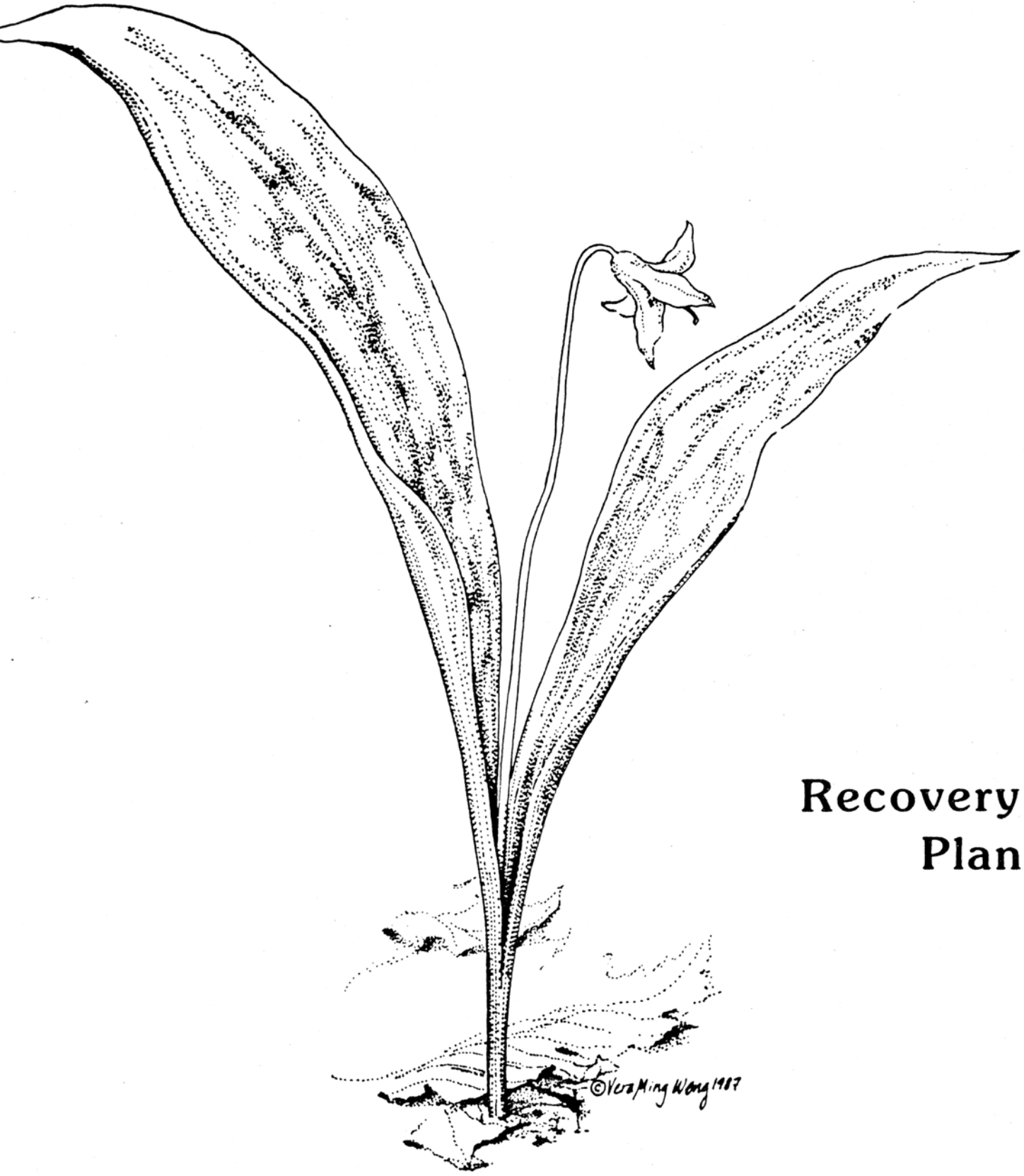
Minnesota Trout Lily



Recovery Plan

Minnesota Trout Lily (*Erythronium propullans* Gray) Recovery Plan

Published by

Region 3

U.S. Fish and Wildlife Service

Twin Cities, Minnesota 55111

Approved: James C. Gritman

Regional Director, U.S. Fish & Wildlife Service

DEC 16 1987

Date

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Literature Citations should read as follows:

U.S. Fish and Wildlife Service 1987. Erythronium propullans Recovery Plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 31pp.

