trillium flexipes in Ontario. Table 1 summarizes the population information from these two sites.

At Strathroy the population is spread over an area measuring approximately 300 meters by 100 meters (3 ha or 7.5 acres), with the largest portion of this area (2.4 ha or 6 acres) being in the floodplain forest on the south side of the Sydenham River and the remainder (0.6 ha or 1.5 acres) on the north side. A well-used hiking trail which is part of the Strathroy Conservation Area's trail system, traverses the site along the south side of the river but crosses to the north side at one point via a small wooden bridge. Upstream of the T. flexipes population, a transition to deciduous swamp on muck soils occurs where the ground cover is dominated by Symplocarpus foetidus (skunk cabbage) and T. flexipes gives way to T. erectum and T. grandiflorum. In 1994 over 500 flowering plants were recorded at this site by the author.

The population in Dunwich Township occupies a position approximately two-thirds the way up a 100-meter slope above the Thames River. It covers an area measuring approximately 100 metres across the slope and 10 meters down it, for a total area of 0.1 ha (0.25 acre). There were approximately 75 flowering plants present in 1993.

Population densities varied from a low of 0.02 plants per square meter at Strathroy, to 0.075 plants per square meter for the Dunwich Township population. The lower density at Strathroy is somewhat misleading because there were some relatively large areas between individual patches or

TABLE 1: Population information for two extant sites of Trillium flexipes (D. McLeod, May 15, 1994; D. McLeod, M.J. Oldham, F. Simpson & L. Spicer, June 7, 1993)

Site Name	Number of Flowering Plants*	Plants/ m²	Area m²
Strathroy C.A. Middlesex County (May 15, 1994)	> 500	ca. 0.02	30,000
Dunwich Township Elgin County (June 7, 1993)	75	0.075	1,000
Total	> 575		31,000

* There were also large, undetermined numbers of sterile, non-flowering plants within each population.

concentrations of flexipes where the species was either absent entirely or almost so. However, there were at least six times more flowering plants at Strathroy, many of which were more vigorous than any of those at the Dunwich Township site. Some non-flowering plants were present at both sites.

Phenology

Fernald (1950) gives April to June as the span of flowering times for Trillium flexipes throughout its range. In Ontario, at the northern limit of its range, collection dates of specimens begin as early as May 1 for Maclagan's 1849 Detroit River islands collection and are as late as August 3 for the T.J.W. Burgess collection from London in 1883. Assuming the latter collection was flowering (it has not been seen by the author), the period given by Fernald would be extended by one full month. It should also be noted that this latest collection was made at a latitude almost one degree farther north than the earliest (May 1) collection. However, based on other collections and the author's recent field experience, the peak blooming period would likely occur during the second week of May and extend to the beginning of June depending on the climatic conditions of any given year.

Reproductive ecology

Type of reproduction

The flowers of Trillium flexipes are perfect and reproduction is sexual. However, Ohara and Utech (1988) state that "the mating systems in the declinate-flowered species are not sufficiently understood at present". It is probably both xenogamous and autogamous, with the latter predominant. Although no information was found specifically for flexipes, this has been reported to be the case for two North American pedicellate-erect-flowered species, T. grandiflorum and T. erectum, by several researchers such as Chimielewski and Ringius (1987). It is a perennial that is also known to have the potential to reproduce vegetatively. Ohara (1989) reports that vegetative offshoots are only rarely formed in large flowering individuals of the North American pedicellate (both erect and declinate) species, depending mostly on seeds for their offspring recruitment. All North American species of Trillium, including flexipes, are known to be diploid (2n = 10), except for rare occasional triploids (Ohara, 1989).

Pollination

Ohara and Utech (1988) state that "no effective pollinators are known at present" for Trillium flexipes, in spite of its long exserted stamens. It has been suggested that because of its declining peduncle at anthesis, only bumblebees and some butterflies could visit and forage the hanging flowers as potential pollinators (Kawano et al., 1992). Ohara et al., (1990) report that two Japanese species

of Trillium, both with white petals like flexipes, "were frequently visited by insects belonging to Diptera and Coleoptera" (fly and beetle orders). One of their breeding experiments, in which they removed the stamens from individual flowers and bagged them with nets to exclude insects, resulted in no seed production, suggesting that wind-pollination does not usually occur.

Seed dispersal

Berg (1958) was the first to report the dispersal of seeds of Trillium species by ants (myrmecochory) that are attracted to the oil-containing seed appendage or elaiosome. More recently Ohara and Higashi (1987) conducted studies on this type of dispersal in populations of two Japanese Trillium species. Seeds were moved mainly by two species of ants an average of 0.60 m and a maximum of 3.30 m from a given plant. By comparison, it has been reported that over 50% of the many-seeded fruits initially fall within just 20 cm of the parent (Higashi et al., 1989). However, Ohara and Higashi (1987) found that only 15% of the total number of seeds that were dropped below the mother plant were dispersed. They also found that the elaiosomes of the remaining 85% of the seeds had been either entirely or partially eaten by six species (from four families) of nocturnal ground beetles (Coleoptera) and the seeds were left where they had fallen. These seeds were no longer attractive to the ants resulting in a clumping of seedlings near the fertile plants. The population structure in terms of the distribution pattern of the various age classes of plants, is thus directly affected by this dispersal scenario. It is quite probable that a similar situation prevails for Trillium flexipes in North America with the involvement of indigenous ant and ground beetle species. Ohara and Hagashi also determined that small mammals such as mice, rats and shrews were not attracted to the Trillium fruits, even during the night, and so are not likely potential dispersal agents in North America either. However, dispersal does occur as a result of herbivory of mature plants by white-tailed deer. The author has observed this feeding behaviour on a patch of Trillium grandiflorum where the leaf whorls with attached flowers or capsules were stripped from the plant, leaving behind only the bare stalks. Provided the seed survives passage through the animal's digestive tract and is voided in suitable habitat, the species could be spread for considerable distances by this means.

