Lakeside Daisy

Hymenoxys Acaulis Var. Glabra

Recovery Plan

DEPARTMENT OF THE INTERIOR • U.S. FISH & WILDLIFE SERVICE

Recovery Plan for the Lakeside Daisy
(*Hymenoxys acaulis* var. *glabra*)

Prepared by

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for
Region 3
U.S. Fish and Wildlife Service
Twin Cities, Minnesota 55111

Approved: _____
Regional Director, U.S. Fish and Wildlife Service

Date: 9/9/90

EXECUTIVE SUMMARY OF THE RECOVERY PLAN FOR THE LAKESIDE DAISY

CURRENT STATUS: This variety is listed as threatened. Lakeside daisy historically occurred in three areas in Illinois (2) and Ohio (1), but is now known only from Ohio. This population is conservatively estimated at 1,000,000 adult plants. Populations have been restored on protected sites in Illinois (3) and Ohio (1).

HABITAT REQUIREMENTS AND LIMITING FACTORS: Lakeside daisy historically occurred in dry prairies, on outcrops of dolomite or limestone bedrock, or on sand and gravel terraces of major river valleys. Nearly all original habitat has been destroyed and only in Ohio has the variety recolonized abandoned quarry habitat where nearly 98% of the essential habitat is in private ownership. Restored populations are threatened with brush encroachment, off-road-vehicle access and high herbivory rates.

RECOVERY OBJECTIVE: Delisting.

RECOVERY CRITERIA: Assure protection of essential habitat at the Marblehead Quarry (Ohio), restore the variety to one large population in each of two geographic areas in Illinois, and the maintenance of a minimum of 5,000 individuals in one restored population per Illinois county for fifteen consecutive years with an additional ten years of monitoring.

ACTIONS NEEDED:

1. Fee simple acquisition of 475 acres of essential habitat at the Marblehead Quarry, Ottawa County, Ohio.
2. Protection of an additional 465 acres at the Marblehead Quarry through conservation easements, restrictive covenances, leases or other preservation method.
3. Monitor existing restored populations, supplement with additional transplants as needed.
4. Develop site management plans for all populations, identify and correct management problems, implement exotic species and herbivore control programs where needed.
5. Initiate research on taxonomic status, seed ecology and response to prescribed burning.
6. Development public awareness and education program.

COST OF RECOVERY: Estimated to be $1,591,600.00 to complete recovery actions and fulfill recovery criteria as described above with a scheduled timeline of 1991-1994. An additional $500,000.00 will be required to complete the population, demographic and community monitoring and management actions for an additional 20 years, including the recommended listing interval from 1995-2005 and the recommended 10 year monitoring interval from 2005-2015.

DATE OF RECOVERY: To be initiated in 2005, with an additional ten years of monitoring of selected experimental populations.

DISCLAIMER

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service **only** after they have been signed by the Regional Director or Director as **approved**. Approved Recovery Plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature Citation should read as follows:

U.S. Fish and Wildlife Service. 1990. Recovery plan for the Lakeside Daisy (Hymenoxys acaulis var. glabra). U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 80 pp. + Appendices.

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ACKNOWLEDGEMENTS

The following individuals are gratefully acknowledged for their helpful reviews and in providing information or assistance during preparation of the plan: R. Betz, M. Bowles, A. Cusick, G. Denny, B. Harrison, J. Johnson, J. Kolar, R. Panzer, B. Parsons, J. Schwegman and J. Windus. An additional list of individuals who reviewed the plan and submitted written comments is provided in **Appendix II.** Cover illustration by Jim Glover, Ohio Department of Natural Resources.

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PART I: INTRODUCTION

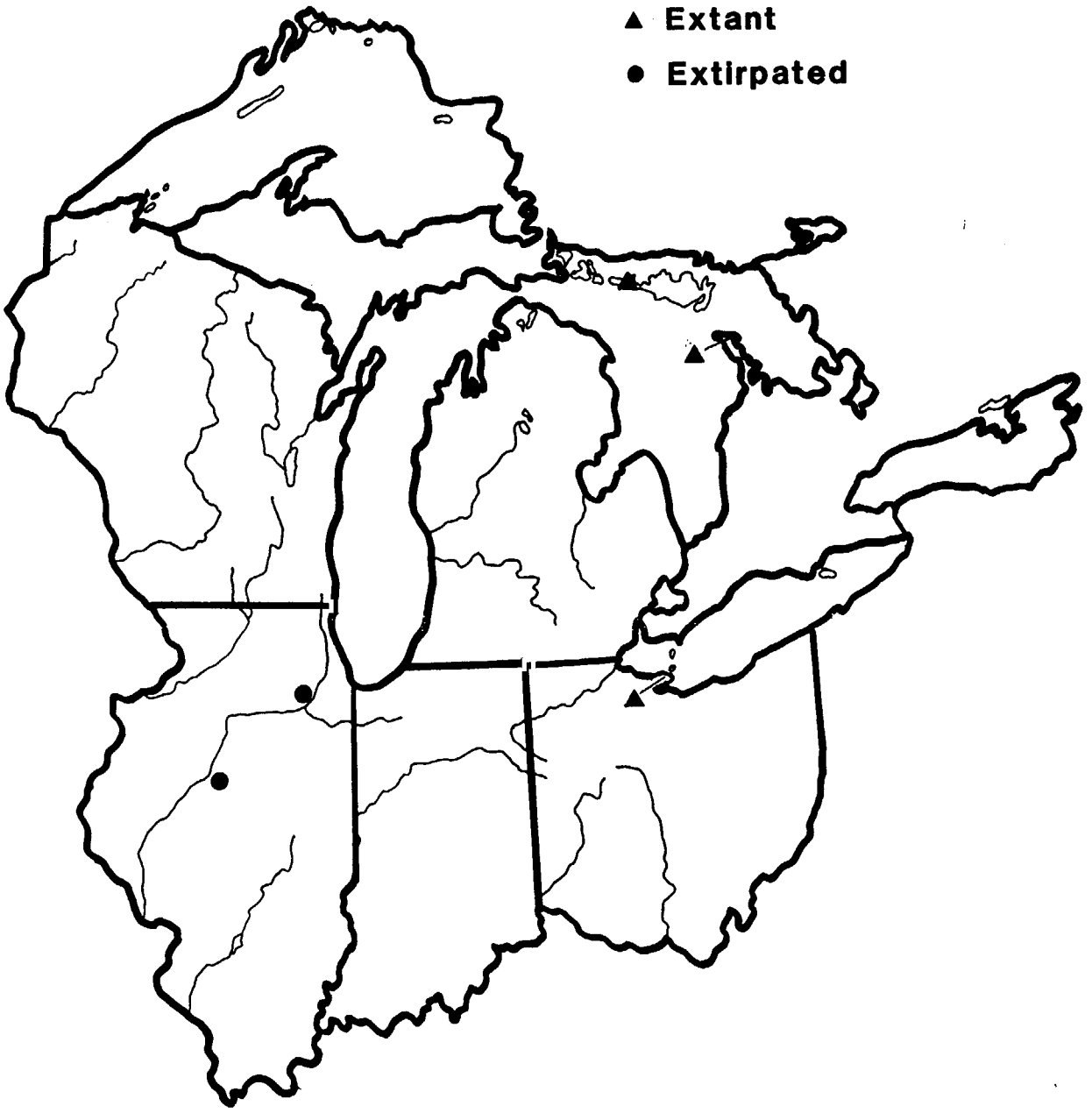
One of the more spectacular sights in nature can be observed in early May when thousands of Lakeside daisies are in flower, blanketing their rocky landscape in bright yellow. Lakeside daisy (Hymenoxys acaulis var. glabra) is known only from Illinois, Ohio and southern Ontario (Fernald 1950) (Figure 1). While Canadian populations have remained intact, habitat fragmentation, alteration and destruction have reduced the variety to one location in the United States.

The U.S. Fish and Wildlife Service (USFWS) proposed Lakeside daisy for listing as threatened on 19 August 1987 (USFWS 1987). The final listing rule was published on 23 June 1988 (USFWS 1988) and became effective 28 July 1988. The variety is state endangered in Ohio (Cusick and Burns 1984) and Illinois (Sheviak 1981), and is considered rare in Ontario (White and Maher 1983). Although proposed for delisting in Illinois due to extirpation (Bowles 1987), Lakeside daisy will remain state endangered as a result of its federal status.

Historic and Current Distribution

Hymenoxys is a western genus consisting of twenty-three perennial and biennial species centered in the southern Rocky Mountains and western Great Plains (Parker 1962). Five varieties have been described for Hymenoxys acaulis (Parker 1950), of which four are distributed from western Canada southward to California, east through the western Great Plains and southeast into Texas (Harrington 1964). The species is disjunct in the Great Lakes

Figure 1. Distribution of Hymenoxys acaulis var. glabra



region where it is represented only by var. glabra (Parker 1950).

The disjunct distribution of H. acaulis var. glabra has resulted in speculation as to its origin. Morton and Venn (1984) consider var. glabra a Great Lakes endemic whose center of distribution is Manitoulin Island, Ontario. Moseley (1899) stated Lakeside daisy was indigenous to the Marblehead Peninsula, Ohio. He later suggested the Great Lakes populations resulted from the introduction of seeds by Indians, and noted the plant was first discovered on an Indian mound near Joliet, Illinois (Moseley 1931). This site was known locally as the Joliet Mound and as early as the seventeenth century, it served as a landmark to early European navigators of the Illinois waterways (Will County Historical Society 1980). Although the area was inhabited by Indians, Joliet Mound was not an Indian mound; the "mound" was in fact a large remnant gravel terrace left by erosion of the original valley train deposits (Will County Historical Society 1980).

Like many other disjunct western species in the prairie peninsula (Gleason 1923; Transeau 1935), Lakeside daisy likely migrated east during the Xerothermic Interval and survived in favorable, dry habitats of gravel deposits as the climate became increasingly moist and humid (Cowles 1926; Voss 1935).

Ohio Population

Lakeside daisy is known only from Ottawa County, Ohio (Cooperrider 1982; Cusick and Burns 1984; Fisher 1989) where it historically occurred on the dry limestone prairies occupying the

east half of the Marblehead Peninsula (see Ross 1970 for summary of collecting records). Moseley (1899) described the variety as "infrequent but occurring at places widely separated" but later indicated it had spread noticeably in forty years (Moseley 1931). This increase may have resulted from grazing that occurred on the prairie during this time span (R. Fiscus, Cleveland Heights, Ohio, pers. comm.). The prairie was never farmed because the soil was too thin (DeMauro 1987).

By the late 1940s, the prairie was destroyed by limestone quarrying. Since the area was not all quarried at the same time, enough Lakeside daisies likely survived in prairie remnants to re-colonize terraces of open bedrock, rock/clay, and slag pile habitats. Old photographs circa 1950 (R. Fiscus) show the heaviest areas of invasion were along quarry roads. Over the past forty years, population levels have fluctuated greatly and in some years were exceedingly low. In addition, the population center, originally located east of Cemetery Point (northwest of the active quarry, Figure 2) has shifted .25 mile to the west (R. Fiscus pers. comm.).

Lakeside daisy is now widely scattered in the abandoned portions of the Marblehead Quarry on the Marblehead Peninsula, Ottawa County, an area encompassing approximately three square miles (Figure 2). The recent acquisition and dedication of the 19 acre Lakeside Daisy State Nature Preserve (Figure 3) by the Ohio Department of Natural Resources (ODNR) represents the only site with a naturally occurring population of Lakeside daisy in

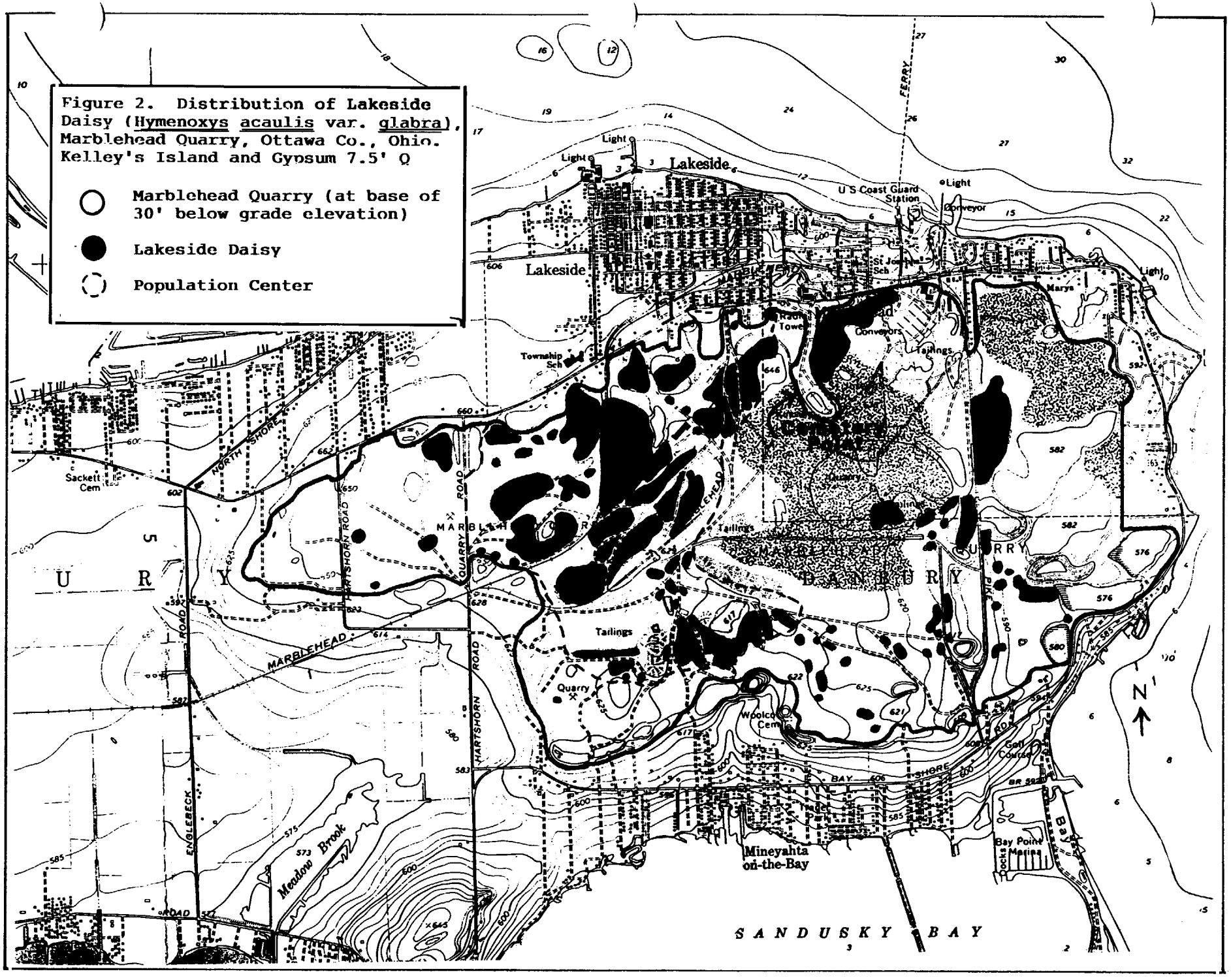


Figure 2. Distribution of Lakeside Daisy (Hymenoxys acaulis var. glabra), Marblehead Quarry, Ottawa Co., Ohio. Kelley's Island and Gypsum 7.5' Q
Marblehead Quarry (at base of 30' below grade elevation)
Lakeside Daisy
Population Center
Lakeside
U S Coast Guard Station
Light
Conveyor
Tailings
Township Sch
NORTH SHORE
Sackett Cem
MARBLEHEAD QUARRY ROAD
HARTSHORN ROAD
MARBLEHEAD
ENGLEBECK ROAD
Quarry
Woolcott Cem
Golf Course
BAY SHORE
Meadow Brook
Mineyahta on-the-Bay
Bay Point Yacht Harbor Marina
SANDUSKY BAY
FERRY
N

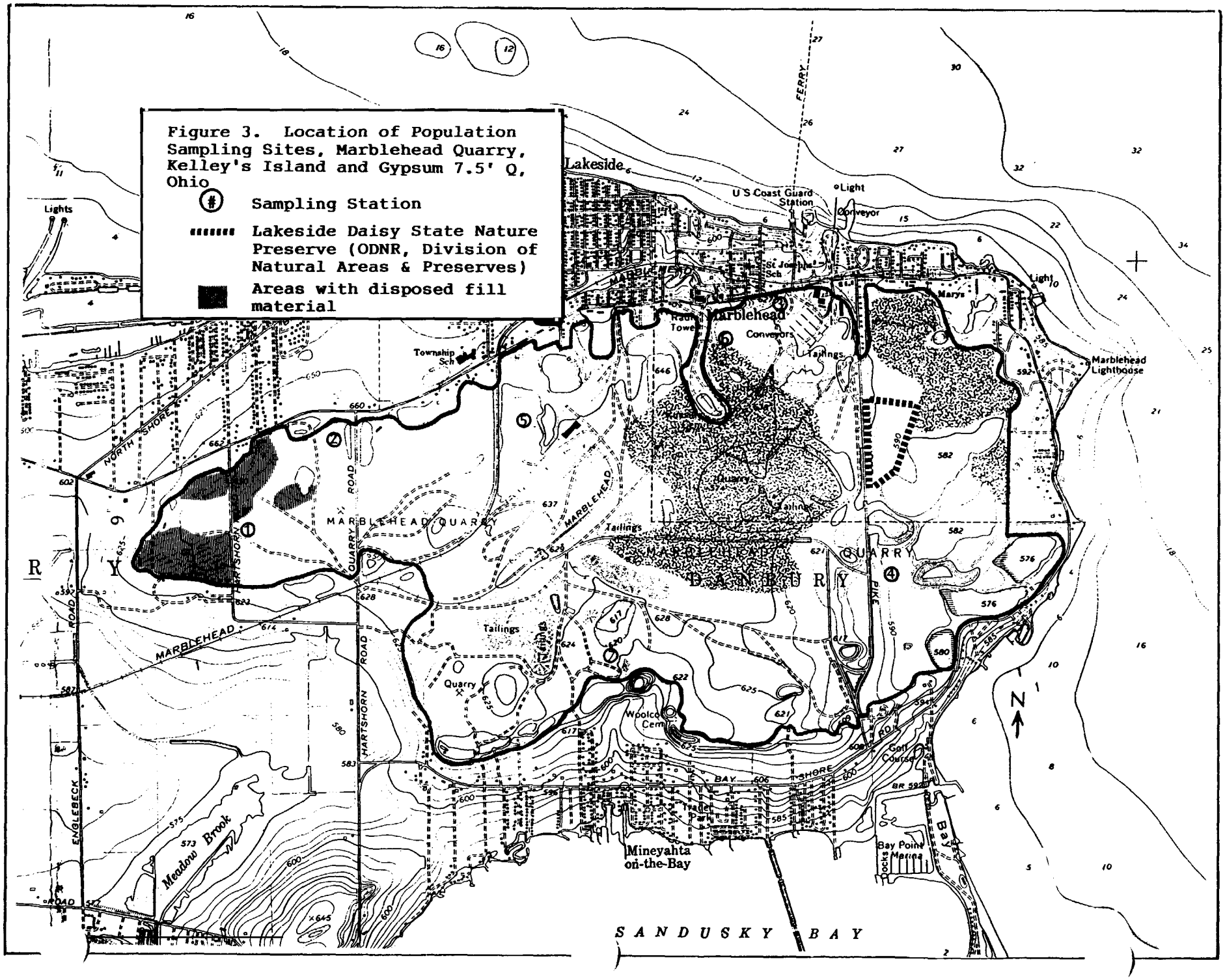


Figure 3. Location of Population Sampling Sites, Marblehead Quarry, Kelley's Island and Gypsum 7.5' Q, Ohio
Sampling Station
Lakeside Daisy State Nature Preserve (ODNR, Division of Natural Areas & Preserves)
Areas with disposed fill material
Lakeside
Marblehead
MARBLEHEAD QUARRY
DANBURY QUARRY
Tailings
Quarry
Conveyors
Conveyor
U S Coast Guard Station
Light
Lights
Marblehead Lighthouse
Township Sch
St Joseph Sch
Marys
NORTH SHORE
MARBLEHEAD
QUARRY ROAD
HARTSHORN ROAD
ENGLEBECK ROAD
PIKE
FERRY
Woolco Cem
Trader Park
Mineyahta on-the-Bay
Bay Point Marina
Golf Course
BAY SHORE
BR 592
Meadow Brook
SANDUSKY BAY
N

public ownership. The site is managed by the Division of Natural Areas and Preserves.