Additional copies may be purchased from:

Fish and Wildlife Reference Service
6011 Executive Boulevard
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Recovery Plan

Minnesota Trout Lily (*Erythronium propullans*)

PART I: INTRODUCTION

History

The Minnesota trout lily was discovered in 1870 by Mary B. Hedges, a botany instructor at St. Mary's School in Faribault, Minnesota (Rice County). She discovered the plant in the Straight River valley, about 600 feet north of the school's garage; this is the type locality. The school's principal, S. P. Darlington, promptly sent a specimen to Asa Gray of Harvard University who published a description of the new species in 1871. In his paper, Gray noted how "peculiar" the new species was, and how it was an unexpected discovery. The type specimen is currently in the Harvard Herbarium, and the trout lilies still occur at the type locality. There were several other specimens collected at (or near) this site during the next 20 years, principally by J. H. Sandberg, G. B. Aiton and E. S. Beane.

A second site was discovered in 1892 by A. L. Ballard, who collected a specimen at an unknown locality near Zumbrota (Goodhue County). Zumbrota is about 30 miles due east of the type locality. Extensive searches have failed to relocate this population, which may have been destroyed by urban expansion.

A third site was discovered somewhere near Cannon Falls (Goodhue County) by G. B. Aiton in 1895. The only site currently known in the Cannon Falls area is about 4 1/2 miles south of town along the Little Cannon River. This site is about 25 miles northeast of the type locality. A line connecting these three collection sites forms a triangle that encompasses an area of about 275 square miles. This area is the extent of the known historical range of the species.

Between 1918 and 1945 several additional sites were discovered within this range, principally by C. O. Rosendahl. Most of the remaining known sites were discovered between 1960 and 1980 by Thomas Morley, who conducted extensive searches for this species (Morley 1978). Morley meticulously mapped all the known sites, as well as all the sites where he searched but failed to find Minnesota trout lilies. He also attempted to relocate all the historical collection sites.

Since 1980, numerous botanists have conducted field work for the purpose of finding new sites and to better document old sites, but only 1 new site has been found. For this reason, it is believed that few undiscovered sites exist. However, it is difficult to account for all the old collection sites, because several of the old herbarium specimens are so poorly labeled.

Description of Species

The Minnesota trout lily is an herbaceous, spring blooming, perennial member of the lily family. Its most constant taxonomic character is its method of vegetative reproduction, from which the species takes its name, "propullans" (sprouting forth). The long subterranean portion of the flowering stem grows at an angle toward the surface, producing an offshoot about halfway between the fleshy bulb and the point of attachment of the leaves (Morley, 1978). Only flowering plants produce this offshoot, which develops a new bulb at its tip. Only one such new bulb is formed per season.

The single flower of the Minnesota trout lily is 8-14 mm long, which is smaller than those of other trout lily species. Like other trout lily species the stamens are heteromorphic, i.e., the two sets of stamens are of unequal length. More unusual is the great variability in number of perianth parts. Rosendahl (1919) observed flowers with 4, 5 and 6 perianth parts and reported

that only 12% of observed specimens possess the full complement of 6 perianth parts characteristic of the lily family. Flower color ranges from pinkish to pale violet to almost flesh to whitish or almost gray white. The fruit is a small loculicidal capsule that often has two rather than three carpels (Rosendahl 1919) and remains in a nodding position rather than becoming erect as in the white trout lily.

The slightly mottled leaves are paired in flowering plants but single in vegetative plants. Leaves have been reported to be 1-2 cm. broad but field measurements suggest a range of 1-3 cm. The elliptic to lanceolate leaves of the flowering plant taper to a sharp point ending in a tip 0.8 to 3.5 mm long with inrolled edges (Morley 1978).

The Minnesota trout lily (Erythronium propullans) can be distinguished from the sympatric white trout lily (Erythronium albidum) by the following characteristics:

1. The single offshoot of Erythronium propullans arises from the subterranean stem of flowering plants at some distance from the original bulb whereas offshoots of Erythronium albidum arise directly from the bulb of both flowering and vegetative plants.
2. Erythronium propullans has smaller flowers that are generally pinker in hue and more variable in perianth number than Erythronium albidum.
3. Leaves of Erythronium propullans taper more gradually toward the apex than do leaves of Erythronium albidum, and the edges of the leaf tips are often inrolled.
4. Fruit of Erythronium propullans is nodding and 4.5-9 mm long, rather than erect and 10.5-27 mm long as in Erythronium albidum.

Life History

The Minnesota trout lily is a spring ephemeral, flowering from late April to mid May. The average date of first-flowering is April 23. The aerial portions of the plant are largely withered by the time the canopy leafs out in mid May to early June. The below-ground portions are perennial and are sustained by the annual formation of renewal bulbs. Each renewal bulb is produced within its parent bulb which it replaces. Vegetative production of a new individual is accomplished by the formation of a second bulb at the tip of a runner that arises from the underground stem of flowering plants. This can result in a new plant being produced at distances as great as 13.5 cm from the parent plant (Morley 1982).