Seed biology

Ohara (1989) reported an average of 128.7 ovules per flower, with a range from 50 to 189 for T. flexipes. The ovule number represents the potential number of seeds which could be produced from a given flower. However, an average of only 43.9 seeds with an average weight of 4.20 mg were actually produced (range was 6 to 85) for an estimated seed

setting rate of 34.11 percent. Although flexipes had the highest average number of ovules per flower of seven eastern North American pedicellate-flowered species (4 erect and 3 declinate), its seed setting rate was the second lowest. This relatively low fertilization rate suggests that flexipes has a low self-compatibility combined with inefficient outbreeding pollination systems. By comparison, T. erectum produced an average of 80.3 seeds from an average of 105.1 ovules per flower, for a seed setting rate of 76.40 percent. In addition, the average weight of a single seed of erectum was 5.04 mg, about 20 percent heavier than for flexipes. It should be noted, however, that in terms of absolute numbers, the average production of approximately 44 seeds per flower for flexipes is surpassed only by erectum, of the seven eastern North American pedicellate species for which Ohara has provided data.

Ohara (1989) also stated that "the detailed mechanisms of seed germination have not been clarified". However, he went on to say that studies by Samejima and Samejima in 1962 and 1987 on the Trillium genus showed that in the first year, only roots develop from the seed and that it is not until the second year that cotyledons emerge as above-ground organs. Since no seedlings appear after the first winter, one might prematurely conclude that the seed was inviable. Pringle (1984) referred to this unusual trait, where two cold periods are required to complete the germination process, as "double dormancy". He also described a detailed method for propagation from seed developed by Zimmerman in 1968 for greenhouse purposes using two, three-month cold storage stratifications in damp peat moss or light, humic soil to break the dormancy, with the optimum temperature being about 7°C. The two cold periods should be interspersed by a five month period in the greenhouse and the seeds should be sown as soon as they ripen in August or September and not be allowed to dry out during any stage of the entire process. When the seed pots are returned to the greenhouse after the final cold period, seedlings should appear within a few weeks. A method more closely resembling natural conditions would be to plant the seeds in flats and place them in a coldframe where they should be kept moist and mulched with about 15 cm of leaves (oak is recommended) for each of two consecutive winters.

No reports of germination rates were found in the literature. However, various researchers (Kawano et al., 1992; Ohara, 1989; Ohara and Higashi, 1987) report aggregations or "clumps" of seedlings near the parent plants of several Trillium species, suggesting that under natural conditions the seeds are quite viable with a good number of them actually germinating.

Seedling ecology

Abiotic factors necessary for seedling development are generally those which are required by the mature plants. T. flexipes seedlings would thus require a stable deciduous forest community in which spring light levels are relatively high and where the remainder of the growing season following canopy closure is characterized by low light levels, combined with mesic, circumneutral soils with a rich humic content. There is also the requirement for two full years from the initiation of germination for complete seedling development because of the "double dormancy" characteristic of Trillium species. In addition, various biotic factors play a significant role in seedling ecology, including those seed dispersal mechanisms mentioned previously which determine both seedling distribution and the ultimate population structure.

Survival and nature of mortality

The species' occurrence in deciduous woodlands where a change from an open spring canopy to a relatively closed summer canopy prevails, suggests the need for the resultant seasonal variation in light levels at all life stages. There is thus a need for maintaining this condition through adequate habitat protection since clearing or extensive cutting of the forest could ultimately destroy the entire population. Seedling mortality is reduced by the relatively short-distance dispersal of seeds by ants because it reduces competition between seedlings that would otherwise germinate in clumps near the parent plant (Higashi et al., 1989). Browsing would be detrimental to survival if it occurred prior to maturation of the capsules but would be beneficial afterward and even essential to the establishment of the species farther afield if the seeds were not destroyed in the process. Known insect predators of the reproductive organs of T. erectum include larvae of two Tortricid moth species that occur throughout the range of erectum in Ontario (Covell, 1984; Davis, 1981). Presumably T. flexipes would also be a suitable host plant, although no evidence of this has been found at the two extant Ontario populations. This type of predation effectively destroys all ovules of a given flower which represents mortality at a very early stage of reproduction. Disease organisms are also known to cause mortality in Trillium species. These include mycoplasmas, best known for causing the various degrees of petal greening and bizaare distortions of plant parts in T. grandiflorum, and which are thought to be spread by leaf hoppers (Gad and Cruise, 1974; Case and Case, 1993). The Cases warn against introducing such plants of grandiflorum into the wildflower garden for fear of the mycoplasmas infecting other Trillium species which may be present. They also mention that all trilliums are highly susceptible to a Botrytis fungus of the leaves that can kill almost all plants in some years,

resulting in weaker plants with fewer blooms the following year.