Methods and Results of 1989 Population Surveys In Ohio

Other than past cursorial references to the location of Lakeside daisy within the quarry, the population size and extent have remained unknown. The extent of Lakeside daisy populations and all potentially suitable habitat were mapped on aerial photographs (1:24000) and were field surveyed during May, 1989. A planimeter was used to derive acreage estimates. Suitable habitat consists of flat, open terraces or ledges either at grade or 30' below grade, or on level to sloping slag piles that were abandoned between forty to fifty years ago. These ledges essentially form a ring around the active quarry. Unsuitable habitat includes the active quarry (i.e. high, smooth, vertical walls); roads; successional, wooded and shaded habitats; and areas that are permanently flooded or seasonally flooded for extended periods.

To obtain a crude average estimate of Lakeside daisy population size, sampling was conducted during 1989 in seven different areas of the quarry that upon initial visual inspection, appeared to have different densities of adult plants (Figure 3). Linear, 1m (3.28') wide transects were randomly located through the selected areas, and $1m^2$ ($3.28\ ft^2$) quadrats were sampled at random points along the transects. All Lakeside daisies encountered were classified by size class (adult, juvenile, seedling). For adult plants, the number of rosettes

and inflorescences were recorded (refer to DeMauro 1987).

Approximately 750 (37.5%) of the 2000 acres of quarry lands are suitable Lakeside daisy habitat. Lakeside daisy occupies approximately 400-450 acres (53%-60%) of the suitable habitat (Figure 2), and is most abundant in areas abandoned during the 1940s (east of Quarry and Alexander Pike Roads) and the 1950s (between Quarry and Hartshorn Roads). The population center is located between Quarry and Alexander Pike Roads to the north, west and southwest of the active quarry pit (Figure 2).

Because Lakeside daisy has a highly aggregated distribution within suitable habitat (DeMauro 1987), variance estimates about the mean densities are high; however, since sample size is large, 99% confidence intervals reflect a better estimate of mean density (Table 1). Mean densities between sites are also variable. Despite these drawbacks, crude estimates of population size are derived (Table 2). For comparison, population sizes were calculated from the highest, lowest and average density estimates for adult plants and for all size classes based on the estimates of area covered by the population. Note that all estimates based on the 1989 sampling data are higher than those estimates derived from 1986 sampling data. A conservative minimum estimate for the number of adult Lakeside daisies in the Marblehead Quarry is approximately 1,000,000 adult plants.

Table 1. Results of Population Sampling From Seven Stations Within the Marblehead Quarry, Ottawa County, Ohio[a].

Variable by Size Class	Site 1	2	3	4	5	6	7	Total
Seedlings								
Number	380	436	286	52	84	237	536	2011
Frequency	.640	.719	.607	.500	.415	.750	.900	.630
Mean Density	15.2	13.6	10.2	2.36	2.05	7.41	26.8	11.0
± 99% C.I.	±16.5	±8.62	±7.13	±2.10	±2.12	±3.51	±15.1	±3.95
Juveniles								
Number	55	195	120	18	114	254	147	903
Frequency	.520	.688	.607	.364	.390	.875	.900	.610
Mean Density	2.20	6.09	4.32	.818	2.78	7.94	7.35	4.52
± 99% C.I.	±1.76	±4.98	±2.82	±.779	±2.83	±2.83	±6.08	±1.21
Adults								
Number	17	154	131	28	48	192	88	136
Frequency	.360	.813	.679	.500	.463	1.00	1.00	.680
Mean Density	.680	4.81	4.68	1.27	1.17	6.00	4.40	3.29
± 99% C.I.	±.618	±2.39	±2.72	±1.13	±.864	±1.93	±2.06	±.747
Totals								
No. of Plots	25	32	28	22	41	32	20	200
No. of Plants	452	785	537	98	246	683	771	3572
Frequency	1.00	.906	.750	.636	.634	1.00	1.00	.805
Mean Density	18.1	24.5	19.2	4.46	6.00	21.3	38.6	17.9
± 99% C.I.	±17.9	±13.6	±11.4	±3.67	±2.24	±7.16	±19.4	±4.39

[a]Mean densities are per $1m^2$

Table 2. Lakeside Daisy Population Size Estimates Based on the Lowest, Highest and Average Sampling Densities of Adult Plants and All Size Classes from Seven Stations Within the Marblehead Quarry, Ottawa County, Ohio.

Description	Population Size Estimates for the Estimates of Population Extent Within the Quarry 400 acres	450 acres
Lowest		
Adults Only ± 99% C.I. (Area 1)	1,101,215 ± 1,000,810	1,238,866 ± 1,125,911
All Size Classes ± 99% C.I. (Area 5)	7,222,672 ± 5,943,320	8,125,506 ± 6,686,235
Highest		
Adults Only ± 99% C.I. (Area 6)	9,716,599 ± 3,125,506	10,931,174 ± 3,516,194
All Size Classes ± 99% C.I. (Area 7)	62,510,121 ± 31,417,004	70,323,887 ± 35,344,130
Average		
Adults Only ± 99% C.I. (From Total Column, Table 1)	5,327,935 ± 1,209,717	5,993,927 ± 1,360,931
All Size Classes ± 99% C.I. (From Total Column, Table 1)	28,923,077 ± 7,115,789	32,538,462 ± 8,005,263
1986 Sampling Data[a]		
Adults Only ± 99% C.I.	787,045 ± 241,296	885,425 ± 271,457
All Size Classes ± 99% C.I.	2,966,802 ± 918,219	3,337,652 ± 1,032,996

[a]Density estimates ± 99% C.I. derived from 553 $1m^2$ quadrats sampled during 1986 (DeMauro 1987): Adults only = .486±.149/m^2; All size classes = 1.83±.567/m^2.

Illinois Populations

There are no extant natural Lakeside daisy populations in Illinois. Historically the variety was known from Manito Prairie Nature Preserve, Tazewell County (Figure 4) and in the lower DesPlaines Valley near Joliet, Will County (Figure 5) (Wunderlin 1971). This variety was also reported along Highway 6 in Kankakee County (Charles Deam letter to Floyd Swink, the Morton Arboretum, Lisle, Illinois, dated 13 April 1947). Since Highway 6 is not in Kankakee County, this author assumes C. Deam was referring to known stations along Route 6 in Will County.

Although Voss (1935) reported many plants from Manito Prairie, the Lakeside daisy had disappeared from this site by the early 1960s (A. Koelling, Illinois Natural History Survey, pers. comm.). Collecting records from 1869 to 1976 (see DeMauro 1988b for summary of collecting records) and other sources (e.g. Pepoon 1927) indicate Lakeside daisy was abundant and widespread within an approximately five mile length of the northwest side of the DesPlaines River Valley near Joliet, Illinois (Figure 5). The population declined as habitat was lost to mining, quarrying and intense industrial development within this river corridor. The type locality, Joliet Mound, was destroyed by the early 1900s as a result of clay and gravel mining (Will County Historical Society 1980). In contrast to the Ohio site, abandoned quarries near historic Lakeside daisy locations in Will County consist of essentially vertical walls with no suitable perimeter ledge habitat (DeMauro pers. obs.).

County TAZEWELL No. 11

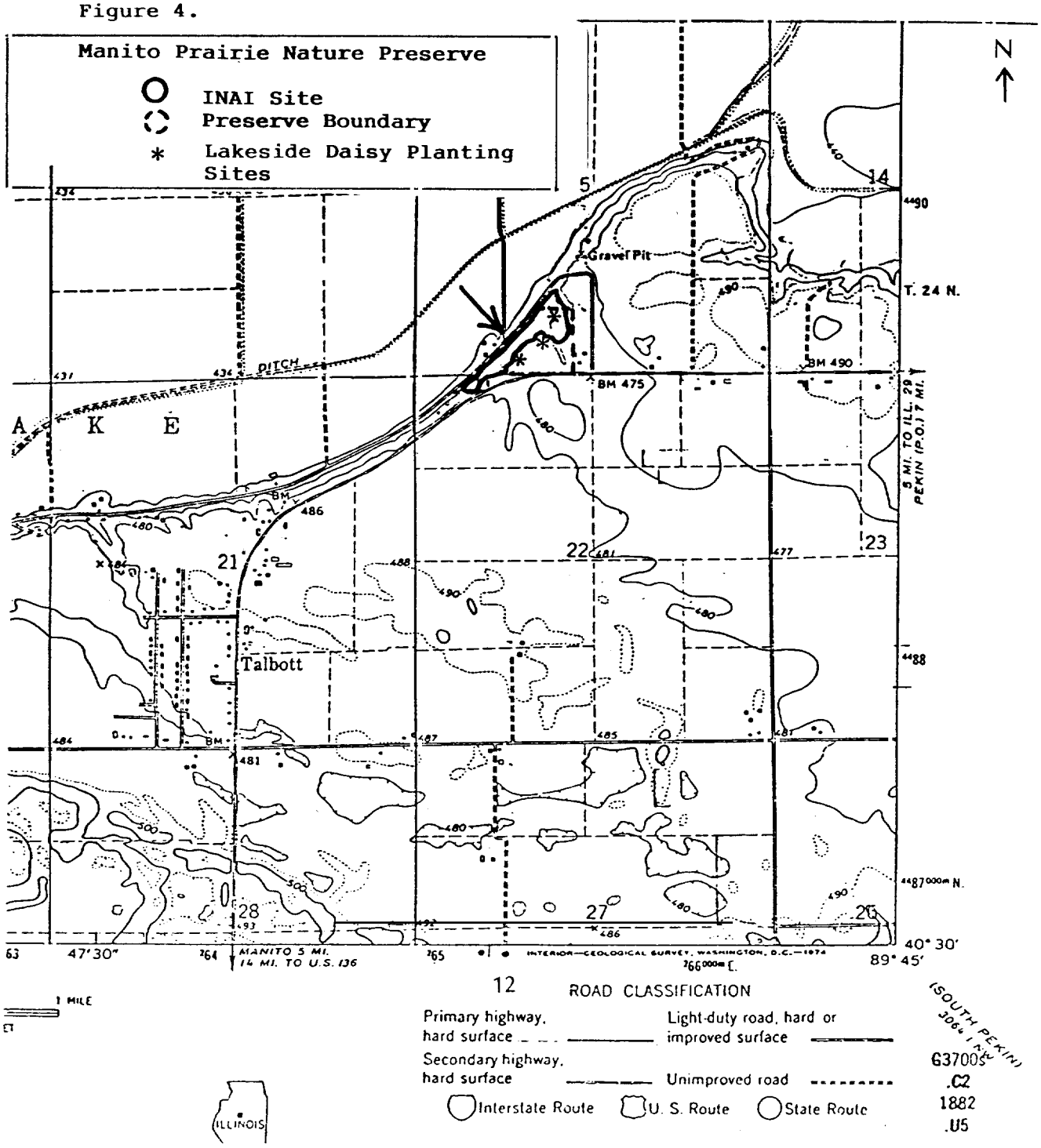
Name of Area TAZEWELL GRAVEL TERRACE PRAIRIE

Quadrangle GLASFORD 7.5'

Location SEC. 15,22 T24N, R6W

ILLINOIS NATURAL AREAS INVENTORY

Figure 4.



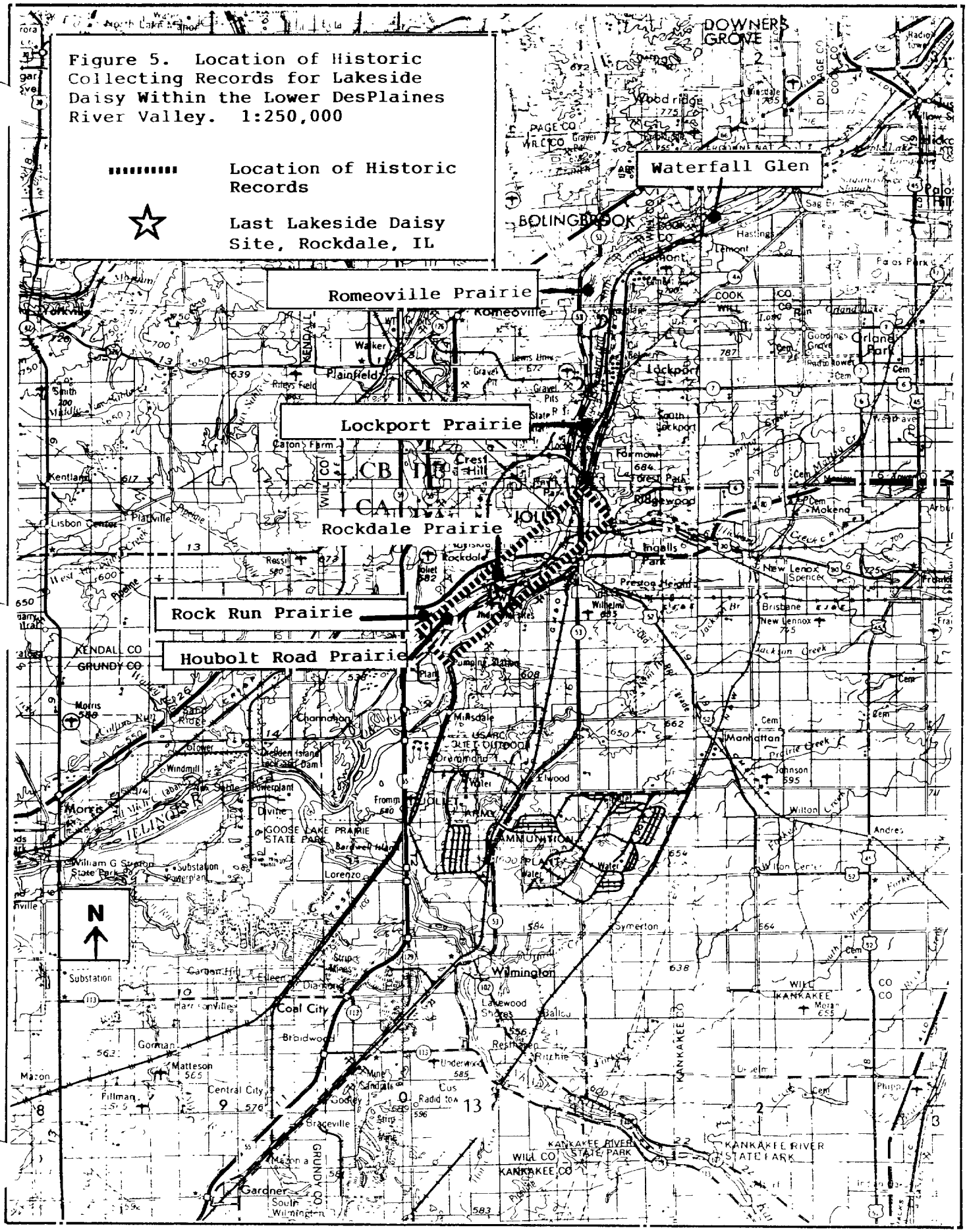


Figure 5. Location of Historic Collecting Records for Lakeside Daisy Within the Lower DesPlaines River Valley. 1:250,000
Location of Historic Records
Last Lakeside Daisy Site, Rockdale, IL
Waterfall Glen
Romeoville Prairie
Lockport Prairie
Rockdale Prairie
Rock Run Prairie
Houbolt Road Prairie
DOWNERS GROVE
BOLINGBROOK
Romeoville
Plainfield
Lockport
Orland Park
Rockdale
Joliet
Wilmington
Coal City
Gardner
Morris
Channahon
Minooka
New Lenox
Manhattan
Mokena
Frankfort
Symerton
Braceville
Gorman
Matteson
Central City
Fillmore
Mazon
Kankakee River State Park
Goose Lake Prairie State Park
William G Stratton State Park
Kankakee River
Des Plaines River
Illinois River
Will Co
Grundy Co
Kendall Co
Kankakee Co
N

The last known Lakeside daisy colony occurred on degraded dry dolomite prairie owned by Commonwealth Edison Power Company in Rockdale, Illinois (Figure 5). This site was destroyed in 1981 when several tons of coal were deposited on the site for storage purposes (Illinois Nature Preserves Commission 1983). Three plants were collected from the site prior to its destruction and have been the source material for breeding system studies (DeMauro 1988a) and species recovery program in Illinois (DeMauro 1988b). In addition a single plant was collected between 1969-1970 from this site and has been used as a clonal source for rock garden collections in the Chicago region.

Canada Populations

Lakeside daisy is known from Manitoulin Island and the Bruce Peninsula, southern Ontario (White and Maher 1983; Morton and Venn 1984). On Manitoulin Island, the variety is distributed more or less continuously on alvars along the south shore of the western 1/4 of the island, although two inland colonies are known (J. Morton, University of Waterloo, pers. comm.; DeMauro, pers. obs.) (Figure 6). The largest colonies occur at Christina Bay, Burnt Island and Misery Bay/Misery Point (J. Morton, pers. comm.).