The flowers of the Minnesota trout lily are available for pollination for 6-7 hours a day and are principally visited by a small bee, Andrena carlini (Banks 1980). Andrena prefers the flowers of the white trout lily (E. albidum) and only visits the Minnesota trout lily in mixed colonies where the white trout lily is more abundant. Other species of bees, flies and beetles infrequently visit the Minnesota trout lily (Banks 1980).

Although the Minnesota trout lily has perfect flowers, studies suggest that it may not produce seed when self-pollinated, or when pollinated by another member of its own species. Fertile seeds have been found only when it is pollinated by the white trout lily (Banks 1980). Indications are that pollen sterility is very high (Banks 1980). Therefore, the predominant, or perhaps only, mode of reproduction is vegetative. However, these results are based on a one year study of three small samples. It is possible that sexual reproduction does occur, but only as a rare, periodic event.

Because of the predominantly vegetative means of reproduction, the Minnesota trout lily is often found in circular clones or colonies. Some colonies are easily discernible and may be up to 4 m^2 in size and contain over 500 flowering and non-flowering individuals. Other colonies are not so discrete, and the plants may be found singly or in loose congregations of a few to several plants.

Estimating the number of plants in a given area is difficult, because only flowering plants can be reliably identified. Vegetative plants cannot be reliably distinguished from those of the white trout lily which usually occurs with the Minnesota trout lily. The percent of flowering plants at any given site has been estimated at approximately 29%, but the reported range is 10-50% (Morley 1978).

The "aggressiveness", or ability of any trout lily colony to spread vegetatively, is dependent on both the number of runners per plant and the distance these runners travel from the original bulb (Morley 1982). Because the Minnesota trout lily produces only a single runner per flowering plant, its aggressiveness is roughly a third of the white trout lily, which can produce more than one runner from each flowering and non-flowering plant (Morley 1982).

Reproductive rates of the Minnesota trout lily have been estimated by Morley's "vegetative reproductive factor", which calculates that 1.29 bulbs can be expected at the end of the growing season for each original bulb in the colony. This assumes that all original bulbs are "renewed" and each flowering plant produces an additional bulb at the tip of its runner. However, when mortality estimates are included in the equation, the actual reproductive factor may be only 1.11 (Morley 1982).

Dispersal mechanisms are unknown, but Morley (1982) suggests that dispersal may occur in the rare situation when a new bulb becomes stranded on the soil surface where it can be moved about, presumably by water. This may have been effective historically, but today the likelihood of a propagule finding a suitable habitat downstream is extremely unlikely.

Habitat

The Minnesota trout lily occurs most commonly on the lower parts of wooded north-facing slopes 15 to 27 meters high, and on adjacent floodplains. Sites are associated either with streams or abandoned stream channels. Elevations range from 860 to 1190 feet above sea level (Morley 1978). These sites are typically dominated by deciduous trees such as American elm (Ulmus americana), box elder (Acer negundo), sugar maple (Acer saccharum) and basswood (Tilia americana). It is believed that the Minnesota trout lily may be intolerant of shade, because it completes its annual life cycle in early spring before the leaves of the canopy trees are fully expanded. However, the summer shade is probably essential to maintaining an herbaceous flora compatible with the trout lily.

The Minnesota trout lily appears to grow best in habitats with a surface layer of rich, black, well-aerated soil. Preferred soils are mainly of loamy to sandy-loam to loamy-sand texture, neutral to slightly acid in reaction, well drained but with high water-capacity. Most sites are on alluvial material, especially those sites that occur within the matrix of pre-Wisconsin "grey till". The alluvial sites are subject to deposition and plants can be found on rather sandy and almost gravelly soil. It appears that plants at four locations may extend onto upland mollisols.

Populations appear to be centered on the easternmost flank of the Bemis moraine of the Des Moines Lobe, where it comes in contact with the older grey till of Kansan age. In the Zumbro River drainage, where upland soils are on grey Kansan till, trout lilies appear to be restricted to soils of alluvial origin. In the Straight River drainage, populations occur on both alluvial soils and on upland soils of the Des Moines lobe. Till throughout the area is underlain by paleozoic limestone and sandstone, and in some areas by an intervening bed of loess. None of the trout lily sites occur in contact with bedrock exposures. Present interpretation of edaphic relationships is based on use of broad county soil surveys. Soil sampling in the field has apparently not occurred at trout lily sites.

Distribution

The Minnesota trout lily occurs in colonies that range in size from one or two scattered plants to more than 500 individuals. It is estimated that about 500 such colonies exist. The major concentration of colonies occurs on north-facing hillsides or floodplains along a 7.5 mile stretch of the Straight and Cannon Rivers from just east of the city of Faribault to about two and a half miles northeast of that city. Plants occur mainly at elevations between 960 and 1000 feet above sea level. Of roughly 600 acres lying at the appropriate elevation along this 7.5 mile stretch of river it can be liberally estimated that 75 acres harbor the Minnesota trout lily.