Overall assessment of reproductive success

The Strathroy population of T. flexipes appears to be reproducing quite successfully. The habitat remains relatively undisturbed and the population is quite large, containing good numbers of both the earlier, sterile age classes (from one to approximately nine years) and very robust, mature flowering plants (ca. 500), with the latter usually being at least ten years of age, the average time required for trilliums to reach maturity (Ohara, 1989).

The presence of approximately 75 flowering individuals along with some non-flowering individuals of earlier age classes at the Dunwich Township site, is likewise an indication of reproductive success in this population, albeit a smaller one.

7. POPULATION ECOLOGY

Summary

In Canada, T. flexipes occurs in rich, mesic, circumneutral, sandy loam soils adjacent to watercourses. Population maintenance and expansion of the species is known to be dependent upon a mutualistic association with ants and possibly with white-tailed deer for short and long range seed dispersal respectively. The timing of herbivory by deer relative to the maturation of capsules would result in either a positive or negative interaction. Various flying insects are thought to be cross-pollinating agents, supplementing flexipes' self-pollinating capability. A blight-like fungus, mycoplasmas, two moth species and ground beetles have been known to interfere with normal growth and reproductive processes in trilliums. Hybridization of T. flexipes has been observed in natural populations as well as achieved artificially in a horticultural setting.

Positive and neutral interactions

T. flexipes is probably facultatively associated with bumblebees (Bombus spp.) and some butterflies for pollination because of the declining peduncle at anthesis (Kawano et al., 1992), but is not obligatorily so because of a degree of self-compatibility possessed by this species. It has also been shown to be obligatorily associated with ants for short range dispersal of seeds (Higashi et al., 1989; Ohara and Higashi, 1987) as a means of reducing seedling mortality by decreasing the competition that would otherwise occur if all seeds were left to germinate where they fell in a very small area below the parent plant. There is probably also an obligatory association with larger mammals such as white-tailed deer for

long range seed dispersal, although this still remains to be definitively shown.

Negative interactions

Seedlings, juveniles and mature plants of all trilliums are known to be considerably weakened by a Botrytis fungus that attacks the leaves (Case and Case, 1993), destroying their photosynthetic capabilities. The entire above-ground portion of some plants may be killed in a given year resulting in a reduction in the number of blooms produced the following season. Case and Case also mention that lilies, especially non-native ones, are strong carriers of this fungus. Lilium michiganense (Michigan Lily) and several other members of the lily family, including Maianthemum racemosum, M. stellatum, Polygonatum pubescens and Uvularia grandiflora, are associates of T. flexipes at Strathroy and so may be potential sources of infection. Mycoplasmas have been shown to interfere with sexual reproduction in Trillium species and continue to spread from year to year in a population with no seed being produced by the infected individuals. Herbivory by deer prior to maturation of capsules would be detrimental to a population because of interference with reproductive processes. Ground beetles have been reported to interfere with seed dispersal by ants since they eat the elaiosomes from the seeds without moving them, thereby rendering the seeds unattractive to the ants and increasing the seedling mortality rate because of the resultant clumping of seedlings near the parent plant (Ohara and Higashi, 1987). Potential predation by Tortricid moths (Clepsis spp.) on the flowers of T. flexipes where the stamens and ovaries are entirely consumed, would interrupt the reproductive cycle at its earliest stage (Davis, 1981).

Hybridization

Case and Case (1993) report that most of the known hybrid Trillium populations involve the two pedunculate species T. flexipes and T. erectum. They have seen natural hybrid swarms in Michigan, Ohio, Kentucky and Tennessee where the ranges of these two species either meet today or have in the fairly recent past. They also report that the incidence of apparent mutants seems to increase in the same areas and suggest that many of them may really be complex hybrids. These two species and some subspecies and varieties have also been artificially hybridized in the Cases' woodland garden near Saginaw, Michigan, where they have produced a multitude of color and form combinations. Several coloured plates of these are shown on pages 200 to 204 of the above publication. Of special interest is the result of their hand-pollination of typical white-flowered plants of flexipes with typical red-flowered erectum. Offspring were produced with colour patterns identical to those that were thought to be natural forms of flexipes (i.e. forma walpolei and forma billingtonii). They had previously noted that Farwell's forms occurred only in

those Michigan counties where the ranges of flexipes and erectum overlapped and had hypothesized that they may have in fact been hybrids. This they were subsequently able to prove.

8. LAND OWNERSHIP AND MANAGEMENT RESPONSIBILITY

The Strathroy population of T. flexipes occurs in its entirety within the Strathroy Conservation Area, owned and managed by the St. Clair Region Conservation Authority. The Dunwich Township population, on the other hand, is on privately owned land. From 1970 to 1984 the landowner had an agreement with the Ontario Ministry of Natural Resources (OMNR) under the Woodlands Improvement Act (W.I.A.) to manage the forested portion of the property. However, the forested slopes of the river valley where T. flexipes is located was designated in the MNR's management plan as "protected forest" and so was not subject to any alteration during the agreement period (Vanderjeugd, pers. comm. 1994). Both Essex County historic sites, as well as the London, Middlesex County location where the population is now considered to be extirpated, are probably under private ownership, although it is not possible to say with certainty because the precise localities are unknown. However, there is perhaps an equal chance that the historic, McGillivray Township, Middlesex County, population site is either publicly or privately owned, since a relatively long stretch of the cited "Mud Creek flats" location, that appears to contain suitable habitat, is currently within the Parkhill Conservation Area which is owned and managed by the Ausable Bayfield Conservation Authority.