There are no early botanical records of Lakeside daisy on the Bruce Peninsula. Krotkrov (1940) did not include the variety in his vascular plant survey of the peninsula. Lakeside daisy was first observed in the mid-1960s near the junction of Rt. 6 and the turnoff road to Dyers Bay (J. Johnson, pers. comm.).

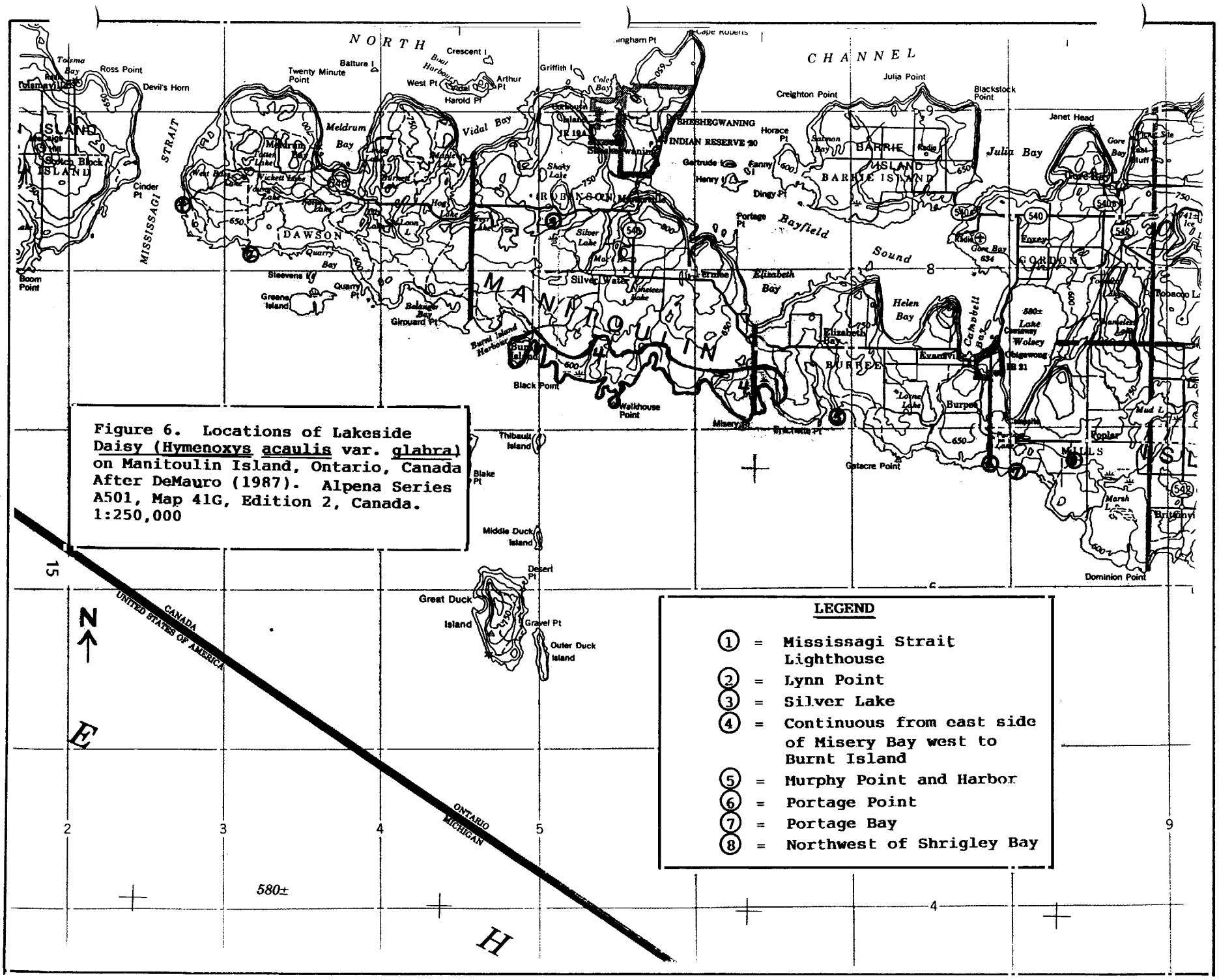


Figure 6. Locations of Lakeside Daisy (Hymenoxys acaulis var. glabra) on Manitoulin Island, Ontario, Canada After DeMauro (1987). Alpena Series A501, Map 41G, Edition 2, Canada. 1:250,000

LEGEND

① = Mississagi Strait Lighthouse
② = Lynn Point
③ = Silver Lake
④ = Continuous from east side of Misery Bay west to Burnt Island
⑤ = Murphy Point and Harbor
⑥ = Portage Point
⑦ = Portage Bay
⑧ = Northwest of Shrigley Bay

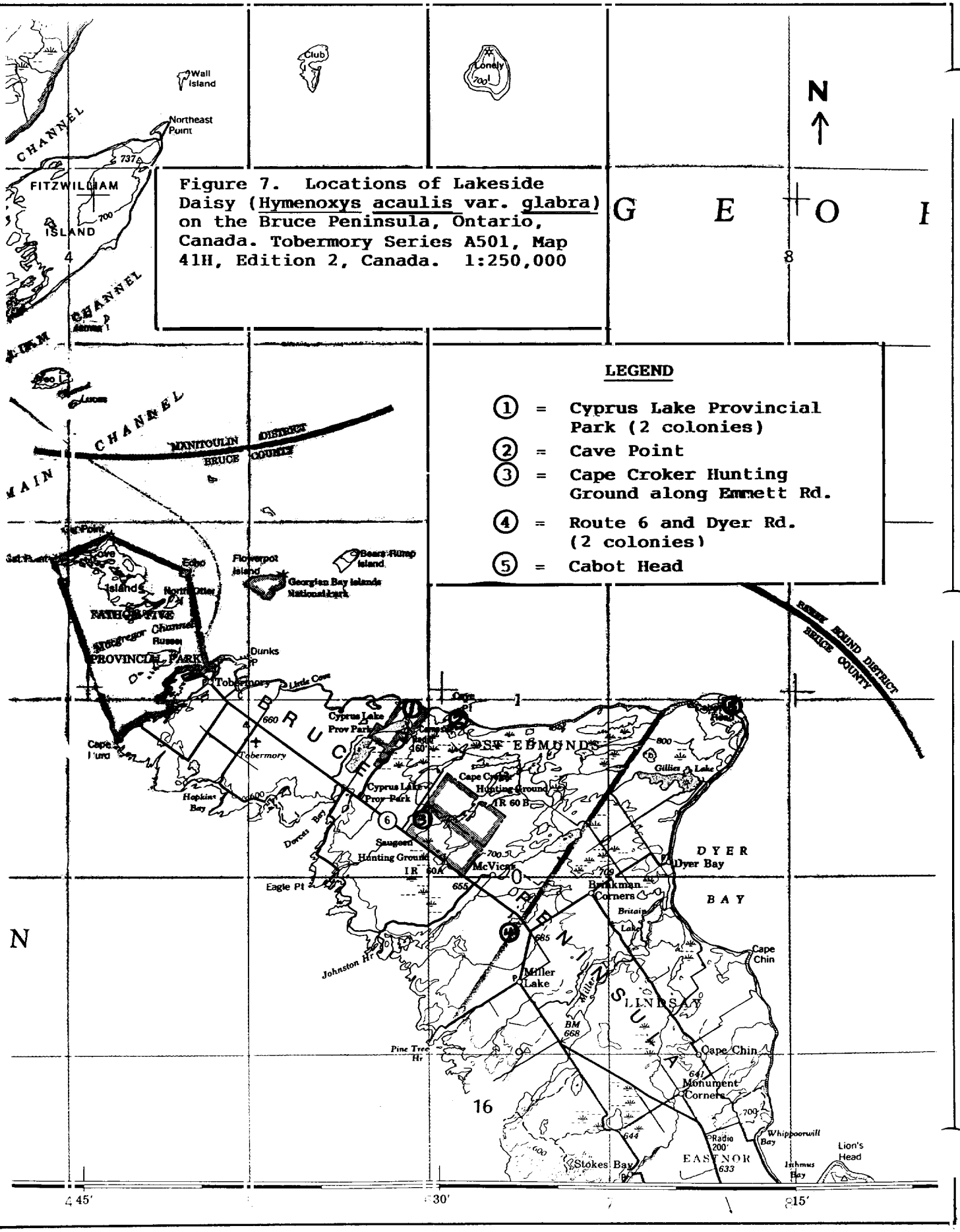


Figure 7. Locations of Lakeside Daisy (Hymenoxys acaulis var. glabra) on the Bruce Peninsula, Ontario, Canada. Tobermory Series A501, Map 41H, Edition 2, Canada. 1:250,000

Currently, seven colonies occur in five areas on the peninsula (J. Johnson, Wyerton, Ontario) (Figure 7). Although most of the colonies are found on alvars, one occurs on "islands" of bedrock outcrops surrounded by forest (Area 3), and another on the north-facing limestone cliffs of the Niagran escarpment (Area 2). The largest colony is the site where the variety was first observed (Area 4) (J. Johnson, pers. comm.).

Description of Species

Nomenclature and Taxonomy

Lakeside daisy is a member of the Asteraceae family. The common epithet was first noted by Clarence Weed (1890) who indicated that local residents in the town of Lakeside, Ohio (located immediately to the north of the Marblehead Prairie) referred to the plant by their town namesake. The plant is also known as the four-nerved star flower (Pepoon 1927), and Manitoulin gold and stemless rubberweed (Morton and Venn 1984).

The type specimen for the variety was collected near Joliet, Illinois by W. Boott and was first described by Asa Gray in 1869 (A. Cusick, ODNR, pers. comm.). Taxa now placed in Hymenoxys were originally included in Gaillardia by Pursh or in Actinella by Nuttall, who recognized A. acaulis as the type for the genus (Greene 1898). Although the Great Lakes populations of this variety were in part included in Nuttall's A. acaulis, Greene (1898) considered the Illinois and Ohio populations as removed from the rest of the genus in habitat and character, and renamed the species Tetraneuris herbacea. Robinson (1908) suggested the

new combination, Actinea herbacea (Greene). Actinea proved to be an invalid name because it was based on a type specimen (A. heterophylla) that was later placed in Helenium; the next available name, Hymenoxys Cass., was utilized (Parker 1950). The recognized name for the plant is Hymenoxys acaulis (Pursh) Parker var. glabra (Gray) Parker (Parker 1950). The variety also has been previously recognized as Actinella scaposa var. glabra and Actinella acaulis (Pursh) Spring var. glabra. Additional work is needed to assess the plant's varietal status.

Morphology

Unless otherwise noted, taxonomic descriptions follow Fernald (1950), Gleason and Cronquist (1963) and Swink and Wilhelm (1979); measurements are from DeMauro (unpub. data). Lakeside daisy is an herbaceous, spring-blooming perennial with a short, thick taproot and a stout, branching caudex. The caudex bears numerous, thick spathulate, oblanceolate to lanceolate leaves that collectively form a rosette. Leaves are one-nerved, strongly punctate, and glabrate to sparingly villous although younger leaves can be densely villous. Leaves are typically dark green but will change to light green or gray and become flaccid when water stressed (R. Moseley, ODNR, pers. obs; DeMauro pers. obs.). Leaf length and width vary greatly from .65-16.7 cm (.256-6.57 in) and .35-1.3 cm (.138-.512 in), respectively.

Peduncles are stout, villous and terminate in solitary inflorescence heads. Cauline leaves are usually absent but rarely one to a few, very strongly reduced bracts may occur.

Peduncles continue to elongate through the blooming season, reaching a maximum height between 8.4-40 cm (3.31-15.75 in) at the time of seed dispersal in early to mid-June. The involucre is naked and convex. Involucral bracts are partly to wholly herbaceous, near equal in length, occur in ranks of two to three, and are broadly rounded at the tip. The disc ranges from .65-2 cm (.256-.787 in) in diameter. The pistillate ray florets are 3-toothed, range from .5-2 cm (.197-.787 in) in length and usually occur in one row numbering between 7-33. Some plants can have 2-3 rows of rays, numbering over 50 ray florets (G. Denny, ODNR, pers. comm.; DeMauro pers. obs.). The hermaphroditic disc florets number between 55-200. Both ray and disc florets are bright yellow and are fertile. Achenes are turbinate, hairy, mostly five-angled with a pappus of five or more ovate to lanceolate, thin, chaffy scales.

Lakeside daisy genets increase in size primarily by sympodial growth; rhizomatous growth can also occur (DeMauro pers. obs.). Typically in fall, new leaves develop at the rosette center. When the inflorescence bud enlarges in early spring, the meristematic tissue at the caudex tip divides a single rosette into three rosettes, and the leaves begin to elongate. Rosettes persist at ground level through the winter and live at least one year. Collectively rosettes give a condensed, circular shape to the plant. As growth continues, older rosettes near the center of the genet senesce, leaving behind the thick, chalky caudex branches. New rosettes are added

at the periphery of the genet, giving the plant a characteristic donut-shaped appearance.

Chromosome Cytology

The base chromosome number for Hymenoxys is x=15 (Strother 1966). Species are primarily diploid, but local tetraploidy (Speese and Baldwin 1952; Strother 1966), pentaploidy (Strother 1966) and hexaploidy (Parker 1970) are known. Aneuploid reductions (n=14, n=11) are known in at least two Hymenoxys species (Taylor and Brockman 1966, Sanderson and Strother 1973). Most variable of all species is H. acaulis. Of the four western varieties, one is diploid and three are tetraploid. Isolated occurrences of aneuploidy (n=14) have been found in H. acaulis populations at the eastern and northern margin of its range in Texas and Alberta, Canada (Powell and Turner 1963), although it is not known which varieties were studied. H. acaulis var. glabra is a reduced aneuploid (n=14, DeMauro 1988a). Aneuploidy in Great Lakes populations may have arisen independently or may have descended from western aneuploid populations that migrated east. While polyploidy may be of little consequence in the formation of species in this group (Strother 1966), aneuploid reduction, particularly those of recent occurrence, is a relatively rare event whose evolutionary significance is not understood (Sanderson and Strother 1973). Cytological data should be used to evaluate the taxonomic status of var. glabra.

Habitat of Former and Present Occurrences

Historical habitat references include outcrops of dolomite

or limestone bedrock, dry, gravelly prairies on terraces or hills associated with major river systems, rocky shores, sandy fields and alvars (Moseley 1899; Wunderlin 1971; Swink and Wilhelm 1979; Morton and Venn 1984). In the U.S., Lakeside daisy is now restricted to dry, thin-soiled, degraded prairies in which limestone or dolomite bedrock is at or near the surface.

There are similarities between Lakeside daisy sites in southern Ontario, Ohio and Illinois. Habitats are alkaline, seasonally wet in spring and fall, and are moderately to extremely drougthy in summer. Typically, habitats have little topographic relief, are relatively open at the ground surface, and vegetation density and diversity are relatively low (DeMauro 1987). Within these habitats, Lakeside daisy occurs in open patches of ground, occupies the dry to mesic portions of the soil moisture continuum and has a highly aggregated, non-random distribution. This species is either absent or infrequently found in shaded or densely vegetated (e.g. Andropogon scoparius, Poa compressa) microhabitats. Despite differences in levels of site degradation, Lakeside daisy is a dominant species in the plant community, ranking second in the relatively undisturbed to lightly disturbed Canadian sites, and ranking third at the Ohio sites where the natural habitat and community have been severely disturbed or entirely eliminated (DeMauro 1987, 1990).

Throughout Lakeside daisy's range the climate is continental. Conditions for Ottawa County, Ohio (Musgrave and Derringer 1985) and Will County, Illinois (Wascher et al. 1962)

are described in Table 3. The major differences between the Ohio site and historic sites in Illinois are a more even distribution of rainfall through the year and more extreme temperatures in Illinois.

Ohio Sites

The Marblehead Peninsula is within the Great Lakes section of the Central Lowland Province of Ohio (Anderson 1983). This section is characterized by Devonian and Silurian dolomite and limestone substrates covered by calcareous, poorly drained soil derived from till and lacustrine deposits (Anderson 1983), and little topographic relief (Gordon 1969).

The Marblehead Peninsula lies on the eastern flank of the Findlay Arch (Sparling 1971). Two geologic formations of the Devonian system are found on the eastern portion of the peninsula, Lucas dolomite and Columbus limestone (Sparling 1971). The Columbus limestone is hard, resistant to erosion, and is the formation exposed throughout much of the Marblehead Quarry (Musgrave and Derringer 1985).

Prior to quarrying, soils of the east half of the peninsula (primarily Castalia) were a very stony fine sandy loam, alkaline, moderately deep, well drained, nearly level to gently sloping on upland knolls or rises (Musgrave and Derringer 1985). Moseley (1897) gives the best ecological description of the limestone prairie soils: "...In many places, especially on Marblehead, the covering of the soil is only a few inches deep and consists of partially decomposed vegetation and lime carbonate derived from

Table 3. Some Climatological Data from Ottawa County, Ohio and Will County, Illinois Stations[a].

Month	Temperature (°F) Avg. Daily Max. OH	IL	Avg. Daily Min. OH	IL	Precipitation (Inches) OH	IL	Other OH	IL
January	31.2	33.0	14.8	17.0	1.89	1.90		
February	34.8	35.0	16.5	18.0	1.36	1.60		
March	48.3	47.0	30.3	28.0	2.98	2.80		
April	60.2	60.0	38.8	37.0	2.76	3.30		
May	71.0	72.0	49.4	48.0	3.08	3.90		
June	80.5	82.0	58.7	57.0	4.64	3.80		
July	84.8	87.0	61.6	62.0	2.79	3.30		
August	82.3	85.0	59.8	61.0	3.80	3.20		
September	74.9	77.0	51.9	54.0	3.81	3.70		
October	63.4	66.0	40.6	42.0	2.10	2.50		
November	49.6	49.0	32.7	31.0	2.67	2.30		
December	35.7	36.0	20.8	21.0	2.42	2.10		
Annual	59.7	61.0	39.7	40.0	34.3	34.4		
Other Variables								
Mean Annual Temp.							49.8	50.0
Lowest Temp.							-15	-25
Highest Temp.							100	109
Avg. Number Growing Days[b]							162	162
Prevailing Wind							SW	SW

[a]Ottawa County Station, Musgrave and Derringer (1985), over the sampling period of 1972-1978.
Will County Station, Wascher et al. (1962), over the sampling period of 1893-1952.
[b]Based on dates of first and last freezing temperatures in 5 of 10 years.

the underlying rock. This soil becomes more parched under the summer sun than any spot in Ohio further east."