Although areas harboring plants are referred to as a series of "sites", this terminology is misleading. Some "sites" contain many colonies, others one or two; some are separated by only a few hundred feet, others by a quarter of a mile; some sites take into account discontinuities of habitat, whereas others

are differentiated mainly by ownership. At the present time Minnesota trout lily colonies in the Faribault area occur on thirteen tracts of land, with different ownerships or management. An additional six tracts harbor the species in other drainages. Using the combined criteria of habitat discontinuity and ownership, the "sites" listed in Table 1 can be distinguished:

Table 1. Location, site name, ownership and estimated population size of each known trout lily site.

State - County - Site Name	Ownership	Estimated Number of Colonies	Comments
Minnesota			
Rice County			
1. Walcott 6	Private	See comments under site #2	Colonies are reported at two locations at the foot of a steep north-facing slope. This site is presently part of a subdivision.
2. Weaver Tract	The Nature Conservancy	See comments	This tract is managed by Riverbend Center. Trout lilies have been reported at three locations here. This site is adjacent to site #1. A total of 18 colonies have been reported from the two sites, which occupy a continuous habitat at the foot of a steep north-facing slope. No plants were found on the Weaver Tract in 1984 and 1985.
3. Type Locality	St. Mary's School (private)	2	This is the type locality for Erythronium propullans.
4. Shattuck School Site	Shattuck School (private)	15	
5. Trout Lily Preserve	The Nature Conservancy	110	The trout lily plants at this site have been monitored at this site for several years by The Nature Conservancy.
6. Haaland Trout Lily Site	Private	3	This site is registered by The Nature Conservancy.

7.	Trout Lily Natural Heritage Registry Site	State of Minnesota	27	This site is in Nerstrand Woods State Park and is managed by the DNR, but it occurs on land partially owned by the School Trust Fund.
8.	Borgstahl 16	Private	28	This site is adjacent to site #9, but the trout lily colonies here are reportedly discontinuous with the colonies at site 9.
9.	Borgstahl 17	Private	79	See comments under site #8.
10.	Van Esch Tract	The Nature Conservancy	116	This site is managed by Riverbend Nature Center, but has been monitored by The Nature Conservancy for several years.
11.	Road Construction Site	Private	2	A third colony previously occurred at this site, but has since been destroyed by road construction.
12.	Walcott 33	Private	1 or 2	This site is registered by The Nature Conservancy.
13.	Schroeder Site	Private	2	This site is registered by The Nature Conservancy, and has been monitored by them for several years.
14.	Straight River Wildflower Preserve	State of Minnesota, Department of Human Resources	?	This site is leased to Riverbend Nature Center for management. Trout lilies at this site have been monitored for several years by The Nature Conservancy.
15.	Riverbend Nature Center	State of Minnesota, Department of Human Resources	"Several"	This site has been leased to the city of Faribault and developed as a nature center (Riverbend Nature Center)

16.	Motor Bike Site	State of Minnesota, Department of Human Resources	2	This site is managed by Riverbend Nature Center, but the colonies are somewhat isolated from the other colonies.
17.	Nerstrand North Site	Private	14	This is the most recently discovered trout lily site; it was found in 1986.
	Goodhue County			
18.	Grace Nature Preserve	The Nature Conservancy	60	This was the first trout lily site preserved, and is the most intensively studied site.
19.	Little Cannon River Site (Robinson Woods)	Private	4	Recent visits to this site indicate that this population may be significantly larger than 4 colonies.

Only one historical record suggests that the Minnesota trout lily may have once had a somewhat larger range. This is the collection by A. L. Ballard in 1892 from Zumbrota, 16 miles east of the present station at Kenyon in the same drainage.

The only other record that might indicate a larger previous range is questionable. This is Rosendahl's 1935 collection (2954) from the "farm of Mr. Helcimons on bank of Little Cannon River, 5 miles east (sic) of Cannon Falls, section 6." This record is probably a previous collection of occurrence 13, which is 5 miles south of Cannon Falls, on the Little Cannon River, in section 6. Section 6 of townships lying east of Cannon River would be in the drainage of Belle Creek.

Over the past 20 years colonies have been lost from at least five of the extant "sites". These losses include the loss of one colony during road construction at site 12, the loss of one colony from motorbike activity at site 18, the loss of colonies when the floodplain just north of extant colonies at occurrence 16 was converted to row crops, the loss of several colonies from site 7 as a result of horticultural collecting, and the loss of one colony at site 8 because of trail construction.

Status

The origin of the Minnesota trout lily is unclear, but Morley (1978) presented two options: either the species originated within its current range after deglaciation about 13,000 years ago, or it survived glaciation in an unglaciated area and migrated to its present range when the climate changed. Morley favors the former explanation and supports his contention with 3 points: (1) The plants appear to be too habitat-specific to have migrated from another habitat. (2) They spread too slowly to have migrated the required distance. (3) The appearance of having spread from its center of distribution

in Faribault is not indicative of a species migrating north and south with the climate.