9. MANAGEMENT PRACTICES AND EXPERIENCE

Habitat management

No intentional management of the species has occurred at either of the two extant stations. However, it may be that some natural events or human disturbances have been unintentionally beneficial or detrimental to its survival. No evidence of recent timber harvesting or other canopy disturbance was noted in the vicinity of either population.

However, it is possible that timber harvesting may have occurred at the Dunwich Township site prior to the MNR's 1970 W.I.A. agreement with the landowner. Agricultural tillage on the adjacent upland area may also contribute to some nutrient enrichment of this site.

It is also quite possible that the Strathroy site has undergone some timber harvesting in the past, but it has nonetheless probably remained relatively unchanged since the initial discovery of this population almost 100 years ago,

due to its bottomland location within a small floodplain that has made it undesirable for agricultural use. This population experiences regular nutrient enrichment from annual flooding of the site.

Performance under changed conditions

There is no way yet of validly assessing this for either population, since no systematic monitoring program has been undertaken to determine what cause-effect relationships may be operable in this respect. However, at Strathroy, the occurrence of more robust plants along the edge of the hiking trail would suggest that the establishment of the trail has produced conditions that are beneficial to the vigour of individual plants that are so situated. It may be that the critical factors responsible for this are increased light levels over the entire growing season and/or decreased trailside competition, but at the present time one can only speculate. These trailside plants have also been subject to greater human impacts, however. During one site visit, it was observed that many of the stems had been broken off by prohibited all-terrain vehicle (ATV) traffic using the trail.

Cultivation

Case (1988) refers to T. flexipes as "a most useful horticultural subject" and has had considerable success both in growing it in the wildflower garden and, through controlled pollination, in hybridizing it with T. erectum to produce flowers in a myriad of colour combinations and patterns (Case and Case, 1993). Case (1988) also reports that "the finest forms for garden use which I have seen come from the limestone country near Louisville, Kentucky, where the species is abundant". These plants are atypical in that flowers with large, heavy textured petals are borne on stiffly erect peduncles above the leaves, thus producing a showier display than flowers of typical plants which are largely concealed on declinate-type peduncles beneath the leaves.

The main requirement for successful cultivation of flexipes is the provision of shade and the rich, circumneutral sandy soils found in its natural habitat. Gardeners usually prefer to transplant stock from local populations because of the slow and difficult process of growing trilliums from seed which has the unusual "double dormancy" characteristic that is discussed under "Seed Biology" in Section 6 of this report. A method described by Pringle (1984) for breaking the dormancy is given in the same section. He also describes a method for the vegetative propagation of established plants by division of the rhizomes as well as a means of increasing the production of small rhizome offshoots from the main rhizome. This is done by carefully removing the soil from the top of the rhizome just after the plant has flowered and cutting a shallow groove around it below the newly developing white

growth of next season's shoot. The soil is then replaced and the plant is left until the autumn of the following year. When the rhizome is then uncovered, several small rhizomes will be found at the incision, each of which can be removed and planted separately. This method is recommended for the propagation of selected clones such as double-flowered plants.

No information was found pertaining to the ease with which cultivated material can be transplanted into natural habitats or to recommended methods and the degree of success experienced in attempting to do so.

The only location known to the author of presently cultivated material of T. flexipes, is in the private garden of Frederick and Roberta Case near Saginaw, Michigan, where, many hybrids with T. erectum are also to be found (Case and Case, 1993).

There are no species of trilliums listed for protection in the appendices to the Convention on International Trade in Endangered Species (CITES). This has resulted in the availability of Trillium species, including T. flexipes, as either mature plants or propagules (seed or rhizomes) from nurseries or garden supply retail firms in various countries. In a survey of firms dealing in trilliums in the United Kingdom, Germany and the United States by Sawkins and McGough (1993) in which responses were received from 18 of 27 U.K., 4 of 13 German and 5 of 16 U.S. firms, none offered T. flexipes for sale. However, they also reported that just four years earlier in a similar survey by Oldfield in 1989, it was determined that T. flexipes was available from a single trade outlet in the United Kingdom.

Current management practices and actions

Although no management plans currently exist for either of the extant populations, the present landowners, both public and private, are aware of the plant's existence and have an appreciation of its status and the need for special protective measures. It is therefore anticipated that a management plan will eventually be developed for the Strathroy site by the St. Clair Region Conservation Authority and, given the co-operative attitude of the current Dunwich Township owner, it should be possible to do likewise with some assistance from the Ontario Ministry of Natural Resources.

Future land use

No changes are likely to occur in the existing land use practices at either extant site in the future. It is likely, however, that the Strathroy population will experience more pressure from human use of the site as the population of the Town of Strathroy, in which it is located, continues to grow. By comparison, the Dunwich Township population is located at

some distance from the nearest urban area.