No original soil profile remains in the Marblehead Quarry. The existing substrate consists of 1) level bedrock pavement with occasional fissures, 2) slag piles with rocks $\geq$ 1 meter (3.28') in diameter, 3) flagstones (> 256 mm, > 10.1 in) and smaller rocks of various sizes (ranging from 2-256 mm (.079-10.1 in) over the bedrock and 4) pebble-sized rocks between 4-64 mm (.157-2.52 in) either loose over the bedrock or within a matrix of "silk". Silk is a fine, clayey dust left from quarrying, and can be several inches thick over the bedrock. In general the organic content and available water capacity are low (Musgrave and Derringer 1985).

Plant succession in abandoned quarry habitat is relatively slow; sections abandoned between 30-40 years ago still have extensive areas of unoccupied substrate. Species diversity is low and although exotic species (ex.) are common, vegetation is dominated by native prairie species (DeMauro 1987, 1990). Lakeside daisy is a community dominant in this early successional community. Other dominant plant species include the mosses Brium argenteum and Dicranella varia, the grasses Panicum sp., P. implicatum, Poa compressa (ex.), the sedge Carex eburnea, and forbs Houstonia nigracans, Solidago nemoralis, Allium cernuum, Liatris spicata, Arenaria stricta, Draba verna (ex.), and Diplotaxis muralis (ex.) (DeMauro 1987, 1990).

One can only hypothesize what natural processes (e.g.

periodic fires or drought, edaphic conditions) maintained open patches for Lakeside daisy in its presettlement habitat at the Marblehead Quarry. In contrast, recent disturbances have simulated these natural processes, albeit with greater intensity on a larger scale. Past grazing likely reduced competitive vegetation while more recently, quarrying has eliminated all natural habitat. Lakeside daisy has since exploited the open, artificial quarry habitat, resulting in a greater abundance and distribution than in the original limestone prairie.

Illinois Sites

Manito Prairie is situated on a west-facing, intermediate sand and gravel terrace (elevation 460') in the Illinois River Valley (Hunter 1966) within the Illinois Section of the Illinois River and Mississippi River Sand Areas Natural Division of Illinois (Schwegman 1973). Soils belong to the Lorenzo-Warsaw-Wea association (Fehrenbacher et al. 1984). They are characterized as loamy to silty, well to excessively drained, moderately sloping, shallow to moderately deep on gravelly outwash deposits having moderately to rapidly permeable subsoils.

Manito Prairie contains four community types (White 1978) and it is likely the Lakeside daisy was associated with the sand and dry gravel prairie. Characteristic plant species include Amorpha canescens, Andropogon gerardi, A. scoparius, Arenaria stricta, Bouteloua curtipendula, Dodecatheon meadia, Echinacea pallida, Lespedeza capitata, Lithospermum incisum, Muhlenbergia cuspidata, Petalostemum purpureum, Potentilla arguta, Sorghastrum

nutans, Sporobolus heterolepis and Ruellia humulis (McFall 1984).

In Will County, Lakeside daisy was collected from dry gravel and dolomite prairies within the lower DesPlaines River Valley. This area is within the Morainal Section of the Northeastern Morainal Division of Illinois (Schwegman 1973). The prairies were associated with mounds of glacial drift and gravel terraces of the Henry Formation and outcrops of unconsolidated formations belonging to the Alexandrian and Niagran Series of the Silurian System (William 1971). Elevations vary from 520' on the valley floor to nearly 600' on south- and west-facing terraces. Soils belong to the Channahon-Dodgeville-Ashdale association and are characterized as drougthy, well-drained and moderately permeable. These soils formed under grass in silty or loamy material over limestone or clayey residuum weathered from limestone at depths ranging from 0"-60" (Fehrenbacher et al. 1984).

By the time plant associates of Lakeside daisy were described from the last Will County station (Rockdale), the site had been degraded and consisted of exotic (ex.), invading species and survivors of the original community. Plant associates include Achillea millefolium (ex.), Allium cernuum, Ambrosia artemisiifolia elatior, A. gerardii, A. stricta, B. curtipendula, Coreopsis lanceolata, Croton capitatus, Guara parviflora, Hedeoma hispida, Isanthus brachtiatus, Kuhnia eupatorioides corymbulosa, L. incisum, M. cuspidata, Onosmodium hispidissimum, Penstemon hirsutus, P. purpureum, Poa compressa (ex.), P. pratensis (ex.), P. arguta, Psoralea tenuifolia, Solidago rigida and Sporobolus

asper (ex.) (based on lists from R. Betz, Northeastern Illinois University, pers. comm.; Illinois Natural Areas Inventory 1978; Swink and Wilhelm 1979; nomenclature follows Swink and Wilhelm 1979).

Life History and Demography

Lakeside daisy is an herbaceous polycarpic perennial that flowers from late April to early June. The earliest flowering date is April 22 and peak flowering time is during the first two weeks of May (DeMauro pers. obs.). Although locally variable, an average of 75% of the adult plant population in any given area is in flower during this time (Table 4). Plants in artificial environments may flower continuously through summer and fall (DeMauro pers. obs.).

For many species, a minimum or critical plant size may be necessary for reproduction to occur (Harper 1977). Under artificial conditions, single rosettes of Lakeside daisy developed their first inflorescence when the mean number of leaves was 32.05 $\pm$ 6.078 s.d. (n=140, DeMauro unpub. data). Under optimal greenhouse conditions, plants grown from seed can achieve this critical size within seven months; in natural populations it may take two to three years for a seedling to reach the critical size (DeMauro 1990).

Inflorescence buds typically form in the fall and overwinter at the base of the rosette. Buds are visible by early spring at the rosette center. Inflorescences are bright yellow. Ray florets open first and within two days, the first row of the disc

florets opens. Disc florets are protandrous. Within twenty-four hours after pollen dehisces, the bi-lobed stigma opens and extends well above the yellow corolla. Rows of florets continue to open sequentially from the periphery to the center of the disc. Depending upon inflorescence size, flowering within a single head can continue for up to two weeks.

The number of inflorescences/plant is related to plant size (Table 5) and although highly variable, the two are positively correlated (DeMauro 1988a). This correlation does not necessarily apply to older, larger plants ($\geq$ 50 rosettes) observed in natural populations. Frequently these plants cover a large surface area, have a high rosette number, but have a few or no inflorescences. Although genets can be distinguished because rhizome connections between rosettes are still visible, the connections are decaying. This essentially leaves isolated, physiologically independent and genetically identical rosettes that individually are not large enough to reproduce.

Flowers are visited by bumble bees (Apidae: Bombus spp.; Dr. R. Betz, pers. obs.), and small carpenter (Xylocopidae: Ceratina sp.) and halictid bees (Halictidae) (R. Panzer, Northeastern Illinois University, pers. obs.). It is possible that pollination is also achieved by wind. Outcrossing is necessary for seed production because Lakeside daisy exhibits sporophytic incompatibility (DeMauro 1988a). This breeding system prevents self-fertilization or cross-fertilization between plants carrying the same incompatibility alleles. In an incompatible mating,

Table 4. Contribution of Size Class to Populations of Lakeside Daisy, Marblehead Quarry, Ottawa County, Ohio.

Size Class		Year Sampled 1987[a]	1989[b]	1989[c]	1989[d]	Total
Seedling	No.	542	879	2011	8140	11,572
	(%)	(53.5%)	(68.6%)	(56.3%)	(61.6%)	(60.67%)
Juvenile	No.	202	125	903	3746	4976
	(%)	(19.9%)	(9.80%)	(25.3%)	(28.4%)	(26.09%)
Adults						
Sterile (No.)		59	67	175	628	929
Flowering (No.)		210	210	483	695	1598
Total Adult	(No.)	269	277	658	1323	2527
	(%)	(26.6%)	(21.6%)	(18.4%)	(10.0%)	(13.25%)
Total All Classes:		1013	1281	3572	13,209	19,075

[a]624 1m² quadrats, DeMauro (1987).
[b]304 1m² quadrats, DeMauro (1990).
[c]200 1m² quadrats, DeMauro (unpub. data).
[d]160 1m² quadrats, DeMauro (1990).

Table 5. Some Characteristics of Adult Flowering Lakeside Daisy Plants, Marblehead Quarry, Ottawa County, Ohio.

Variable	Year Sampled 1987[a]	1989[b]	1989[c]	1989[d]
Total Number	210	210	483	695
Mean No. Inflorescence per plant ± s.d.	3.862 ± 4.280	3.224 ± 3.530	2.802 ± 4.056	2.286 ± 4.585
Mean No. Rosettes per plant ± s.d.	10.19 ± 10.45	11.51 ± 11.78	11.76 ± 16.29	11.05 ± 22.48
Correlation Coefficient	.83	.69	.71	-

[a]624 1m² quadrats, DeMauro (1987).
[b]304 1m² quadrats, DeMauro (1990).
[c]200 1m² quadrats, DeMauro (unpub. data).
[d]160 1m² quadrats, DeMauro (1990).

these alleles produce proteins that block the growth of "illegitimate" pollen grains on the stigma. Plants that are cross-incompatible belong to the same mating group while plants that are cross-compatible belong to different mating groups.

In natural populations, seed production averages 49 seeds per inflorescence or 46.9% $\pm$ 15.1% s.d. (percent seed set=number of seeds/total floret number, DeMauro 1988a). Herbivory on inflorescences and peduncles can be high, and seed production declines with increasing rates of herbivory. Seed set can be as high as 75% in unherbivorized inflorescences (DeMauro 1988a).

Achenes develop quickly and are wind-dispersed three to four weeks following fertilization. It is not known how far seeds disperse, however the greatest numbers of seedlings appear within .5m (1.64') of adult plants (DeMauro pers. obs.). There is no seed dormancy; it appears that germination occurs as soon as enough moisture is available. Under laboratory conditions, germination occurred in light and dark treatments, although germination rate was much reduced in the latter case (DeMauro 1988a). In natural populations, spring and fall seed germination have been observed (DeMauro pers. obs.). Under optimal artificial storage conditions, seeds can remain viable for at least three years (DeMauro unpub. data). In natural populations, it is not known how long seeds remain viable or if there is a seed bank.

In natural populations, several microhabitats varying in slope, rock particle size and vegetation density are available

for seedling recruitment and establishment. The greatest number of plants for all size classes (inferring the highest germination and survivorship rates) were observed in flat, open areas in which rock particle size was between 4-64 mm (.157-2.52 in) (DeMauro 1987).

Population sampling in seven areas of the Ohio population (as described on pages 7-8) shows that seedlings on the average account for 56% of all plants observed, while juveniles and adults account for approximately one-fourth and one-fifth, respectively (Table 4). Variation in size class numbers among different areas may indicate differences in the invasion histories and colony age, local site conditions, and local population dynamics, including clonal demography.

The size distribution of adult plants sampled during 1989 is strongly skewed to the smaller size classes (Table 6). Nearly 61% of all adult plants had $\leq$ 5 rosettes, while less than 2.0% had > 50 rosettes. The most frequently observed size was 3 rosettes (27%). Although genet longevity is not known, plants can grow up to one meter in diameter; under field conditions it may take on the order of decades to achieve this size.

Preliminary demographic data indicate population turnover rate may be high. Three hundred and four of the 624 $1m^2$ (3.28 ft^2) quadrats originally established in 1986 at one site in the Ohio population (DeMauro 1987) were resampled in 1989. During that time overall mortality was 82% and was highest in the smallest size classes. Cotyledon, seedling and juvenile

Table 6. Comparison of Frequency Distributions for Plant Sizes (Rosette Number) in Lakeside Daisy, Marblehead Quarry, Ottawa County, Ohio.

	1989[a]		1989[b]		Total	
Rosette No.	No.	%	No.	%	No.	%
1 - 5	364	55.32	837	63.30	1201	60.63
6 - 10	118	17.93	281	21.20	399	20.14
11 - 15	69	10.49	82	6.20	151	7.62
16 - 20	27	4.10	33	2.49	60	3.03
21 - 25	20	3.04	22	1.66	42	2.12
26 - 30	15	2.28	11	0.83	26	1.30
31 - 35	6	0.91	14	1.06	20	1.00
36 - 40	10	1.52	13	0.98	23	1.20
41 - 45	5	0.76	1	0.08	6	0.30
46 - 50	8	1.22	6	0.45	14	0.71
51 - 60	4	0.61	5	0.38	9	0.45
61 - 70	4	0.61	5	0.38	9	0.45
71 - 80	1	0.15	1	0.08	2	0.10
81 - 90	2	0.30	5	0.38	7	0.35
91 - 100	2	0.30	0	-	2	0.10
101 - 125	3	0.46	1	0.08	4	0.20
126 - 150	0	-	4	0.30	4	0.20
151 - 300	0	-	1	0.08	1	0.05
> 300	0	-	1	0.08	1	0.05
Total:	658	100%	1323	100%	1981	100%

[a]200 1m² quadrats from seven different areas in the quarry (DeMauro unpub. data).
[b]160 1m² quadrats (DeMauro 1990).

mortality were 100%, 85% and 75%, respectively (Table 7). Only 81 (29.2%) adult plants survived from 1986; 56 (70.4%) increased in size by a mean of 13.79 $\pm$ 10.90 s.d. rosettes, 19 (23.5%) decreased in size by a mean of 12.0 $\pm$ 10.69 s.d. rosettes, and the remaining 5 plants (6.1%) had no net change in size (DeMauro 1990). Of the remaining adult plants observed in 1989, 25.6% were recruited from smaller size classes mapped in 1986 while 45.2% were recruited from smaller size classes not present in 1986. These preliminary data are largely descriptive and were sampled over a period of severe drought. Long term demographic data are needed to determine average birth and death rates, seedling recruitment, and population turnover rate. Most importantly, these data are needed to determine the significance of clonal growth to population demography. An experimental approach is needed to determine the existence or role of the seed bank in population demography.

Threats

Threats to Habitat

The primary threat to Lakeside daisy is habitat destruction, as this has resulted in the reduction of U.S. populations to one site in Ohio. At Marblehead Quarry, past quarrying eliminated all natural habitat; however at present, abandoned quarry land provides the only remaining suitable habitat for the variety. Except for the 19 acre Lakeside Daisy State Nature Preserve, the Marblehead Quarry is in private ownership.

Core areas of the Marblehead Quarry habitat have been

Table 7. Preliminary Demographic Data for a Lakeside Daisy Population at the Marblehead Quarry, Ottawa Co., Ohio[a].

Description by Size Class	Tot. No. of Individuals
Cotelydons	
No. Recorded in 1986	244
No. Died by 1989	244
No. Recorded in 1989	1149
Total Cotelydons Present in 1989	1149
Seedlings	
No. Recorded in 1986	431
No. Died by 1989	367
No. to Juvenile Size Class in 1989	27
No. to Adult Size Class in 1989	37
New in 1989	879
Total Seedlings Present in 1989	879
Juveniles	
No. Recorded in 1986	135
No. Died by 1989	101
No. to Adult Size Class in 1989	34
No. Recruited from Seedling Size Class	27
New in 1989	98
Total Juveniles Present in 1989	125
Adults	
No. Recorded in 1986	182
No. Died by 1989	101
No. Recruited from Seedling and Juvenile Size Classes	71
New in 1989	125
Total Adults Present in 1989	277

[a]Summary of data from 304 $1m^2$ quadrats originally established in 1986 (DeMauro 1987) and resampled in 1989 (DeMauro 1990).

recently lost to and are under threat by expansion of quarrying and filling activities, and runoff from gravel washing. Planned implementation of more efficient mining technology by new owners of the quarry property may accelerate loss of existing Lakeside daisy habitat (G. Denny, ODNR, pers. comm.). Runoff from slurry piles to the north of the Lakeside Daisy Nature Preserve has encroached upon the east boundary of the site. Although of no immediate danger, excessive runoff could bury daisies on the preserve.

Lakeside daisy colonies west of Quarry Road are threatened by the disposal of fill material from U.S. Army Corps of Engineers permitted dredging sites (Figure 3). The USFWS has requested the Corps to prohibit use of land east of Hartshorn Road as a spoil site and to notify dredging permit holders as such (letter dated 3 August 1989 from K.E. Kroonmeyer to Colonel Hugh F. Boyd, III). Although the Corps will comply with this request for all future dredging projects in the Marblehead area, the continued existence of Lakeside daisy populations could not be guaranteed because 1) no critical Lakeside daisy habitat was designated in the listing package; 2) past and current filling are from permits issued before federal listing; and 3) excavation outside of the Corps jurisdiction could still use the quarry as a disposal area (letter dated 1 September 1989 from Colonel Boyd to K. Kroonmeyer).

Ecological Threats

Habitat loss as a result of ecological changes also poses a

threat to Lakeside daisy. At the restoration sites in Will County, Illinois and the nature preserve site in Ohio, past disturbances and possibly post-settlement fire suppression, have made conditions favorable for invasion by woody and/or exotic species. This can be controlled by active management (e.g. cutting, removing and herbiciding brush and herbaceous weeds) on protected sites or sites targeted for restoration.

Herbivory has been observed in both natural and restored populations (DeMauro, pers. obs); locally it can be very intense. Herbivory on both the inflorescence (deer, rabbit) and peduncle (weevils) prevents seeds from maturing and can drastically lower seed production. If herbivory on leaves (deer and rabbit) is too intense, rosettes are not able to regenerate (DeMauro, pers. obs.). In addition, mortality at the Tazewell County, Illinois restoration site has resulted from the digging up of plants by small mammals (J. Schwegman, Illinois Department of Conservation, pers. comm.).

Commercial/Horticultural Threats

Because Lakeside daisy is readily transplanted, easily grown from seed and has showy flowers, collecting, commercial trading and use as a horticultural plant are known and potentially could pose hazards. However, these activities are not considered serious threats at this time. Three small, private nurseries, one in Illinois, one in Wisconsin and one in Minnesota, were known to carry Lakeside daisy plants, although it is not clear if there was any commercial clone or seed trading. It is doubtful

that these suppliers have an existing seed stock, thus it is highly unlikely that any seeds are now being commercially sold.

Lakeside daisy and other species of Hymenoxys are used in private rock gardens by Chicago area members of the American Rock Garden Society. All of the var. glabra plants were taken as cuttings from a single plant collected at the Rockdale, Illinois site approximately twenty years ago. Cuttings were exchanged among Society members because their clones never produced seeds.