The Minnesota trout lily is Minnesota's only endemic plant species and has been the subject of much research. The trout lily received national attention in 1975 when it was recommended for endangered status in the Smithsonian Institutions Report on Endangered and Threatened Plant Species of the U.S. On May 3, 1985, the U.S. Fish and wildlife Service published a proposed rule to list the Minnesota trout lily as endangered. The rule became effective on April 25, 1986.

Probably the most significant reasons for the current status of Erythronium propullans are biological and historical. The species is a narrow endemic that spreads very slowly. Its only means of reproduction may be the production of a single offshoot each year. But offshoots occur only from flowering plants, which constitute approximately 29% of the population (Morley 1982). Both its restricted distribution and the age and relationship of the underlying till suggest that the species may be of late-glacial or early postglacial origin and has probably expanded its range very little beyond its center of origin.

Direct habitat destruction probably accounts for the greatest population losses over the last century. Expansion of the cities of Faribault and Zumbrota probably has destroyed colonies. One colony is known to have been destroyed by road construction.

It is difficult to assess the past impact of agricultural development. Floodplain sites are generally used for grazing rather than growing row crops. However, where cultivation has occurred at the base of the bluffs, colonies may have been destroyed, as is the case for a field 1.5 miles northeast of Faribault.

The effect of grazing probably depends on grazing intensity and the season at which cattle are turned to pasture. At present Minnesota trout lilies appear to withstand light to moderate grazing because the cattle are turned to pasture after the above-ground parts have withered.

Recreational impacts on Erythronium are increasing. Hiking trails have been developed that channel foot traffic through populations at both Nerstrand Woods State Park and the Riverbend Nature Center. Several plants were lost from Nerstrand Woods in 1985 because of the misplacement of a trail through the population. A large concentration of plants in the undeveloped portion of the Riverbend Nature Center, south of the Straight River, is vulnerable to impact from outdoor activities and casual visitors from an adjacent housing development. Three colonies in this area have been damaged by motorbikes.

It has been suggested that transport by spring meltwaters may have originally served as a natural dispersal agent for the Minnesota trout lily. But because of recent land conversion, the chances of encountering suitable downstream habitat are slim. Therefore, water movement resulting in sheet erosion, gully formation and stream bank sloughing is now considered a potential threat to the remaining population. This threat is exacerbated by upslope clearing and development that increases the erosional process.

Gross changes in local water regimes could pose even greater threats. Such changes could include inundation by reservoirs, stream diversion, flooding, dike building and channelization.

Horticultural collection is also a significant threat. Several colonies were illegally removed from the Grace Nature Preserve during the 1960's and 70's for replanting at the Minnesota Landscape Arboretum.

A potential threat may also exist from vegetation changes following the loss of elm trees from Dutch Elm disease. Elms originally constituted an important component of the forests where trout lilies occur, but are now mostly gone. In some cases, the loss of elms has been accompanied by an invasion of buckthorn (Rhamnus cathartica) and honeysuckle (Lonicera sp.) which are not native to the region.

In view of the threats facing the species, none of the 19 known trout lily sites can be considered adequately protected. Four of the sites occur on public land, including 3 at Riverbend Nature Center and one in Nerstrand Woods State Park. Riverbend Nature Center is owned by the State of Minnesota, Department of Human Resources, and leased to the City of Faribault for management. The site in Nerstrand Woods State Park occurs on land owned partially by the School Trust Fund, but is managed by the DNR, Division of Parks and Recreation. Neither of these sites is adequately protected because management priority is not formally given to the preservation of the Trout lily or its habitat. In both cases, recreational uses (i.e., foot traffic) pose potential conflicts with preservation of the trout lily.

All of the remaining sites are privately owned, and are in varying degrees of jeopardy. Four sites are currently owned by The Nature Conservancy, and are managed for purposes of conservation. These are perhaps the best protected of the privately owned sites, but the level of protection is still inadequate to deal with the potential threats.

The greatest single concentration of plants occurs on the Borgstahl farm. As many as 30% of the surviving plants occur there. The farm was put on the market in 1985, and it could be purchased by private development interests. Loss of this site would seriously hamper any recovery effort.

Several of the remaining private sites are being voluntarily protected by their landowners under a non-binding registry program administered by The Nature Conservancy. Under such an agreement, however, landowners are under no legal obligation to protect the plants, and the agreement is not transferred to subsequent landowners.

PART II: RECOVERY

Objective

The Minnesota trout lily can be considered for reclassification to threatened status when a minimum of 400 naturally occurring colonies (clones)* in at least 10 geographically and ecologically distinct sites are adequately protected and managed to assure their continued existence. Delisting can be considered when a total of 500 colonies in at least 15 sites, representing the entire extant range of the species, are adequately protected and managed.