10. EVIDENCE OF THREATS TO SURVIVAL

Summary

The greatest threat in the past, presently or potentially, is from habitat destruction or modification. The result of the former is usually immediate elimination of the species, as is suspected to have occurred at the London site and possibly at the two Essex County sites as well. On the other hand, habitat modification, whereby any condition critical to the species' survival is altered and an unfavourable environment is subsequently maintained over a sufficient period of time, usually results in a more gradual process of elimination that often goes unnoticed until it is too late for remedial action. This is the type of threat that the two extant populations are most likely to experience. The Dunwich Township population could still be experiencing negative effects from pre-1970 woodlot management practices that may have occurred there, long before it was known that the trillium even existed at this site. Past and on-going disturbance of the habitat at the Strathroy Conservation Area from both permitted and prohibited recreational use of the site, coupled with the potential threat of plant removal for wildflower gardening purposes, may likewise contribute to the gradual decline of the species there. Other potential threats to both extant populations include disease organisms and insect pests as well as untimely white-tailed deer herbivory.

Habitat destruction or modification

The historical population at London has apparently succumbed to the encroachment of development within the rapidly expanding City of London that has resulted in the destruction of its habitat. Likewise, development pressure with its consequent habitat destruction in the densely populated area of Essex County along the Detroit River, may have caused the demise of the two historical populations that have not been seen now for almost 150 years. The habitat at the McGillivray Township site, on the other hand, still appears to be relatively intact and so holds the most promise for eventual re-discovery of the population that was last reported from the site over 100 years ago.

Although the habitat at the extant population sites remains relatively undisturbed, both sites have probably undergone some habitat modification in the past, the effects of which are still evident today. Since the Strathroy site became a publicly-owned Conservation Area, a hiking trail network has been constructed through the area, including that

portion occupied by the T. flexipes population, in order to promote passive recreational use. This ease of access to the site was no doubt a contributing factor to the recent rediscovery of the population in 1989 but it has also increased the human impact. Where the trail passes directly through the population, inadvertent damage to trailside plants has occurred, both from trampling by hikers and from the unauthorized use of all-terrain vehicles. Since the ATV's are too wide for the trail to accomodate, they do considerable damage, leaving a continuous swath of crushed vegetation in their wake along one and sometimes both sides of the trail. The anticipated future growth in the population of the Town of Strathroy will likely result in a greater demand for recreational use of the Conservation Area, putting greater pressure on the T. flexipes population unless some mitigative measures are implemented. Increased competition from alien plant species such as garlic mustard (Alliaria petiolata) may also pose a future threat to the trillium.

Habitat modification at the site of the Dunwich Township population may have been produced by pre-1970 selective timber harvesting that has resulted in today's more open canopy of approximately 75% closure, compared to that which prevails at Strathroy. This condition along with direct damage caused by logging equipment, may have been detrimental to this population. However, the lack of historical data for the trillium at this site makes it impossible to assess the impact.

Overutilization of species

The increasing popularity of wildflower gardening and of the use of Trillium species for this purpose in particular, may pose a future threat to both extant populations because of the demand by local gardeners for mature plants that can be readily transplanted from nearby natural areas such as these. However, the Strathroy population is likely to be at greater risk in this respect because of its urban setting, even though removal of plants from the Conservation Area is prohibited.

Disease or predation

No diseases or insect damage were noted at either of the populations in 1993 and 1994. Nor was any evidence of herbivory observed. However, there is still the potential for any of these to occur at any time in the future. Possible disease agents would include the Botrytis fungus and mycoplasmas, while insect damage could result from Clepsis moth infestations. All of these organisms and herbivory by white-tailed deer (Odocoileus virginianus) before maturation of seed could present a threat if one or more of them were widespread within either population for several successive years.

Other natural or man-made factors

The relatively small size of the Dunwich Township population with approximately 75 flowers in 1993, may represent a critically low number for this species, placing its future viability in jeopardy. The relatively small area occupied by this population also renders it more vulnerable to destruction as a result of disease and insect infestations and white-tailed deer herbivory.

11. PRESENT LEGAL OR OTHER FORMAL STATUS

Summary

Trillium flexipes was thought to be extirpated from Canada/Ontario for over 90 years (Argus and Pryer, 1990; Patrick, 1987). However, it was recently rediscovered at one of the five historical sites and a new population was also found. It has consequently been rated by the Nature Conservancy ranking system as **extremely rare** in both Canada (**N-1**) and Ontario (**S-1**), but has yet to receive legal protection at either the federal or provincial level of government.

Although relatively common in some parts of its range in the eastern United States, including the states of Ohio (Cooperrider, 1982; Braun, 1967), southern Michigan (Voss, 1972; Case and Burrows, 1962), Illinois (Swink and Wilhelm, 1974; Mohlenbrock, 1970), Kentucky (Browne and Athey, 1992; Wharton and Barbour, 1971) and eastern Missouri (Steyermark, 1963), it is rare to endangered in the states of Arkansas, Delaware, Georgia, Maryland, Mississippi, New York, North Carolina, Pennsylvania, South Dakota, Virginia and West Virginia, of which only four currently afford it some measure of legal protection.

International status

Trillium flexipes has been given a **G-5** rating by the Natural Heritage Information System (1994), meaning that the species is "demonstratably (sic) secure" on a global basis. It currently receives no legal protection internationally and was not included in a 1978 list of Canadian flora affected by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to which Canada is a signatory (Argus, 1978). However, a proposal was made in 1991 by the Natural Resources Defense Council in the U.S. to place the genus Trillium on Appendix II of CITES (Sawkins and McGough, 1993). The genus Trillium was also included as part of a proposal by the European Community in 1992 to revise EC Regulation 3626/82 implementing CITES. This would make all Trillium imports subject to an import declaration system (ibid.). It is not known if these proposals have yet been implemented.