Other Factors that Contribute to Rarity

Several biological and historical factors pre-dispose Lakeside daisy to rarity (sensu Rabinowitz et al. 1986). The variety's disjunct and limited distribution in the Great Lakes region suggests a wider, more continuous range early in post-glacial history that has been reduced in more recent times. Within its narrow geographic range, Lakeside daisy is limited to specialized dry, open habitats. This distribution and relative size of suitable habitat within the Great Lakes basin is patchy and small; for example, gravel hill prairies and limestone or dolomite prairies are among the rarest community types in Ohio and Illinois. Absence of Lakeside daisy in other similar prairie habitats that are more "closed" or structured, or in shaded habitats, suggests narrow habitat requirements or inferior competitive abilities under these conditions.

In general, small, isolated populations are highly vulnerable to extinction-causing phenomena such as stochastic environmental and demographic processes, erosion of genetic

variation through genetic drift, and expression of genetic load through inbreeding. These processes may result in lower rates of survival, growth and reproduction (Franklin 1980; Soule 1980; Wilcox 1980; Frankel and Soule 1981; Shaffer 1981; Waller 1984; Gilpin and Soule 1986; Ledig 1986; Goodman 1987; Lande and Barrowclough 1987). With respect to plant species having a genetically-enforced outbreeding system, i.e. incompatibility, small populations likely harbor a lower number of incompatibility alleles relative to large populations (sensu Bateman 1954; Sampson 1967; Imrie and Knowles 1971; Ockendon 1974). Thus small population size may increase the probability of obtaining the same two alleles in a given mating, resulting in no fertilization. By using computer simulations and making certain assumptions about the incompatibility system, Imrie et al. (1972) studied the effects of genetic drift and migration on the maintenance of incompatibility alleles and found that 1) within a few generations, genetic drift caused the rapid loss of incompatibility alleles in small populations; 2) populations of 16 plants or less always went extinct; 3) a threshold of 32 plants could maintain the minimum number of alleles for successful reproduction; and 4) migration increased the time to extinction by reintroducing alleles that were previously lost to genetic drift.

There is good circumstantial evidence that genetic stochasticity resulted in the extinction of at least one Lakeside daisy population. Even if the Rockdale, Illinois site was not

destroyed, it is likely the population was effectively extinct. Before 1981 the population numbered between 20-30 plants that were somewhat equally divided into three groups and distributed over approximately 1.25 acres (Illinois Natural Areas Inventory 1976). No viable seeds were found between 1970-79, although insect visitation occurred during anthesis (Dr. R. Betz pers. comm.; J. Kolar, Riverside, Illinois, pers. comm.). Given that 1) population size was near the extinction threshold predicted from the Imrie et al. (1972) model, 2) the lack of seed production, 3) the small area occupied by the population, increasing the probability that the plants were related, and 4) evidence of cross-incompatibility among the last three plants (DeMauro 1988a), it is likely that Lakeside daisies from the Rockdale site belonged to a single mating group. Historically these plants were part of a larger and more widely distributed population within the DesPlaines River valley that was fragmented and isolated as habitat was destroyed. This would suggest a limited number of cross-compatible mating groups may exist within colonies of larger populations; this in fact was observed within a colony at the Ohio population (DeMauro 1988a).

The often limited dispersal distances of seed and pollen can result in clusters of related individuals or neighborhoods (Levin and Kerster 1974; Levin 1981) that would contribute to inbreeding (Ledig 1986). Consistently high levels of inbreeding would be expected in self-incompatible species as this would be necessary to maintain this breeding system within populations (Charlesworth

and Charlesworth 1987). Seed set can be a sensitive measure of inbreeding depression (Franklin 1970). In controlled pollinations with Lakeside daisy, DeMauro (1988a) observed significantly lower seed set after just one generation of full sib crosses and maternal backcrosses. Although the effects of inbreeding depression on maintenance of natural populations are not known, small populations of strictly outbreeding species would certainly be more vulnerable to the consequences of inbreeding.

Legal Protection

While there is adequate protection for state or federal listed plants on public lands, there is little protection for populations on private lands. The 1988 amendments to the federal Endangered Species Act will greatly strengthen state regulations; specifically, any violation of federal law is now also a violation of state law. Federal law prohibits the removal, malicious damage or destruction of any federal-listed plant on federal property, or on any other areas that violate any state law, including state criminal trespass laws. Federal law also prohibits the import/export, transport or sale of listed plants in interstate or foreign commerce. Exceptions to this are 1) activities on private lands; 2) listed species held in captivity or a controlled environment on December 28, 1973 or on the date of the final regulation in the Federal Register; 3) the non-commercial holding or use of listed species after the published final regulation; and 4) that seeds from cultivated specimens of threatened species are exempt from trade prohibitions provided a

statement of "cultivated origin" appears on the container.

Ohio and Illinois have very similar endangered species protection laws. Illinois law prohibits the commercial delivery, transport, or receipt of any federal endangered plant without a permit from IDOC while Ohio law prohibits such activities for any state listed species; Ohio law does not prohibit these activities for federal listed species if a permit has been issued by the federal government. The taking of any state listed plant on state lands is illegal in both states without a permit from the appropriate agency, i.e., ODNR and IDOC. Without written permission from the landowner, collecting of state listed plants on private lands is illegal in both states. The sale of plants or plant products on the state endangered list is prohibited in Illinois and for any state listed species in Ohio. In addition, the malicious damage or removal of any state listed species from a dedicated state nature preserve would also be in violation of the nature preserves act in each respective state.

Lakeside daisy is not protected by the Ontario Endangered Species Law because it is not a listed species in that province.

Conservation Measures

Ongoing In-Situ Restoration Projects - Illinois

By 1981, all historic Illinois sites for Lakeside daisy were extirpated. The Illinois population consisted of three plants in cultivation that belonged to the same mating group (DeMauro 1988a), effectively precluding any seed production. Thus Illinois plants could not be used as the sole genetic stock for

recovery actions. As a result of breeding system studies (DeMauro 1988a), seeds representing genotypes from Ohio, Canada, and hybrid progeny from crosses between Illinois and Ohio plants were available for restoration in Illinois. Although experimental, use of hybrid progeny insured representation of the Illinois gene pool in restored populations (which may or may not have a selective advantage on Illinois sites). In addition, introducing new incompatibility alleles into the Illinois breeding line 1) increased the chances of successful reproduction between plants carrying Illinois genes (i.e. hybrids) and 2) reduced the chances of inbreeding.

Seeds were germinated and plants were greenhouse grown under sodium vapor lamps for six months. Plants rather than seeds were used in recovery actions because of 1) potentially low seed viability (seeds had been in storage for three years); 2) use of plants maximized the probability of successful seed production because the transplanting design insured genets of compatible mating types were planted adjacent to one another; and 3) use of seeds would not allow reliable tracking of the success of different breeding lines.

Preliminary searches of potentially suitable sites within the lower DesPlaines River valley were conducted during the variety's flowering season in 1987 and 1988 (DeMauro pers. obs.). While no Lakeside daisy populations were discovered, several sites within the species historic range were found to be suitable for introduction. Criteria in determining suitable areas were

sites that possessed, as nearly as possible, habitat conditions (as documented from former Illinois sites e.g. geology, soils, topography, slope, aspect, hydrology, plant community, plant associates) that either supported, reasonably could have supported or are now capable of supporting Lakeside daisy (DeMauro 1988b). Other criteria included site size, habitat quality, and protection status (DeMauro 1988b).

Six sites were found to be suitable, but three were considered inviable because of the limited amount of daisy habitat, poor habitat quality that would require management prior to initiating restoration, and they were unprotected (in private ownership). With the approval of the Illinois Endangered Species Protection Board and the Illinois Nature Preserves Commission, single rosette plants were transplanted into three nature preserves in Illinois during 1988: Lockport Prairie Nature Preserve (Figure 8) and Romeoville Prairie Nature Preserve (Figure 9), both owned/leased and managed by the Forest Preserve District of Will County; and Manito Prairie Nature Preserve (Figure 4), owned and managed by the Illinois Department of Conservation. While Manito Prairie is a historic location for the variety, the two Will County sites are not. These two sites are located within the variety's historic range in lower DesPlaines River valley, three and six miles, respectively, to the north of Joliet (Figure 5). Portions of the restoration area at Romeoville Prairie are in private ownership, and the Forest Preserve District of Will County is pursuing a lease agreement.

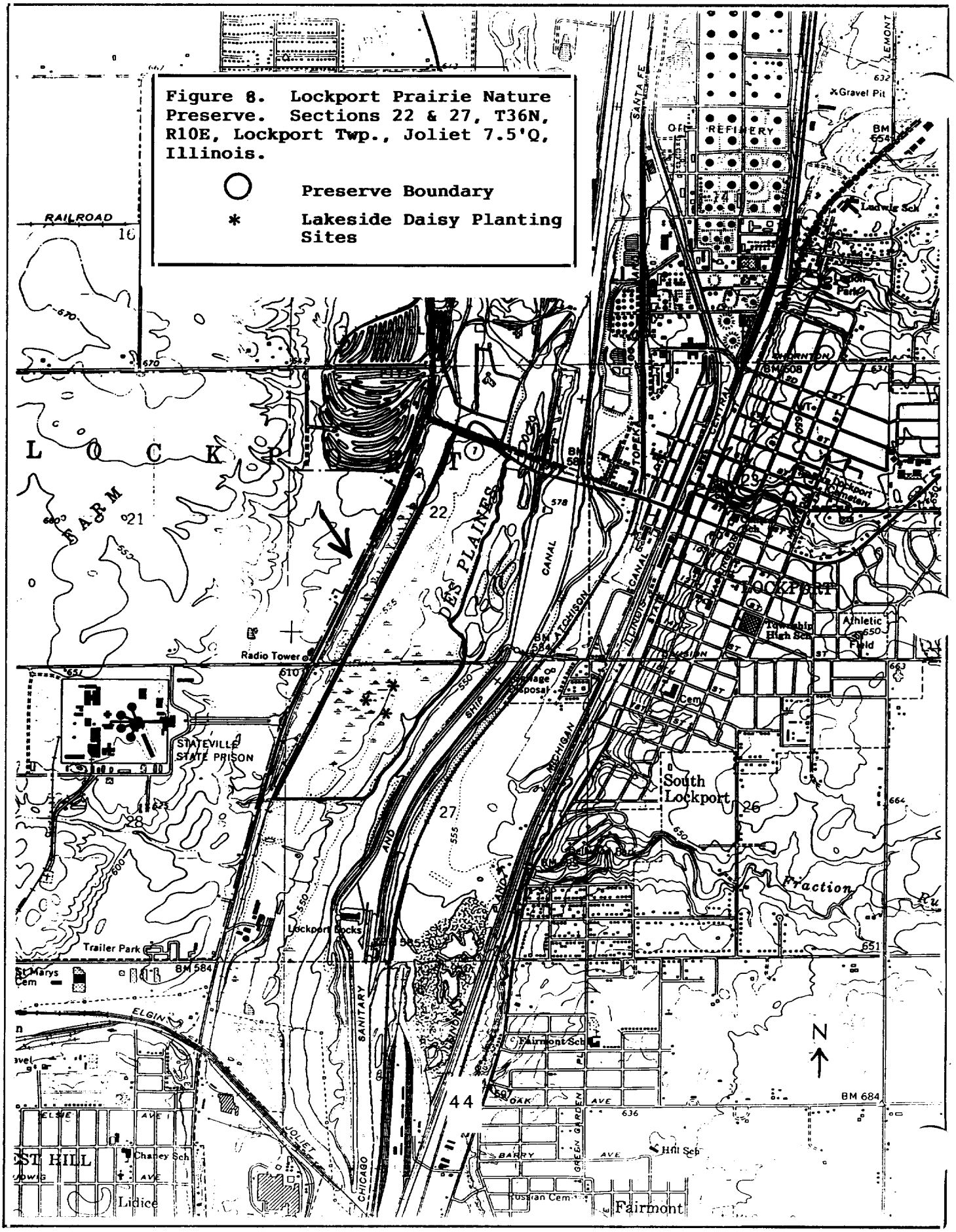


Figure 8. Lockport Prairie Nature Preserve. Sections 22 & 27, T36N, R10E, Lockport Twp., Joliet 7.5'Q, Illinois.
Preserve Boundary
* Lakeside Daisy Planting Sites
RAILROAD
L O C K P O R T
FARM
DES PLAINES
CANAL
ILLINOIS AND MICHIGAN CANAL
SANITARY AND SHIP CANAL
STATEVILLE STATE PRISON
Radio Tower
Lockport Locks
Trailer Park
St Marys Cem
ELGIN
JOLIET
CHICAGO
BARRY
OAK
GREEN GARDEN
AVE
Fairmont Sch
Hill Sch
Lidice
Fairmont
South Lockport
Fraction
LOCKPORT
Athletic Field
Cem
Gravel Pit
REFINERY
Ladwig Sch
Lincoln Park
Lockport Cemetery
Russian Cem
BM 584
BM 684
N

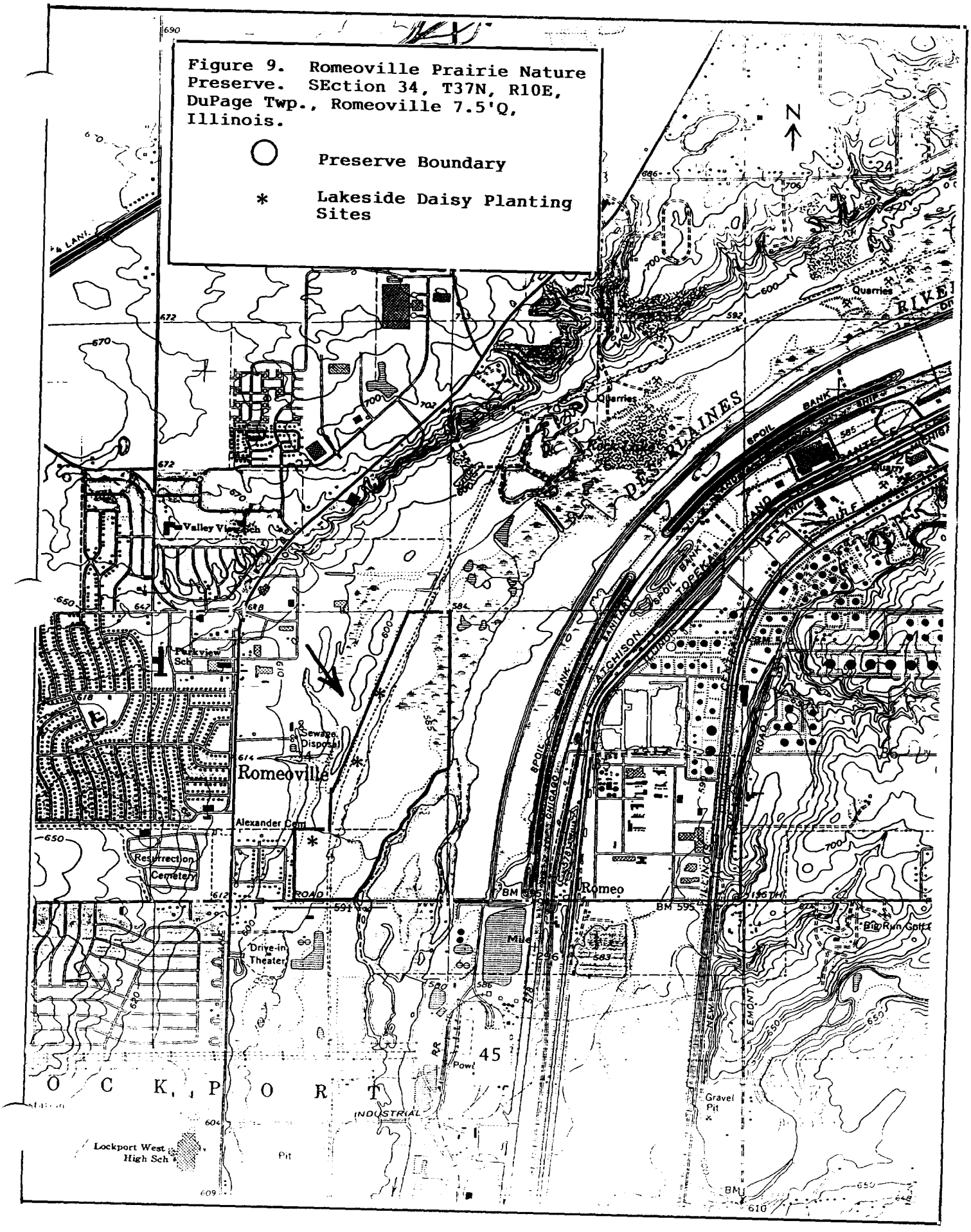


Figure 9. Romeoville Prairie Nature Preserve. SEction 34, T37N, R10E, DuPage Twp., Romeoville 7.5'Q, Illinois.
Preserve Boundary
Lakeside Daisy Planting Sites
N
Romeoville
Romeo
Quarries
Valley View Sch
Parkview Sch
Sewage Disposal
Alexander Cem
Resurrection Cemetery
Drive-in Theater
Lockport West High Sch
Gravel Pit
INDUSTRIAL
ROAD
BM 595

In May, 1988 1200 Lakeside daisies were transplanted in Lockport and Romeoville Prairies (600/site) at densities varying between one to four plants/m^2 (depending upon the microhabitat conditions). This is within the range of adult plant densities observed in natural populations (DeMauro 1987, 1990).

Only 60 plants survived the 1988 drought, the worst recorded in Illinois (Illinois State Water Survey 1989). During fall 1988, an additional 1000 plants (500/site) were transplanted into these two sites and 300 daisies were transplanted into Manito Prairie. Population censuses in spring, 1989 indicated 84%, 85% and 78% survivorship at Lockport Prairie, Romeoville Prairie and Manito Prairie, respectively. While an average of two-thirds of the restored populations across all sites flowered in 1989 and 1990, snow and freezing temperatures during the first week of May, 1989 and intense herbivory on inflorescences in May-June, 1990, drastically reduced the number of flowering plants at the Will County sites. Despite these setbacks, seedlings and juveniles have been observed at both sites since fall, 1989 (DeMauro, pers. obs. and unpub. data). Long-term population monitoring will continue to evaluate the success of these recovery actions.

Ongoing In-Situ Restoration Projects - Ohio

Because of ongoing threats to the Lakeside daisy population by quarrying and filling activities, ODNR, Division of Natural Areas and Preserves initiated recovery actions in 1989.

During spring, 1989, aerial photographs (1:24000) and 7.5'

topographic maps were used to locate abandoned quarries in Ottawa, Erie and Sandusky counties, Ohio (DeMauro, unpub. data). Except for Kelleys Island, no suitable sites were found.