Stepdown Outline

1. Provide adequate protection for selected sites of naturally occurring colonies of Minnesota trout lilies, and the habitats in which they occur.
    11. Seek the highest level of land protection possible.
    12. Assign protection priority on the basis of biological and management criteria.
        121. The Borgstahl property.
        122. Riverbend Nature Center.
2. Provide appropriate management at each protected site.
3. Monitor population trends at known sites.
    31. Conduct a census of Minnesota trout lilies at each site and map the location of each colony.

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* boundaries of individual colonies are sometimes indistinct, and difficult to distinguish. In such cases, 100 flowering plants will constitute the equivalent of one colony.

32. Establish permanent sampling plots and conduct periodic sampling of population and habitat parameters.

4. Conduct appropriate research into the biology, management and habitat requirements of the Minnesota trout lily to allow evaluation of trends.

41. Investigate the effects of competition from successional species in disturbed habitats, and from the common white trout lily (E. albidum) in all habitat types.

42. Investigate the effects of siltation and erosion on colonies.

43. Investigate the role of dispersal mechanisms.

44. Investigate methods of artificial propagation.

45. Investigate the relationship of the Minnesota trout lily to certain components of its habitat (i.e., soil type).

46. Determine the degree of genetic variability present within the surviving population.

5. Reestablish populations at known historic locations.

6. Provide appropriate public information.

Narrative

1. Provide adequate protection for selected sites of naturally occurring colonies of Minnesota trout lilies, and the habitats in which they occur.

11. Seek the highest level of land protection possible.

Adequate protection for colonies of Minnesota trout lily can be achieved only when a public agency holds fee title, or long-term lease, to the habitat in which the colonies occur. Any lease agreement must allow legal access for management purposes, and must also provide authority to control all non-compatible land use practices. However, ownership or lease by a public agency does not in itself constitute adequate protection. For example, public lands

are often managed for purposes of recreation, transportation, agriculture, forestry or mining, which may be incompatible with the preservation of the Minnesota trout lily. Therefore, the primary management objective for the site must be the protection and preservation of the population of the trout lily. It is also necessary that a detailed management plan be prepared for each site. Only after all these conditions have been met can the population be considered adequately protected. On state administered properties, only state Scientific and Natural Areas, administered by the Section of Wildlife in the Department of Natural Resources, meet these criteria.

Voluntary, non-binding agreements with private land owners do not provide an adequate level of protection because of the lack of legal obligation on the part of the land owner. Even direct ownership by a private conservation organization is inadequate because privately owned land can be easily condemned for public development projects. Furthermore, private organizations cannot provide the assurance of perpetual ownership and management in the manner of a public agency.

12. Assign protection priority on the basis of biological and management criteria.

The selection of sites to be protected should be based on biological and management considerations. This requires an evaluation of each site to assess parameters such as colony vigor, habitat stability and defensibility. For example, any large concentration of plants (more than 10 colonies) should be a high priority for preservation, but other factors must also be considered, such as the size of the habitat, the potential for control of adjacent upland, defensibility from recreational use, and other immediate threats to the site.

Emphasis should also be placed on protecting colonies that occur in geographical and ecological separation from other colonies. This would reduce the likelihood that any single event, natural or otherwise, would affect more than one protected site. Presumably by protecting a greater number of distinct sites we are also protecting a greater range of genotypic diversity within the species (Grant 1963, Stebbins 1950).

The amount of land necessary to assure the survival of a given concentration of plants should include the entire habitat as well as adjacent potential habitat to allow for future expansion or dispersal of the colonies. In all cases, adequate buffer against encroachment from adjacent lands must be acquired. Since most of the colonies occur on steep slopes or at the base of slopes, it is imperative that additional acreage be acquired above the slope to allow for erosion control.

A majority of the known plants occur at just two locations: Riverbend Nature Center (includes at least 5 "sites") and the Borgstahl farm (includes 2 "sites"). Protection efforts should concentrate at these two locations because recovery of the species cannot be accomplished until both these sites are protected. However, additional sites must also be protected to complete the recovery effort.

121. The Borgstahl property

In the case of the Borgstahl property, the entire portion of the property lying below the bluff top (approximate elevation 1070 feet) should be protected as primary habitat for the trout lily. Additionally, a buffer of at least 200 feet in width along the bluff top should be established to protect the primary habitat. Legal access to the site should also be secured if possible. Protection efforts should primarily be the responsibility of the Minnesota Department of Natural Resources, possibly aided by a private

intermediary such as The Nature Conservancy. Ultimately, the site should be designated a state Scientific and Natural Area.

122. Riverbend Nature Center

The property currently managed as the River Bend Nature Center is already in state ownership. But because of complicated administrative procedures and lease agreements, the trout lilies do not receive an optimal level of protection. This situation could be improved by designating the areas where the trout lilies occur as a Scientific and Natural Area, and preparing a detailed plan for future management.