National status

Canada

T. flexipes has no legal protection in Canada under federal law. It is currently considered "extremely rare" in Canada with an **N-1** rating according to the Natural Heritage Information System Database (1994). As recently as 1989, the species was thought to be "apparently extirpated, without expectation that it will be rediscovered" since it had not been collected in Canada since 1898, but was nevertheless given a Canadian Priority Rating of 2 (Argus and Pryer, 1990).

United States

T. flexipes is not listed for protection under the U.S. Endangered Species Act. However, the Lacey Act does prohibit the transfer of any Trillium species across the border of any state if the plant has been collected in contravention of a state endangered species law, as would be the case in Maryland where flexipes is protected under such a law (Sawkins and McGough, 1993).

Provincial/State status

Ontario

- Present designated or proposed legal protection: None.
- Other status recommendations:
  - **S-1** "**extremely rare**" (Natural Heritage Information System Database, 1994).
  - **S1** Nature Conservancy Rank - "**Critically imperiled** because of extreme rarity (5 or fewer occurrences)." (Argus and Pryer, 1990).
  - **Rare** (Patrick, 1987. In Argus et al., 1982 - 1987).

Arkansas

- Present designated or proposed legal protection: Unknown.
- Other status recommendations:
  - **S1** Nature Conservancy Rank - "**Critically imperiled** because of extreme rarity (5 or fewer occurrences)." (Argus and Pryer, 1990).
  - **Rare** (Patrick, 1987).

Delaware

- Present designated or proposed legal protection: Unknown.
- Other status recommendations:
  - **SH** Nature Conservancy Rank - "**Historical occurrence**, not having been verified since the turn of the century but with the expectation that it may be rediscovered." (Argus and Pryer, 1990). "**Possibly extirpated**" (Patrick, 1987).

Georgia

- Present designated or proposed legal protection: Unknown.
- Other status recommendations:
  - **S1** Nature Conservancy Rank - "**Critically imperiled** because of extreme rarity (5 or fewer occurrences)." (Argus and Pryer, 1990). "Only recently discovered in Georgia" (Patrick, 1987).

Maryland

- Present designated or proposed legal protection: under **State Endangered Species Law** (Sawkins and McGough, 1993).
- Other status recommendations:
  - **S1** Nature Conservancy Rank - "**Critically imperiled** because of extreme rarity (5 or fewer occurrences)." (Argus and Pryer, 1990). The species is restricted to a very small area on the west side of the Susquehanna River in the northeastern corner of the state (Reed, 1956).
  - **Rare** (Patrick, 1987).

Mississippi

- Present designated or proposed legal protection: Unknown.
- Other status recommendations:
  - **S1** Nature Conservancy Rank - "**Critically imperiled** because of extreme rarity (5 or fewer occurrences)." (Argus and Pryer, 1990). "**Critically imperilled?**" (Sawkins and McGough, 1993).
  - **Rare** (Patrick, 1987).

New York

- Present designated or proposed legal protection: on the **list of protected plants of New York State**, meaning that it is illegal to collect it on state or private land without the permission of the landowner (Young, 1994). "**State Exploitably Vulnerable & protected**" (Sawkins and McGough, 1993).
- Other status recommendations:
  - **SH** Nature Conservancy Rank - "**Historical occurrence**, not having been verified since the turn of the century but with the expectation that it may be rediscovered." (Argus and Pryer, 1990). "Possibly extirpated in New York" (Patrick, 1987). Pechuman (ca. 1961) stated that "Whether this species is found in Western New York is open to question.". However, two

of the five historical populations were rediscovered in 1993 (Young, 1994), so it is still extant in the state.

E-3 "**Endangered** (the species is in danger of extirpation from New York State)." (Mitchell, 1986).

North Carolina
- Present designated or proposed legal protection: "**State Candidate**" (Sawkins and McGough, 1993).
- Other status recommendations: "under review"; "specimens from North Carolina have recently been verified" (Patrick, 1987).

Pennsylvania
- Present designated or proposed legal protection: None.
- Other status recommendations:
  - **S3** Nature Conservancy Rank - "**Rare or uncommon** (on the order of 21 to 100 occurrences)." (Argus and Pryer, 1990).
  - **Rare** (Sawkins and McGough, 1993; Patrick, 1987; Wherry et al., 1979).

South Dakota
- Present designated or proposed legal protection: "**Undetermined**" (Sawkins and McGough, 1993).
- Other status recommendations:
  - **SU** "**Uncertain** status, **possibly in peril**; more information needed; no data are available on the number of occurrences." (Argus and Pryer, 1990).

Virginia
- Present designated or proposed legal protection: Unknown.
- Other status recommendations:
  - **S1** Nature Conservancy Rank - "**Critically imperiled** because of extreme rarity (5 or fewer occurrences)." (Argus and Pryer, 1990). "Specimens from Virginia have recently been verified." (Patrick, 1987).

West Virginia
- Present designated or proposed legal protection: Unknown.
- Other status recommendations:
  - **SX** Nature Conservancy Rank - "**Apparently extirpated**, without expectation that it will be rediscovered." (Argus and Pryer, 1990). "**Critically imperilled**" (Sawkins and McGough, 1993). "Specimens from West Virginia have recently been verified." (Patrick, 1987).