Kelleys Island is located 3.5 miles north of the Marblehead Peninsula. There are no historical records for Lakeside daisy. The island was primarily forested (Moseley 1899) and in recent geologic time, water likely was a barrier to plant migration. As a result of extensive quarrying, three abandoned quarries with suitable habitat now exist on the island, two of which are owned by ODNR, Division of Parks and Recreation. An agreement between the ODNR, Division of Parks and ODNR, Division of Natural Areas (inter-office memo dated 23 June 1989 from R.E. Moseley to S. Spaulding) set procedures for use of these quarries as Lakeside daisy recovery sites.

With the permission of Standard Slag, ODNR, Division of Natural Areas collected 200 Lakeside daisies from different sections of the Marblehead Quarry to insure genetically different and compatible plants. Plants were transplanted into the abandoned southeast quarry on Kelleys Island (Figure 10) on September 28, 1989. By May, 1990, 166 plants (83%) survived, of which 91 (55%) flowered.

In June, 1990, ODNR, Division of Natural Areas collected 40,000 seeds from Marblehead Quarry. Two experimental plots were established in the north quarry on Kelleys Island and approximately 15,000 seeds were hand-broadcast into each plot. The remaining 10,000 seeds were hand-broadcast into unoccupied

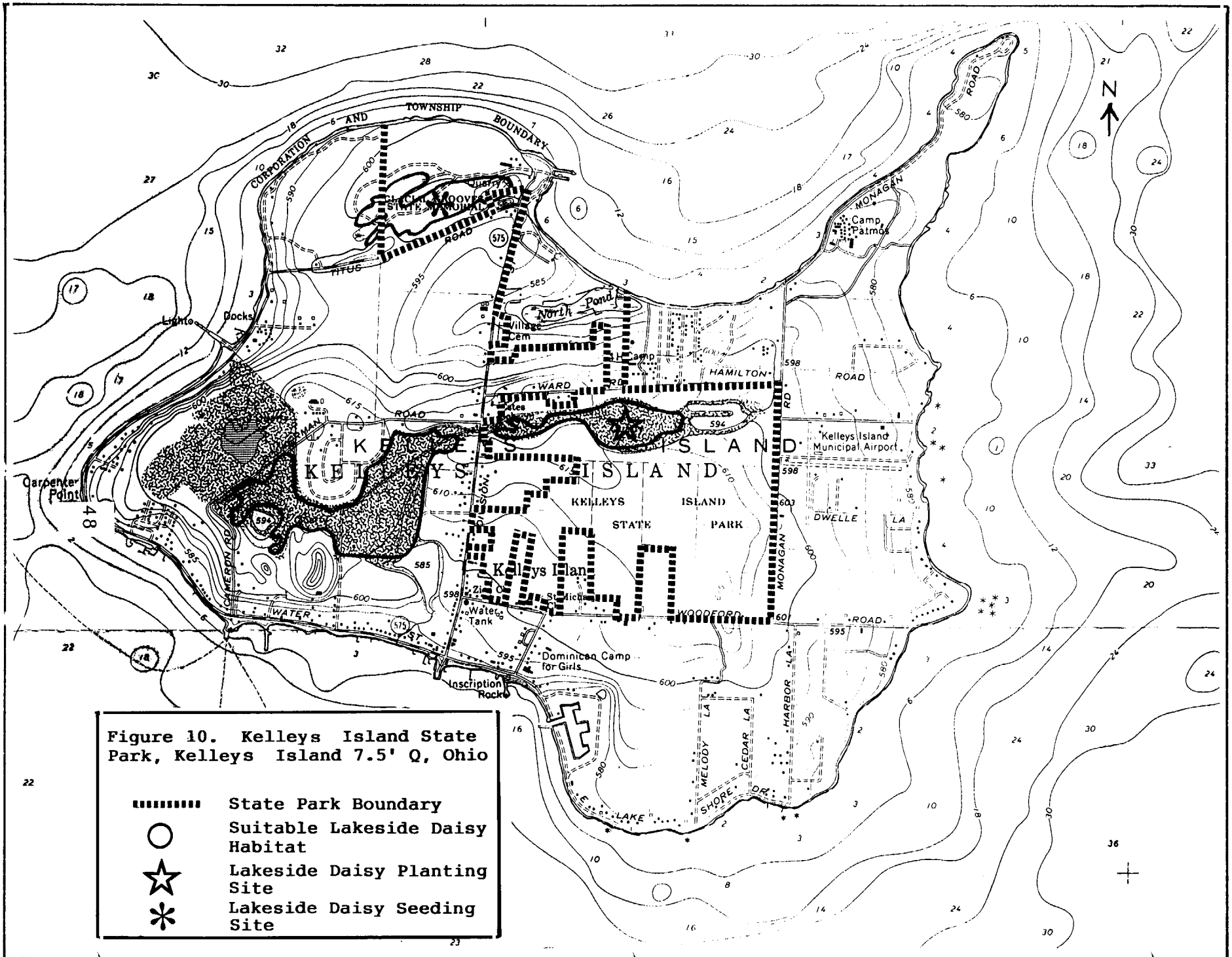


Figure 10. Kelleys Island State Park, Kelleys Island 7.5' Q, Ohio

- State Park Boundary
- Suitable Lakeside Daisy Habitat
- Lakeside Daisy Planting Site
- Lakeside Daisy Seeding Site

areas suitable for the variety at the Lakeside Daisy State Nature Preserve.

Ex-Situ Collections

As part of the Center for Plant Conservation's National Collection of Endangered Plants program, approximately 200 Lakeside daisies are maintained in habitat plantings at the Holden Arboretum, Ohio. In 1986, approximately 800 seeds collected from the Marblehead Quarry population were placed in conventional (low humidity, low temperature) long term seed storage at the USDA facility in Pullman, Washington (B. Parsons, Holden Arboretum, pers. comm.).

During fall 1989, 315 Lakeside daisies (each containing from 25-50% of the Illinois gene pool) were transplanted into a dry gravel hill and dolomite prairie habitats at the Morton Arboretum, Lisle, Illinois. These rare Illinois prairie habitats were recreated to conserve the local gene pool and to publicly display Illinois endangered and threatened species as they would appear within their natural communities.

The University of Illinois at Chicago greenhouse maintains approximately 2500 plants that are available for expanding recovery projects in Illinois. In addition, a small outdoor habitat recreation on the greenhouse grounds houses the original three Illinois plants; eventually these will be transferred to the Morton Arboretum, Lisle, Illinois. Clones from these plants are still maintained in the private garden of the original collector (John Kolar, Riverside, Illinois) since the late 1970s.

Approximately 100 Lakeside daisies (representing Ohio, Canada, and hybrid progeny from crossing Illinois x Ohio plants) are housed at the University of Chicago greenhouse for research on incompatibility systems by Dr. D. Charlesworth, Department of Biology.

PART II: RECOVERY

Objective

Lakeside daisy can be considered for delisting when 1) 475 acres of essential habitat containing the population center at the Marblehead Quarry, Ottawa County, Ohio are acquired and managed; 2) 465 acres of additional essential habitat at the Marblehead Quarry is protected through easements, restrictive covenances or leases; 3) the variety is restored to a minimum of one large, stable population in each of two geographically distinct, protected sites of suitable size within the variety's historic range in Illinois; and 4) restored populations are maintained for fifteen consecutive years, with monitoring to continue for an additional ten years. Based on current recovery criteria, the estimated date for recovery completion is 2005.

Definition of Recovery Criteria

Essential habitat is defined as occupied and unoccupied suitable Lakeside daisy habitat between Hartshorn and Bay Shore Roads (Figure 11).

A large restored population is defined as having $\geq$ 5,000 adult plants. This number should buffer the population from potentially high turnover rates. In addition, depending upon the number of incompatibility alleles segregating in a population and the dominance relationships between alleles, the effective population size (N_e) will be lower than the total number of plants in the population (N). For a self-incompatible species, N_e may be best estimated as the number of compatible individuals

or mating groups. For example, DeMauro (1988a) found that among Lakeside daisies used in initial breeding experiments, the N_e (=14) was 30% lower than N (=20).

Minimum size requirements for restoration sites are areas that contain 3 hectares (7.41 acres) of suitable Lakeside daisy habitat. Using one of the lowest mean density estimates observed in the Ohio population (.5987 adult plants/m^2 $\pm$ .1613 95% C.I., n=304, DeMauro 1990), 3 hectares statistically could contain between 13,122 to 22,800 adult plants. In reality, Illinois sites have more dense ground cover, and would likely have a lower plant density and total plant number on 3 hectares. In addition, the distribution of suitable habitat is patchy (DeMauro 1987, 1988b). Thus a much larger site (e.g. on the order of > 50 acres) may be needed to contain 3 hectares of suitable habitat.

Primary criteria to evaluate the stability of a restored population are evidence of reproduction, and the recruitment and establishment of younger age classes at rates or levels comparable to those observed in natural populations (DeMauro 1988a, 1990). Annual seed set should average between 40% and 60%, and at the end of fifteen years, size class proportions should fall within the ranges of 10%-27% for adults, 9%-29% for juveniles and 53%-69% for seedlings. A fifteen year recovery period and an additional ten year monitoring period are appropriate given 1) the perennial life habitat, 2) the minimum three year gap between establishment and reproductive maturity (DeMauro 1990), and 3) the fact that the Ohio population has

reached its present level of abundance and distribution after the cessation of quarrying operations forty to fifty years ago.

Other sampling data (e.g. plant frequency, density, and coverage) from the Ohio population were not used as recovery criteria because they were considered potentially unreliable in assessing population stability in geographically different areas. Although superficially similar both in terms of physical attributes and plant associates, the Ohio site is different from Illinois restoration sites in past disturbance regime, successional stage, plant community structure, management regime and climatic stresses. Illinois sites have been heavily grazed, have a more dense grass matrix, and are frequently burned. Illinois sites are inland at the southern-most extension of the variety's range and may thus experience greater variance in temperature and precipitation. These conditions are likely to have different affects on the demographic responses of Lakeside daisy when compared to Ohio habitats.

Demographic and genetic parameters were not used as delisting criteria. Although monitoring has been initiated at natural and restored populations, there are not enough data at this time to utilize models that would be of predictive value. Use of genetic criteria are not considered necessary for recovery. Genetic considerations are important primarily in small populations; since existing populations are relatively stable and large, it is more critical to determine if there is ample seed production and recruitment.

The current recovery criteria, however, should be considered preliminary and subject to revision based on new information. Future reassessment of restored populations and recovery criteria may indicate that delisting is not a practical objective.

Stepdown Outline

1. Provide adequate habitat protection for the only naturally occurring Lakeside daisy population in the U.S., the Marblehead Quarry.
    - 1.1. Increase the amount of preserved acreage through the highest level of land protection.
    - 1.2. Assign protection priority.
        - 1.21. Area 1.
        - 1.22. Areas 2.
        - 1.23. Areas 3 through 5.
2. Establish Lakeside daisy populations on suitable sites within the species historical range.
    - 2.1. Site selection and establishment.
    - 2.2. Size and genetic constitution of transplant populations.
3. Monitor population status.
    - 3.1. Conduct annual census at each site and map extent of the population.
    - 3.2. Establish permanent plots for demographic monitoring at selected sites.
    - 3.3. Periodic sampling of plant community at each site.

4. Provide necessary management at all protected sites.

4.1. Develop site management plans.

4.2. Primary site management actions.

4.3 High priority management actions.

4.31. Exotic species control.

4.32. Herbivore control.

5. Conduct appropriate research into the biology, ecology and habitat requirement of Lakeside daisy.

5.1. Investigate taxonomic status of var. glabra.

5.2. Investigate the response of Lakeside daisy to ongoing management at protected/restored sites.

5.3. Determine the role of seed banks in natural populations.

6. Provide appropriate public information.

Narrative

1. Provide adequate habitat protection for the only extant, naturally occurring population in the U. S., the Marblehead Quarry.

1.1. Increase the amount of preserved acreage through the highest level of land protection.

Nearly 98% of essential Lakeside daisy habitat, including all of the population center, is in private ownership and as such, is afforded virtually no legal protection. Due to residential/commercial development and unsuitable wooded habitats adjacent to the quarry, there is nowhere that Lakeside daisy can retreat to if its existing habitat is lost.

Preservation strategies, e.g. nature preserve dedication of private lands, conservation easement, restrictive covenance or long term lease agreement may be considered. Any dedication, easement, covenance or lease must allow legal access for monitoring and management purposes and provide authority to limit all land uses that threaten Lakeside daisy. Another option is an agreement allowing quarry expansion with ODNR holding the first right of refusal on lands having potential for recolonization by Lakeside daisy after quarrying is completed. While such easements or agreements may be more cost effective in the short term, they require the willing cooperation of the landowner. Given 1) the historic attitude of the landowners toward land preservation, 2) the current land use, with potential for quarry expansion, and 3) the perceived future value of abandoned quarry land in light of development pressure on the Marblehead Peninsula, preservation methods other than outright purchase may not be viable options at this time or may compromise the recovery objective by not providing the highest level of protection. Protection is best achieved through 1) fee simple acquisition of priority essential habitat by a public agency and dedication of the site as a state nature preserve and 2) easement/lease of other priority essential habitat as indicated in this plan.

The ODNR, Division of Natural Areas and Preserves should be the lead agency responsible for protection and management, with funding assistance for land acquisition provided by the USFWS, the Land and Water Conservation Fund or by other organizations

such as the Nature Conservancy.

1.2. Assign protection priority.

Using Shaffer's (1981) definition of minimum viable population size, the best available evidence suggests that for long term survival and maintenance of evolutionary potential of a strictly outbreeding species such as Lakeside daisy, large populations (on the order of thousands) are required over large areas of suitable habitat (on the order of hundreds of acres).

Ideally, all abandoned quarry land containing Lakeside daisy and all suitable, unoccupied habitat should be preserved. If this is not feasible or if preservation can only be accomplished in phases, then key areas must be assured of protection. Five preservation blocks totaling 1200 acres were identified (Figure 11) and prioritized based on whether or not the area 1) contained extensive/dense Lakeside daisy colonies; 2) contained defendable boundaries from illegal access or uses, i.e. including land to roads, gates, water bodies or areas of sharp topographic grades; 3) provided access for surveillance, management and monitoring; 4) contained other rare species or prairie vegetation; 5) required extensive management (i.e. open areas vs. areas invaded by woody and exotic plant species); and 6) was involved in or threatened by quarrying or other activities.

1.21. Area 1.

Fee simple purchase of Area 1, approximately 475 acres of contiguous habitat within the population center, is required for recovery (Figure 11). Area 1 contains the most extensive and

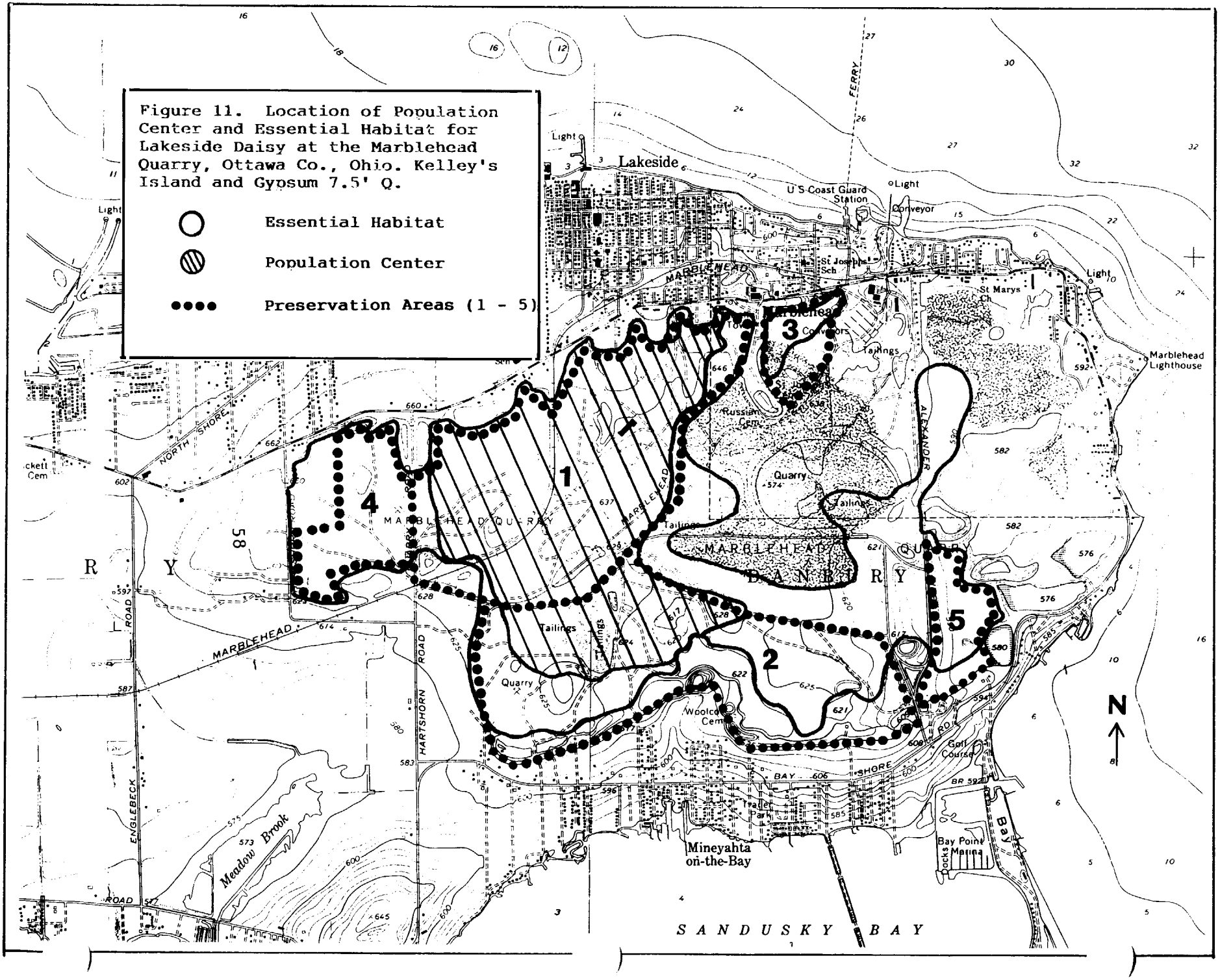


Figure 11. Location of Population Center and Essential Habitat for Lakeside Daisy at the Marblehead Quarry, Ottawa Co., Ohio. Kelley's Island and Gypsum 7.5' Q.
Essential Habitat
Population Center
Preservation Areas (1 - 5)
1
2
3
4
5
Lakeside
U S Coast Guard Station
Light
Conveyor
MARBLEHEAD
St Joseph Sch
St Marys Ch
Marblehead Lighthouse
Conveyors
Tailings
Russian Cem
ALEXANDER
Quarry
MARBLEHEAD QUARRY
NORTH SHORE
MARBLEHEAD QUARRY
Tailings
Quarry
Woolcott Cem
Golf Course
BAY SHORE
BR 592
Trailer Park
Mineyahta on-the-Bay
Bay Point Marina
Docks
Bay
SANDUSKY BAY
ENGLEBECK ROAD
HARTSHORN ROAD
MARBLEHEAD
Meadow Brook
N

dense concentration of Lakeside daisy over the greatest diversity of microhabitats in the quarry. In addition, Area 1 contains the only degraded but intact prairie remnant within the quarry, contains six other state listed or potentially state threatened taxa (A. Cusick, pers. comm.), requires minimal management (brush/weed control), and has potential for prairie restoration. Fencing may by required along sections of Rt. 163. Area 1 could become threatened if the quarry expands west and northwest.