2. Provide Appropriate Management at each protected site.

The Management needs of the Minnesota trout lily are largely unknown at this time. However, there is an obvious need to secure each site from the effects of gross human disturbances such as land clearing, accelerated erosion, unnatural water level manipulation etc. Once this level of security has been reached, there may be no need for active management. However, where active management is used, the effects should be closely monitored. An evaluation of management must be based on changes in the size of the colonies, the number of plants and the maintenance of important habitat parameters. Any significant decrease in these factors over a period of several years may be related to management (or lack of management). Such a decrease would also mean the recovery objective has not been met, and reclassification or delisting cannot be considered.

3. Establish monitoring stations at each protected site to determine colony and habitat trends.

31. Conduct a census of Minnesota trout lilies at each site and map the location of each colony.

Certain baseline data must be obtained before monitoring can commence. These include a census of the area and mapping of the location or distribution of the plants. This is accomplished by counting individual plants and/or colonies (when discernable) and plotting their location on a large-scale map. The map should relate to a grid system or other set of permanent markers on the ground. If the plants are widely distributed over the site, it may be necessary to assign the plants to grid compartments rather than mapping them individually. A grid should be based on permanent reference points such as brass monuments or stakes, and it should be properly surveyed for accurate mapping. The size and scale of the grid will depend on the area occupied by the plants. A large area may require grid compartments as large as 500 square meters, but 100 square meters is more desirable. Within these primary grid compartments, smaller or secondary grid compartments of 1-10 square meters can be established to facilitate censusing and mapping. Topographical features should also be represented on the map.

32. Establish permanent sampling plots and conduct periodic sampling of population and habitat parameters.

Once the locations of all the plants have been determined, sample plots should be solected to monitor population fluctuations. The number and size of plots should be chosen to represent a statistically valid sample of all the plants or colonies present. Each sample plot should be censused periodically for the number of flowering individuals. If any pure colonies of the Minnesota trout lily (without the white trout lily) occur on the site, these should be monitored for both flowering and non-flowering plants. This could provide a rough index to the proportion of non-flowering plants at the site. Some habitats may be too fragile to allow frequent sampling. This is

especially true on steep, erodable slopes. In this case, sampling frequency should be decreased.

At certain sites, it may also be necessary to monitor the habitat as well as the plants. Such habitat monitoring may involve looking for changes in human uses of the area, such as dirt bike trails or encroachment from adjacent lands. Monitoring of erosion and siltation may also be important. This can be accomplished by sinking graduated brass stakes into the ground (below the frost line) at locations of concern, and measuring how much soil has eroded from its base each year, or conversely, how much silt has accumulated.

4. Conduct appropriate research into the biology, management and habitat requirements of the Minnesota trout lily to allow evaluation of trends.

   41. Investigate the effects of competition from successional species in disturbed habitats, and from the common white trout lily (E. albidum) in all habitat types.

   There are several colonies of the Minnesota trout lily that occur in areas that were previously forested but no longer support a continuous tree cover because of intensive cattle grazing. This does not appear to pose an immediate problem for the trout lily because it is adapted to full sunlight, and normally completes its annual cycle before cattle are put out to pasture in late spring. Furthermore, cattle grazing appears to reduce competition allowing the trout lily to maintain its numbers and possibly increase. However, this is not a stable habitat for the trout lily, and when cattle are removed, the habitat will change. Immediately following the removal of cattle, there will be an increase in sod forming grasses such as Kentucky bluegrass (Poa pratensis), then a succession of coarse herbs, then shrubs and eventually a return to forest cover. Since the trout lily

presumably evolved in a stable woodland habitat, it may not be able to survive the early stages of forest succession. This may present a problem for the long-term management of colonies that are currently being grazed. Therefore, there is a need to know how colonies respond to the changing conditions associated with succession from pasture to forest. The successional process that follows loss of canopy trees from Dutch Elm disease may present similar problems, and could be studied using the similar methods.

It is unknown at this time what effect, if any, the presence of the white trout lily has on the Minnesota trout lily. The two species occur sympatrically at every site, and they appear so similar in habit and ecology that it is likely they compete for some of the same resources (i.e., nutrients, moisture, space, light, etc.). Since the white trout lily is more aggressive and has a higher reproductive potential than the Minnesota trout lily, its presence could have a negative effect on colonies of the Minnesota trout lily. However, it may require long-term demographic research to determine what, if any, effects there are.