II. ASSESSMENT OF STATUS

12. GENERAL ASSESSMENT

Trillium flexipes, although relatively common in some parts of its range in the eastern United States, including the states of Ohio, southern Michigan, Illinois, Kentucky and eastern Missouri, is rare to endangered in eleven other states. It reaches its northern limit in the Carolinian Zone of southwestern Ontario where it is a very rare species. Just six populations have ever been recorded for the species in Canada, only two of which were confirmed as being extant in 1993 and 1994. One of the other four is believed to have been extirpated because of habitat destruction. The two populations from Essex County have not been reported since they were found in 1848 and 1849, and the lack of precise location information makes it difficult to search for them. It is probable that the Amherstburg population no longer exists because of extensive development in this area. The McGillivray Township population has not been seen since 1892, and it was not refound during a recent search of the general area.

Of the two extant populations, the Strathroy Conservation Area population is the largest and most vigorous, with over 500 flowering stems recorded in 1993. At the same time, the Dunwich Township population contained only about 75 flowering stems, none of which attained the same robust stature of many in the Strathroy population. The limited supply of suitable habitat, characterized by mature, deciduous woodland that is restricted to permanent watercourses within the species' very limited range in the southwestern corner of southwestern Ontario, the increasing development of floodplain forests for recreational uses that are near densely populated urban areas such as Strathroy, the growing demand for wild plant stock for horticultural purposes, the apparent ineffectiveness of long range dispersal mechanisms for establishment of new populations farther afield, and the ever-present threat from diseases, insect pests and predators, together pose a serious threat to the survival of T. flexipes in Canada.

13. STATUS RECOMMENDATION

It is recommended that Trillium flexipes be officially recognized as **Endangered** in Canada. As recently as 1989 it was thought to have been extirpated from Canada since it had not been seen in over ninety years. It is currently known to exist at just two sites that are separated by a distance of 27 kilometres. Only one of these contains a vigorous, self-sustainable population spread over approximately three

hectares, but it occurs on public land in an urban area where it is threatened by the ever increasing human impacts on the site. The other less viable population is restricted to a relatively small area of approximately 0.1 hectare (0.25 acre) on private land. There is a paucity of suitable habitat within the very restricted and apparently decreasing range of the species in Canada. Unless adequate protection is provided at the existing sites, the permanent loss of these two populations may soon become a reality.

14. RECOMMENDED CRITICAL HABITAT

This species requires mature, deciduous woodland with a relatively closed canopy (75% - 100% closure) on mesic, circumneutral, sandy loam soils usually associated with watercourses. Its range in Canada is presently, and has historically been, restricted to the western half of the Carolinian Zone. New populations are, therefore, more likely to be discovered here than elsewhere. This critical habitat type is relatively rare within the known range of the species, where clearing of forests has been extensive in the past and continues unabated today in this densely populated area of the province. The publicly owned property at the Strathroy Conservation Area represents the best opportunity for protection of the approximately three hectares (7.5 acres) of habitat presently supporting the population within the floodplain forest of the Sydenham River. Any additional forest cover, beyond that actually occupied by the trillium population within the Conservation Area, should be retained as a buffer to the adjacent residential area, and so should also be defined as critical habitat. Protective mechanisms should likewise be developed for the Dunwich population with the assistance of the Ontario Ministry of Natural Resources, because of the previous experience it has had in working with the landowner under a W.I.A. management agreement. The population itself occupies approximately 0.1 hectare (0.25 acre) on the upper portion of the southern slope of the Thames River valley. However, in this instance it is recommended that the critical habitat should include the entire forested slope for a distance of at least 500 metres upstream and downstream of the population to provide both an adequate buffer and the opportunity for expansion of the trillium to other suitable microhabitats within this area.

15. CONSERVATION RECOMMENDATIONS

The author's recommendations for the conservation of this species have been transmitted separately to COSEWIC and are available only at the discretion of this agency. Inquiries regarding these recommendations should be addressed to COSEWIC.

III. INFORMATION SOURCES

16. REFERENCES CITED IN REPORT

Ambrose, J.D. and S.W. Aboud. 1982. Status Report on the Blue Ash Fraxinus quadrangulata. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 21 pp.

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Patrick, T.S. 1994. Personal Communication. He is an expert on the Trillium genus in eastern North America and currently works as a botanist for the Georgia Natural Heritage Program under the auspices of the Georgia Department of Natural Resources, Wildlife Resources Division in Georgia. He has verified the identities of all Canadian specimens of T. flexipes referred to in this report.

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Reznicek, A.A. 1994. Personal Communication. Tony Reznicek is Associate Curator of vascular plants at the University of Michigan Herbarium (MICH) in Ann Arbor, Michigan. He provided information about the current knowledge of T. flexipes in the area of the historic Detroit River/Amherstberg populations.

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Schuyler, A.E. 1994. Personal Communication. He is the correspondent for the Philadelphia Herbarium (PH) of the Botany Department at the Academy of Natural Sciences, Philadelphia, Pennsylvania. He did a search for and provided information about the Rafinesque type specimen of T. flexipes.

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18. COLLECTIONS CONSULTED

During research for the Atlas of the Rare Vascular Plants of Ontario in 1986, T.S. Patrick searched the major herbaria where Ontario specimens of Trillium flexipes might be expected. Specimens were located at Agriculture Canada (DAO) - 3, the University of Edinburgh (E) - 2, McGill University in Montreal (MTMG) - 4, and the University of Toronto (TRT) - 1. The information obtained from these collections is stored on computer disks at the Botany Division of the National Museum of Natural Sciences. A printout of the data was provided for this study. In addition, the University of Michigan (MICH), the University of Guelph (OAC), the University of Western Ontario (UWO) and the Wilfred Laurier University (WLU) herbaria were consulted as was the personal herbarium of M.J. Oldham which is housed at his current residence in Peterborough, Ontario.