In fall of 1988 the ODNR purchased the 19.086 acre Lakeside Daisy State Nature Preserve from Standard Slag for per acre price of approximately $2,620. This cost is an underestimate because it does not take into account other incurred expenses e.g. appraisals, surveyors, title search and commitment, attorney fees and administrative costs. If the per acre price is increased by approximately 10% to cover these costs, the estimated per acre cost is $2,900. Extrapolating this estimate to the purchase of 475 acres in Area 1 totals $1,377,500.00. A higher acquisition cost per acre would be expected because of frontage along State Route 163 and Quarry Road, and the appreciation in land value over time.

1.22. Area 2.

The protection of Area 2 (465 acres) through conservation easements, covenances or leases is required for recovery. Costs for obtaining an easement/lease are unknown but could be minimal depending upon the terms of the agreement and assuming cooperation by the landowner. Area 2 contains the remainder of

the current population center as well as some acreage of unoccupied, suitable Lakeside daisy habitat and extensive open water areas. Steep topographic grades along the south and west borders provide easily defendable boundaries and minimal management is required.

1.23. Areas 3 through 5.

Although not included as part of the recovery objectives, four additional blocks totaling 260 acres were identified for protection because of the occurrence of Lakeside daisy and suitable habitat. Although not required for recovery, these blocks may be considered for protection by other preservation strategies (e.g. easement, covenant, lease) and are prioritized in descending order. If the survival of Lakeside daisy is threatened or compromised as a result of habitat loss, then these blocks are to be reassessed for future acquisition.

Area 3 (60 acres) is the last remnant of the original population center prior to quarrying. It contains a dense colony of Lakeside daisy as well as other plants from the original prairie community. As a result of past dumping activities, area 3 would require clean-up. Although not of immediate concern, Areas 2 and 3 are adjacent to the active quarry and could be threatened by future expansion.

In Area 4 (125 acres), Lakeside daisy is highly localized. Although the variety is not as abundant here as in other portions of the quarry, area 4 contains extensive acreage of unoccupied habitat. This area is currently under threat from filling by

dredged materials. As a result of past dumping activities, some clean-up is required. Area 5 (75 acres east of Alexander Pike Road) contains low density, locally-occurring "patches" of Lakeside daisy, although extensive unoccupied acreage is present.

Remaining essential habitat between the active quarry and Alexander Pike Road is not considered for protection at this time because some portions are under immediate threat of quarry expansion (and may have already been lost), while other portions have been used as storage for gravel fill.

2. Establish Lakeside daisy populations on suitable sites within the variety's historical range.

2.1. Site selection and establishment.

Criteria for locating sites of suitable habitat and size have been detailed on pages 42, 43, and 52. Several sites were identified and recovery actions have been initiated on a total of four sites: one in Erie County, Ohio (Kelleys Island); two in Will County, located in northeastern Illinois (Lockport Prairie and Romeoville Prairie Nature Preserves), and one in Tazewell County located in central Illinois (Manito Prairie Nature Preserve). All sites had greater than the minimum size criterion of 3 hectares (7.41 acres). Maintenance of existing restored Illinois populations at Manito Prairie and one of the Will County sites for fifteen years is required for recovery.

While not required for recovery, other sites have been identified as suitable for restoration efforts. Three sites (Houbolt Road, Rock Run and Rockdale, Figure 5) originally

identified by DeMauro (1988b) for recovery actions were dropped from final consideration (p. 43). These sites have been identified by the Forest Preserve District of Will County as suitable for preservation. Because the three sites are centrally located within Lakeside daisy's known range, recovery actions should be reconsidered if the Forest Preserve District pursues acquisition, easement or leasing of these properties.

During the summer of 1989 a more systematic search for restoration sites in the Kankakee River and DesPlaines River watersheds (Illinois) was conducted using aerial photographs (1:4800) and 7.5' topographic maps. Only in the DesPlaines River basin were patches of suitable habitat found, primarily as bedrock outcrops along roads, railroads and the Illinois and Michigan National Heritage Corridor. Most patches were too small and isolated to sustain long term, stable populations. One potentially suitable site, Waterfall Glen Forest Preserve (Figure 12), was located along the north side of the DesPlaines River in southeastern DuPage County, five miles northeast of Romeoville Prairie. Waterfall Glen is owned and managed by the Forest Preserve District of DuPage County. This site may be considered for future recovery actions if needed.

2.2. Size and genetic constitution of transplant populations.

Given that localized incompatibility can be found within large populations and the potential deleterious effects from inbreeding, transplant populations should maximize genetic

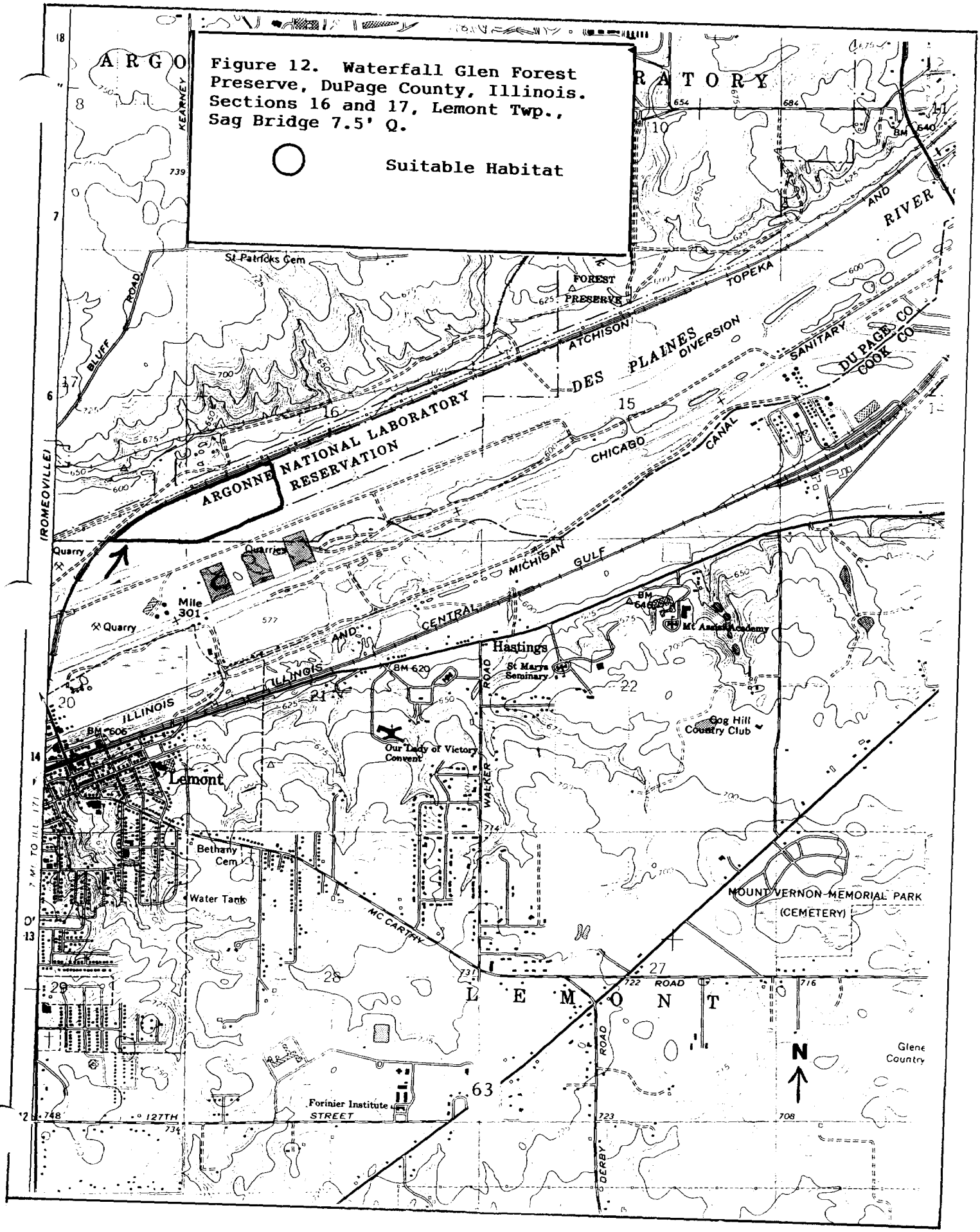


Figure 12. Waterfall Glen Forest Preserve, DuPage County, Illinois. Sections 16 and 17, Lemont Twp., Sag Bridge 7.5' Q.
Suitable Habitat
ARGONNE NATIONAL LABORATORY RESERVATION
FOREST PRESERVE
DES PLAINES DIVERSION
CHICAGO SANITARY AND SHIP CANAL
DU PAGE CO
COOK CO
ATCHISON TOPEKA AND SANTA FE
MICHIGAN GULF CENTRAL AND ILLINOIS
Lemont
Hastings
St Patricks Cem
Bethany Cem
Water Tank
Our Lady of Victory Convent
St Marys Seminary
Mt Assisi Academy
Sag Hill Country Club
MOUNT VERNON MEMORIAL PARK (CEMETERY)
Forinier Institute
BLUFF ROAD
KEARNEY ROAD
WALKER ROAD
MC CARTHY ROAD
DERBY ROAD
127TH STREET
Mile 301
Quarry
BM 606
BM 620
BM 646
N

diversity. Protocols addressing this issue for Illinois restorations are detailed on pages 41-42. Long term monitoring can gauge the success of the mixed gene pools in the initial transplant cohort. This can help determine if there are better adapted genotypes and may provide guidelines for the genetic composition of future supplemental plantings if needed. For the Kelleys Island, Ohio restoration, widely separated plants (≥ 100m/≥ 328') were collected from different areas within the Marblehead Quarry.

Depending upon availability, the initial number of transplants should be on the order of several hundred. This would insure survival of a enough plants that presumably are genetically different and compatible. Small to medium sized genets (i.e. 3 to 10 rosettes) are ideal for transplanting; because of ease in handling and transporting, more of the root system remains intact in smaller plants (DeMauro pers. obs.). In all four restoration actions to date, the number of initial transplants is within the recommended range.

If seeds are used as the transplant material in future restorations, then a minimum of 25,000 (essentially one mature seed head from each of 500 plants) should be collected to insure adequate levels of germination, survival and establishment.

3. Monitor population status.

3.1. Conduct annual census at each site and map extent of the population.

The location and distribution of Lakeside daisy at all

Illinois restoration sites are to be mapped and surveyed to permanent field markers (e.g. rebar) so that specific colonies can accurately be relocated. For a more systematic approach to mapping and censusing, transects can be established at set intervals so that the site map is subdivided into a grid. Annual counts should be taken, at the minimum, of all plants, with reference given to life history stage. For adult plants, reproductive status (flowering vs. nonflowering), presence or absence of seeds, general vigor and evidence of herbivory (on inflorescences, leaves or roots) should be noted. This level of monitoring will provide data on changes in the area occupied by the species, population number (refer to Table 8), or determine if supplemental plantings are needed. More detailed demographic information should be collected on a subset of the population (see below).

Because Lakeside daisies are dense and extensive in distribution in Ohio, annual mapping and censusing is not needed. Instead these data should be collected in conjunction with community monitoring (see below).

Annual site reconnaissance at all sites will help identify illegal uses or threats to the population such as collecting, off-road-vehicles, or damage/mortality as a result of herbicide use on sites with brush control programs.

Periodically, mature seed heads should be collected and seed set quantified (number of achenes/total floret number) to determine if there is adequate seed production; this is

particularly important in restored populations. The number of inflorescence heads to be examined should represent a statistically valid sample of the population.

3.2. Establish permanent plots for demographic monitoring at selected sites.

Permanent plots are to be established for more detailed monitoring in at least one protected site within the Ohio population and at one restoration site in each Illinois county. Demographic monitoring includes mapping and/or marking of plants, and resampling plots annually to document growth rate, general vigor, herbivory rates, fecundity, mortality, and life span of individuals as well as the recruitment of new plants (refer to Table 8). Mapping of individuals is probably more appropriate because almost all sites have little or no soil. Mapping can more accurately track clonal growth, which can be very extensive in Lakeside daisy and may be important for population maintenance.

Demographic monitoring can also be used to address specific objectives e.g. 1) comparison of population trends at varying densities (i.e. population core vs. margin); 2) population assessment in a specific management regime, successional stage or microhabitat; 3) assessment of the success of geographically different gene pools; or 4) project population trends based on responses to monitoring in response to observed shifts in population size/number as determined by the annual mapping and censusing. Although time consuming, demographic monitoring

provides the best information on long term population status and can suggest the appropriate research or management actions if problems are detected.

3.3. Periodic random sampling of plant communities at each site.

Baseline plant community data should be collected at a minimum of one protected site within the Ohio population and at each restoration site to date in Illinois. In restored populations, baseline sampling should be conducted near the time of the initial transplant. Resampling will tract changes in the plant communities, particularly in response to management and/or community restoration efforts (refer to Table 8), and should be conducted at intervals of no less than 5 years. Sampling should be stratified random within planting areas and at least include frequency and cover estimates for all plant species encountered. The number and size of plots should be a representative sample of the local community.

4. Provide necessary management at all protected sites.

4.1. Develop site management plans.

Management plans are to be developed for each protected Lakeside daisy site. These plans should address site specific management problems, recommend actions, and estimate completion times and costs. Although not providing specific information, a master plan is available for Lakeside Daisy State Nature Preserve (Appendix I).

4.2. Primary site management actions.

With the exception of any direct intervention that may be suggested by population/demographic monitoring (e.g. supplemental seeding or transplanting, hand pollinations), species management will be dictated to a large extent by the site and community management needs. These may include 1) protection from extensive human disturbances (e.g. ORVs, dumping, filling, collecting) by erecting fences, posting boundary signs or limiting site access by the public, 2) the maintenance of open habitat by exotic species control or prescribed burning, and 3) restoration of the native prairie community.

The primary management objective at all sites is exotic species control, i.e. the removal of encroaching or competing non-native plant species. This includes the cutting, herbiciding and removal of invasive woody species, and the herbiciding or hand pulling of invasive herbaceous exotic plants. A secondary management goal is the enhancement of the native prairie community.

Because exotic species pose no immediate threat to Lakeside daisy or to its suitable habitat at the Ohio sites (Lakeside Daisy State Nature Preserve, Kelleys Island restoration) and Manito Prairie (central Illinois), there is minimal management required at this time. At Manito Prairie, brush control is ongoing in areas not containing Lakeside daisy. Prescribed burning is ongoing at all Illinois restoration sites.

4.3. High priority management actions.

4.31. Exotic species control.

Brush and weed control are of high priority at Will County, Illinois restoration sites. The upland habitats at Lockport and Romeoville Prairies have been badly degraded by past grazing, dumping and excavating, and decades of fire suppression. This has allowed the proliferation of exotic woody and herbaceous plants (e.g. Rhamnus cathartica, Crataegus spp., Melilotus alba, Pastinaca sativa, Poa compressa, P. compressa) that shade/compete with Lakeside daisy, and require removal. At Romeoville Prairie, off-road-vehicles (ORVs) have damaged at least one Lakeside daisy planting area; continued unauthorized access may require fencing of the preserve's west boundary.

4.32. Herbivore control.

Preliminary results from 1990 demographic monitoring at the Will County, Illinois restoration sites indicate very high herbivory rates on inflorescences. Most damage is by eastern cottontail rabbits, with some additional damage by white-tailed deer. These herbivores should be excluded at least during the months of May and June either by exclosures, scent marking with predator urine/feces, or in extreme cases, herbivore removal.

5. Conduct research on the biology, ecology and habitat requirements of Lakeside daisy.

5.1. Investigate the variety's taxonomic status.

Research is needed to determine if Lakeside daisy is a variety of H. acaulis or a separate species. Information on the

geographic distribution, morphology and cytology should be employed in the analysis. Specific studies may include: 1) determining if varieties are reproductively isolated by differences in flowering time, chromosome number, presence or absence of incompatibility, or the success in producing fertile hybrid progeny from cross pollinating varieties; 2) determining if there are differences in life habit, extent of clonal growth, or possible dormancy stages (both in overwintering vegetative growth and seed phase); 3) determining if there are differences in key morphological characters e.g. leaf shape, size and/or area, inflorescence size, floret number, seed size; or 4) determining if varieties differ in their responses to environmental conditions (soil pH, soil moisture, temperature extremes). Once the variety's status has been assessed and published, the appropriate nomenclature changes should be made.

5.2. Investigate aspects of seed ecology and determine the role of seed banks in Lakeside daisy populations.

Seed viability, the extent of seed herbivory, seed dispersal rates and what role, if any, the seed bank has in population dynamics are unknown for this species. This research will provide information that is important in understanding population maintenance and would be particularly useful in managing restored populations.

5.3. Investigate the response of Lakeside daisy to ongoing management at protected/restored sites.

Restored Illinois Lakeside daisy populations occur within

state nature preserves in which the primary objective is managing for total species/natural community diversity. This is accomplished primarily by prescribed burning. Preliminary observations after a spring prescribed burn at Lockport Prairie indicate fire can kill emerging inflorescence buds and damage leaves. Permanent plots should be established within these burned areas to determine specific effects on reproduction, plant growth and general vigor (refer to Table 8).

6. Provide appropriate public information.

Lakeside daisy has received considerable local and statewide attention with the purchase and dedication of the state nature preserve in Ohio and with recovery actions in Illinois. Although not a serious problem at this time, Lakeside daisy is vulnerable to collection because it is easy to locate, propagate, and is attractive as a horticulture/landscape plant. An information pamphlet should be developed that describes status, rarity, threats, recovery efforts, and extent of legal protection. This information should be distributed to wholesale nurseries, local commercial propagators/retailers (especially those specializing in native plants), and native plant and rock garden societies in Region 3. This effort can be part of a more comprehensive program that is coordinated by the USFWS, specifically the development of an information brochure for all federal listed Region 3 plant species that are vulnerable to collecting or propagating.