42. Investigate the effects of siltation and erosion on colonies of the Minnesota trout lily.

Because the dwarf trout lily occurs on steep slopes and on floodplains, it is presumably adapted to natural patterns of erosion and siltation. However, human activities have, to some extent, changed the natural patterns. Examples include land clearing for agriculture, road building, stream channelization and dike building. The effects of these changes on colonies of dwarf trout lily are largely unknown. The current rates of siltation and erosion can be

measured, and if historical conditions can be determined, a useful comparison can be made. In cases where unnatural levels of siltation or erosion are found to be negatively affecting colonies, it should be possible to take corrective action.

43. Investigate the role of dispersal mechanisms.

Research by Morley (1982) has described methods by which colonies maintain themselves. But the role and mechanism of dispersal in establishing new colonies is unknown. An understanding of the mechanisms of dispersion could aid in better managing existing colonies.

44. Investigate methods of artificial propagation.

Research into artificial propagation could help recovery efforts by making plant material available for research and horticultural uses. This would hopefully relieve pressure on wild colonies.

45. Investigate the relationship of the Minnesota trout lily to certain components of its habitat (i.e., soil type).

It is unclear which aspects of habitat limit the distribution of the Minnesota trout lily, or how habitat influences reproduction and survivorship. However, based on what is already known, it appears that soil characteristics may be among the more important habitat components. For this reason, soil samples should be taken from each Minnesota trout lily site and analyzed for a variety of physical and chemical properties. The results could be used to better define the boundaries of potential habitat and aid in management.

46. Determine the degree of genetic variability present within the surviving population.

It is assumed that by preserving a large proportion of the surviving plants at a number of different locations we will be preserving a comparable proportion of the total genetic diversity present within the species. It is possible, however, that a disproportionate amount of the total genetic diversity resides in only a few colonies or sites. If that were true, these sites would be a high priority for preservation. Unfortunately, the degree and distribution of genetic diversity has not been determined. Therefore, there is a need to develop a relative index of genetic variability to be used to compare variability between individual colonies and between "sites" or concentrations of colonies. This task cannot be accomplished on the basis of morphology alone, but must employ cytological or molecular analysis.

5. Conduct systematic search for new sites.

Identify potential habitat where the Minnesota trout lily may occur, based on the known distribution and habitat preference. Sites should be searched during the flowering period (mid April to early May).

6. Provide appropriate public information.

Produce a brochure intended for the general public to emphasize the need to preserve the Minnesota trout lily. It should explain why the species is rare, and what is being done to preserve it. The brochure should also provide descriptive material to allow easy identification of the plant and explain the extent of legal protection covering the species. A color poster would also help enlist public support.

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PART III: IMPLEMENTATION SCHEDULE

General Category	Plan Task	Task #	Priority #	Task Duration	Responsible Agency FWS Region	Responsible Agency FWS Program	Responsible Agency Other	Fiscal Year Costs (Est.) FY 1	FY 2	FY 3	Comments
A1,A2,A6	Protect sites of naturally occurring populations	1	1	Ongoing	3	DES	TNC MDNR	230,000	50,000	50,000	Costs for FY 1 relate to task 121
M3,M7	Provide appropriate management at protected sites	2	2	Ongoing	3	DES	TNC MDNR RNC	1,500	1,500	1,500	
I1,I2,I6	Monitor populations at known sites	3	2	Ongoing	3	DES	MDNR TNC RNC	10,000	10,000	5,000	
R4,R10	Investigate the effects of competition	41	3	3 years	3	DES	MDNR TNC	2,500	1,000	1,000	
I2	Investigate effects of siltation & erosion	42	3	Ongoing	3	DES	MDNR TNC	5,000	1,000	1,000	
R7,R8	Investigate the role of dispersal mechanisms	43	3	3 years	3	DES	MDNR TNC	2,500	2,000	1,000	
R7,R13	Investigate methods of artificial propagation	44	3	Ongoing	3	DES	HA CPC MDNR	3,000	2,500	2,500	
R3	Investigate relationship to habitat	45	3	3 years	3	DES	MDNR TNC	2,000	2,000	2,000	

General Category	Plan Task	Task #	Priority #	Task Duration	Responsible Agency FWS Region	Responsible Agency FWS Program	Responsible Agency Other	Fiscal Year Costs (Est.) FY 1	FY 2	FY 3	Comments
R5	Determine degree of genetic variability	46	3	3 years	3	DES	MDNR TNC	10,000	7,500	7,500	
I14	Search for new sites	5	3	3 years	3	DES	MDNR TNC	2,500	2,500	1,500	
O1	Provide public information	6	3	2 years	3	DES	MDNR TNC	2,500	2,000		

DES - Division of Endangered Species
TNC - The Nature Conservancy
MDNR - Minnesota Department of Natural Resources
RNC - Riverbend Nature Center
HA - Holden Arboretum
CPC - Center for Plant Conservation

General Categories for Implementation Schedule

Information Gathering - I or R (research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Acquisitions - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

Recovery Action Priorities

1 = an action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

2 = an action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

3 = all other actions necessary to provide for full recovery of the species.

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