19. FIELDWORK

Site inspections were made of the following populations to determine presence and extent, collect voucher specimens, describe the habitat, list associates and obtain photographic documentation:

Population	Date	Investigators
Strathroy Conservation Area Middlesex County	15 May, 1990	D. McLeod and M.J. Oldham
	24 May, 1991	M.J. Oldham
	11 May, 1993	D. McLeod and M.J. Oldham
	16 May, 1994	D. McLeod

Dunwich Township Elgin County	7 June, 1993	D. McLeod, M.J. Oldham, F. Simpson and L. Spicer

Unsuccessful searches were made for T. flexipes at the following locations:

Location	Date	Investigators
McGillivray Township Middlesex County	11 May, 1993	D. McLeod and M.J. Oldham
City of London Middlesex County	14 May, 1993 21 May, 1993	M.J. Oldham D. McLeod

20. KNOWLEDGEABLE INDIVIDUALS

Information on Trillium flexipes in Ontario may be obtained from the following individuals:

Muriel Andreae
St. Clair Region
Conservation Authority
205 Mill Pond Crescent
Strathroy, Ontario
N7G 3P9
(519) 245-3710

- familiar with the Strathroy population of T. flexipes.
- biologist for the C.A. that owns the site.
- knowledgeable about the flora of Southwestern Ontario.

Frederick W. Case, Jr.
Saginaw
Michigan, U.S.A.

- expert on the Trillium genus in the State of Michigan and the western Great Lakes area including Southwestern Ontario.
- authority on the cultivation and hybridization of T. flexipes.

Dave Martin
Upper Thames River
Conservation Authority
R.R. #6
London, Ontario
N6A 4C1
(519) 451-2800

- rediscoverer of the Strathroy population of T. flexipes in 1989.
- Dave is the Education Specialist for the C.A. and is a long-time local naturalist.

Dave McLeod
48-92 Stroud Crescent
London, Ontario
N6E 1Y8
(519) 681-4218 (Home)
(519) 773-9244 (Work)

- report author
- familiar with both extant populations of T. flexipes.
- knowledgeable about the flora of Southwestern Ontario.
- Area Ecologist at the Ontario

	Ministry of Natural Resources office in Aylmer, Ontario.
Michael J. Oldham Natural Heritage Information Centre Box 7000 Peterborough, Ontario K9J 8M5 (705) 745-3939	- familiar with both extant populations of Trillium flexipes. - very knowledgeable about the flora Ontario. - Mike is the botanist and herpetologist at the NHIC.
Thomas S. Patrick Georgia Natural Heritage Program 2117 U.S. Hwy 278, SE Social Circle Georgia 30279, U.S.A. (404) 918-6411	- expert on the Trillium genus in eastern North America. - determined all specimens of T. flexipes referred to in this report. - Dr. Patrick is a botanist at the Georgia Department of Natural Resources, Wildlife Resources Division. - author of the Trillium flexipes account in the Atlas of the Rare Vascular Plants of Ontario.
James B. Phipps Plant Sciences Dept. University of Western Ontario London, Ontario N6A 5B7 (519) 679-2111 Ex. 6484	- familiar with the Dunwich Township population of T. flexipes. - knowledgeable about the flora of Ontario. - Dr. Phipps is Curator of the herbarium (UWO).
A.A.(Tony) Reznicek Herbarium University of Michigan Ann Arbor, Michigan 48109 (313) 764-5544	- provided information about the current status of T. flexipes in Essex County. - Dr. Reznicek is Assistant Curator of the herbarium (MICH) and is very knowledgeable about the flora of Ontario and Michigan.
Fred Simpson R.R. #1 Dutton, Ontario N0L 1J0 (519) 762-3008	- owner of the Dunwich Township population site.
Lorne Spicer 100 Union Road Sheddon, Ontario N0L 2E0 (519) 764-2070	- familiar with the Dunwich Township population. - long-time Elgin County naturalist.

William G. Stewart 6 Yarwood Street St. Thomas, Ontario N5P 2Y3 (519) 631-0775	- familiar with both extant populations of T. flexipes. - discoverer of the Dunwich Township population in 1987. - co-author of A Guide to the Flora of Elgin County. - knowledgeable about the flora of Southwestern Ontario.
Ron Vanderjeugd Ontario Ministry of Natural Resources 353 Talbot Street West Aylmer, Ontario N5H 2S8 (519) 773-9241	- familiar with both extant T. flexipes populations. - knowledgeable about the flora of Elgin and Middlesex counties. - acquainted with the terms of the expired W.I.A. agreement with Mr. Fred Simpson and the forestry management history of his Dunwich Township property.

21. OTHER INFORMATION SOURCES

None.

22. SUMMARY OF MATERIALS ON FILE

Field data, original slides, herbarium record data, correspondence and references cited in this report are in the possession of the author.

IV. AUTHORSHIP

23. INITIAL AUTHORSHIP OF STATUS REPORT

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24. MAINTENANCE OF STATUS REPORT

This report will be maintained by the author. Any new information, revisions or corrections should be sent to him at the above address for updating.