Table 8. Monitoring Guidelines for the Lakeside Daisy, (*Hymenoxys acaulis* var. *glabra*)

Population/Demographic Monitoring

Variable	Null Hypotheses	Data Collected	Data Analysis	Schedule
Population Size	There is no change in the extent of the *Hymenoxys* colony	Locate and map individuals within site	Changes in extent (% of site occupied) of population	Initially map annually; reassess for mapping at 3 - 5 year intervals.
	There is no change in the density of plants/m^2 (unit area) or ecological density (does the plant occupy all available habitat?)	No. genets/m^2	Changes in mean genet density	Population census annual.
	There are no changes in extent of colony, density of plants or plant size related to a specific management regime?	Establish control and management plots, sample genet density (per m^2) and size (no. rosettes/genet)	Change in size of colony or genet density, change in plant plant size	As needed after management prescription.
Population Structure	There are no changes in size classes (number of plants within size classes)	Record plants by size classes	Monitor changes in numbers of plants/size class	Population census annual.
	There is no significant turnover in numbers of plants between size classes. What is the average lifespan of a genet?	Map/mark seedling cohorts and follow until senescence	Quantify mortality by changes in seedling number and density; rate of seedling replacement into population	Initially either all or a subsample of site to be sampled annually. Based on the data collected, future sampling frequency to be re-assessed.
	There are no significant changes in genet size	Map individuals to the nearest 1/4 dm^2, count no. of rosettes	Changes in coverage (area) or mean number of rosettes/genet	Data will be generated as a result of following cohorts (annual sampling).
Reproduction	There is no change in the number or density of flowering adults	Frequency and density of flowering and nonflowering adults/m^2	Number of reproductive adults in the population, changes in mean frequency and density	Initially either all or a subsample of site to be sampled annually. Based on data collected, future sampling frequency to be re-assessed.
	There is no difference in reproductive effort	Quantify number of inflorescences/genet	Changes in reproductive effort (mean no. infl./genet)	Same as above.
	There is no difference in reproductive success	Collect inflorescences and count no. seeds/total floret no. x 100	Change in mean no. florets per infl. (reproductive effort) or in seed set	Reconnaisance monitoring to determine frequency of quantitative sampling; ideally mean seed set should be quantified in years of extreme conditions (i.e. drought, cold spring temperatures, insect infestations) and "normal" environmental conditions.
General Vigor of Plants	There are no diseases, insect infestations or herbivore damage that contribute to lowered reproductive success or mortality	Note signs of any symptoms; quantify herbivory e.g. the no. of florets or seeds damaged, no. of peduncles damaged	Identify mortality factors; lowered reproductive success, i.e. lower seed set	Reconnaissance monitoring annually. Factors e.g. herbivore damage will be documented in years that seed set is quantified (see above).

Community Monitoring

Community Structure	There are no changes in species composition	Document species' occurrences	Loss or gain of species	Quantitative monitoring from randomly selected plots every 3-5 years.
	There are no changes in species dominance (i.e., importance values)	Quantify frequency, density and coverage (either map or estimate by % cover classes)	Shifts in species importance values, in percent contribution to community structure	Data will be generated as a result of the community sampling.
	There are no changes in community structure related to changes in the *Hymenoxys* population	Same as above	Are changes in the importance values of *Hymenoxys* occurring with changes in for example, an increase in importance values in woody plants? grasses?	Same as above. If a more direct measure of this change is desired, consideration should be given to re-sampling the same random quadrats to quantify the increase or decrease in *Hymenoxys* and the decrease or increase of other species.
	There are no potential threats of management concern	Document threats such as ORV use, dumping, or expansion of woody vegetation or noxious weeds	Will help guide future research and management activities	Reconnaissance - annual.

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PART III: IMPLEMENTATION SCHEDULE*

PRIORITY	TASK NO.	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY FWS REG.	FWS PROG.	OTHER	COST ESTIMATES ($000) FY1991	FY1992	FY1993	FY1994	FY1995-2015**	COMMENTS
2	1.21	Acquisition of 475 acres of essential habitat	3	3	DES		229.6	229.6	229.6			
						ODNR	229.6	229.6	229.6			
2	1.22	Protection of 465 acres	4	3	DES	ODNR	-	-	-	-		Costs unknown
2	3.1	Annual census on restored sites	ongoing	3	DES	IDOC	1.0	1.0	1.0	1.0	1.0	FPD higher costs due to larger sites
			ongoing			FPDWC	2.5	2.5	2.5	2.5	2.5	
2	4.1	Develop site management plan	partial	3	DES	ODNR	.25					
			.5			IDOC	.25					
			.5			FPDWC	.50					
2	4.31	Exotic species control	ongoing	3	DES	FPDWC	10.0	10.0	10.0	10.0	5.0	
2	4.32	Herbivore control	1	3	DES	FPDWC	2.0	2.0	2.0	2.0		
3	3.1	Annual site reconnaissance	continuous	3	DES	ODNR	1.0	1.0	1.0	1.0	1.0	
			continuous			IDOC	.5	.5	.5	.5	.5	
			continuous			FPDWC	1.0	1.0	1.0	1.0	1.0	
3	3.2	Demographic monitoring	ongoing	3	DES	ODNR	4.0	4.0	4.0	4.0	4.0	Costs vary due to differences in site size, site number and number of plants
			ongoing			IDOC	1.5	1.5	1.5	1.5	1.5	
			ongoing			FPDWC	4.0	4.0	4.0	4.0	4.0	
3	3.3	Plant community monitoring	ongoing	3	DES	ODNR	1.0				.25***	Costs are for baseline sampling only; resample at 5 year intervals
			1			IDOC	1.0				.25***	
			1			FPDWC	2.0				.50***	
3	4.2	Primary site management actions	ongoing	3	DES	ODNR	.50	.50	.50	.50	.50	Costs vary due to differences in site size and work needed
			continuous			IDOC	1.0	1.0	1.0	1.0	1.0	
			continuous			FPDWC	2.0	2.0	2.0	2.0	2.0	
3	5.1	Investigate taxonomic status	3	3	DES		15.0	15.0	15.0			
3	5.2	Response to burning at restored sites	3	3	DES		1.0	1.0	1.0			
						IDOC	1.0	1.0	1.0			
						FPDWC	2.0	2.0	2.0			
3	5.3	Investigate aspects of seed ecology and role of seed bank	3	3	DES		8.0	8.0	8.0			
3	6.0	Provide appropriate public information	2	3	DES		2.0	2.0				
							524.2	519.2	517.2	31.0	25.0/yr @ 20 yrs.	

*DES = U.S. Fish and Wildlife Service, Division of Endangered Species; ODNR = Ohio Department of Natural Resources; IDOC = Illinois Department of Conservation; FPDWC = Forest Preserve District of Will County.

**Annual costs for site management and population, demographic and community monitoring for the recommended listing period (1995-2005, excluding FY1991-1994) and the recommended 10 year monitoring period after delisting.

***Assuming 5 sampling periods at 5 year intervals from 1995-2015; costs are annualized.

APPENDIX I

Master Plan for the Lakeside Daisy State Nature Preserve
Ottawa County, Ohio

Date Prepared: March 1989
Date Revised:
Date Adopted: December 12, 1989

Approved

MASTER PLAN

Legal Name: Lakeside Daisy State Nature Preserve

Location: Ottawa Co., Danbury Twp., Kelleys Island 7.5' Quad.

Acreage: 19.086 Acres

Owner: ODNR, Division of Natural Areas & Preserves

Custodian: ODNR, Division of Natural Areas & Preserves

Classification: Interpretive - Articles Accepted: 5/13/89
Articles Recorded: 5/18/89

Funding: Fee Simple - State Income Tax Refund Checkoff Funds

Special Conditions Stated in Articles of Dedication:

"No facilities or improvements shall be permitted within the preserve unless the Chief of Natural Areas & Preserves deems that such facilities or improvements are necessary for visitation, use, restoration, and protection and that they do not significantly impair the natural character of the preserve or the viability of the Lakeside daisy."

Site to be Legally Preserved:

"... as habitat for the Lakeside daisy, Hymenoxys acaulis (Pursh) Parker var. glabra (A. Gray) Parker".

I. ECOLOGICAL MANAGEMENT PLAN

Those occurrences or conditions which significantly damage the feature or features for which this preserve is to be protected and managed, as stated in the primary and secondary management goals, shall be eliminated whenever possible.

A. Primary Management Goal - "shall be managed in such a manner as to perpetuate the species" (Lakeside daisy).

Habitat Management Plan and Objectives:

(1) Woody species will be removed from the preserve whenever they shade the Lakeside daisy and harbor non-native species. Woody species which should be controlled include cottonwood, red cedar, sycamore, mulberry, and dogwood. Woody species such as fragrant sumac (Rhus aromatica) and dwarf hackberry (Celtis tenuifolia), if present, should not be cut.

(2) Non-native species such as sweet clover (Melilotus sp.), Phragmites, and multiflora rose (Rosa multiflora) should be eliminated from the preserve.

(3) Efforts will made to seed and salvage plants of the Lakeside daisy and other prairie species, present in other parts of the quarry, into the preserve. Lakeside daisy seed will be collected from other parts of the quarry and scattered in the preserve, particularly the western end. Seeds from other plants, such as grama grass (Bouteloua curtipendula) and rock sandwort (Arenaria stricta), will also be collected from the quarry and scattered in the preserve.

B. Secondary Management Goal - to protect and perpetuate other rare species in this community.

C. Potential Ecological Threats:

Filling of the quarry by dumping of dredge material from Lake Erie is a threat to the species within the quarry.

Slippage of the slurry piles at the northern boundary of the preserve; runoff from the slurry piles.

Continued limestone quarrying poses an ecological threat to the Lakeside daisy within the Marblehead Quarry area.

Non-native and woody species within the preserve may threaten the Lakeside daisy.

D. Monitoring Programs:

(1) Active

The preserve was photographed from the air in April 1989.

A monitoring project for the Lakeside daisy was developed at the preserve during 1989 in cooperation with Marcella DeMauro.

(2) Proposed

E. Research/Experimentation Projects:

"Investigation of the Reproductive Biology of Hymenoxys acaulis var. glabra: Implications for Conservation and Management" - a 1986 Natural Areas research grant awarded to Marcella DeMauro.

~~"Monitoring and Management of the Lakeside Daisy (Hymenoxys acaulis~~ var. glabra) in Ohio" - a 1989 Natural Areas research grant awarded to Marcella DeMauro.

F. **Published References:**

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G. **Problem Exotic and/or Native Species Present:**

Phragmites is encroaching into the preserve from the north and northeast boundaries. Problem species within the preserve include ccottonwood, red cedar, mulberry, multiflora rose, Phragmites, and sweet clover.

H. **Relocated Species:**

I. **Documented Disturbances:**

The site was last quarried in 1958; the upper 20' of limestone has been removed by quarrying. The area south of the preserve is actively mined for limestone. The areas north and northeast of the preserve are used for dumping of slurry and other quarry debris.

J. **Significant Plant Communities Present - 1989 Data Base:**

K.Significant Species Present - 1989 Data Base:

(1) Floral

Scientific Name	Common Name	Status - Abundance*
Arenaria stricta	Rock Sandwort	P - Infrequent
Asclepias viridiflora	Green Milkweed	P - Rare
Carex aurea	Golden-fruited Sedge	P - Rare
Carex crawei	Crawe's Sedge	P - Infrequent
Carex garberi	Garber's Sedge	E - Frequent
Carex viridula	Little Green Sedge	T - Frequent
Eleocharis compressa	Flat-stem Spikerush	T - Infrequent

(1) Floral - Continued

Scientific Name	Common Name	Status - Abundance*
Houstonia nigricans	Narrow-leaved Summer Bluets	P - Dominant
Hymenoxys acaulis	Lakeside Daisy	E-OH, T-US - Dominant
Juncus alpinoarticulatus	Alpine Rush	T - Frequent
Juncus balticus	Baltic Rush	P - Infrequent
Potentilla arguta	Tall Cinguefoil	E - Rare
Satureja arkansana	Limestone Savory	T - Frequent
Senecio pauperculus	Balsam Squaw-weed	T - Common
Spiranthes magnicamporum	Great Plains Ladies'-Tresses	P - Infrequent

(2) Faunal

*Abundance Index Key

(1) Dominant - one of the few (usually 3 or less) most abundant species
(2) Common - non-dominant but widespread
(3) Frequent - occurring throughout a site in low numbers
(4) Infrequent - few individuals scattered in a few locations
(5) Rare - usually less than 10 individuals known mostly from 1 or 2 locations.

L. **Other Notable Features or Species Present:**

(1) Geological - The area is abundant with fossils. The bedrock of the area is Devonian Columbus limestone.

(2) Biological -

II. SITE DEVELOPMENT PLAN

The development of the preserve shall be limited to those facilities which are necessary and appropriate for achieving the primary management goal with the least impact to the ecological integrity of the preserve. Visitor use, within the preserve, will be directed by its classification, and will be used to promote maximum understanding and appreciation of the aesthetic, cultural, educational, scientific and/or spiritual values of nature preserves by the people of the state, without significant impairment of the preserve's natural values.

A. Visitor Use and Accessibility - On the basis of the preserve's Interpretive classification and the endangered status of the Lakeside daisy, access into Lakeside Daisy State Nature Preserve will be by permit only, except in the case of an open house program. Visitors must remain within the boundaries of the preserve at all times.

B. Physical Development - Section 1517.02 of the Revised Code mandates the provision of facilities and improvements within the state system of nature preserves that are necessary for their visitation, use, restoration and protection, and do not significantly impair the preserve's natural character.

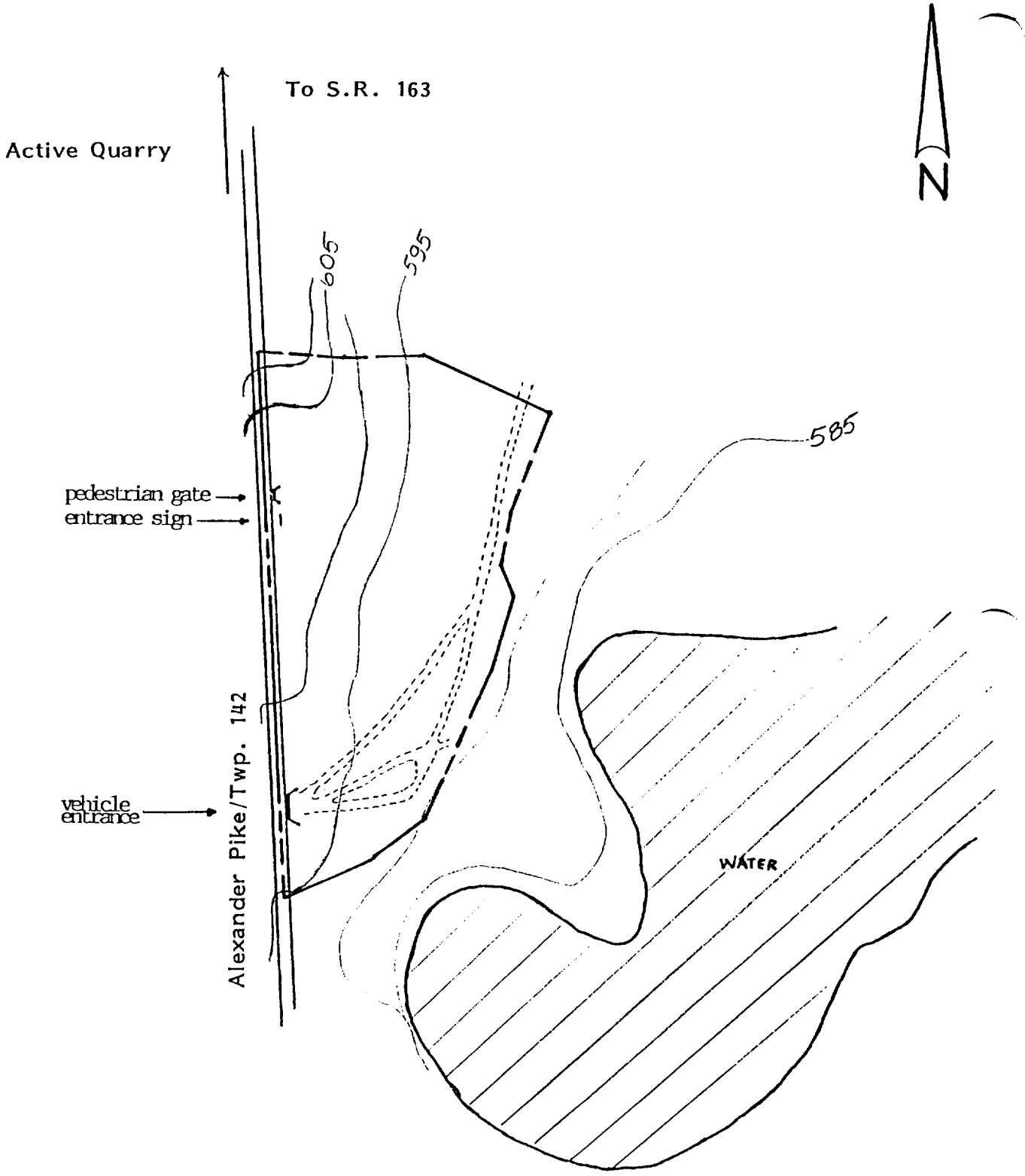
Facilities to be provided at Lakeside Daisy State Nature Preserve include fencing, an entrance sign, a parking area and an interpretive sign and brochure. Presently the preserve is fenced along Township Road 142. At some point in the future, when funds become available, the entire boundary should be completely fenced.

Parking at the preserve will be provided for with a pull-off area along T.R. 142 or a parking lot will be developed at the south end of the preserve on an old roadbed. A decision on the parking situation will be made in conjunction with the Village of Marblehead, which presently restricts off-road parking. When an agreement is reached with the Village of Marblehead the Division will provide all signs. In either case parking will be developed for 4-6 cars maximum.

Along with the entrance sign, an additional informational sign will be posted. The sign will state directions for obtaining a permit to visit the preserve. Also, an interpretive sign and brochure will be developed to educate the preserve visitor on the uniqueness of the Lakeside daisy.

C. Future Acquisitions - First priority is to acquire more Lakeside daisy habitat; another 370-412 acres are desired. Due to active quarrying near the preserve and the adjacent crushing and washing operation, future acreage will be surveyed in other areas of the Marblehead Quarry.

D. Management of Buffer - There are no recommendations at this time.



LAKESIDE DAISY STATE NATURE PRESERVE
Ottawa County 1" = 400'

APPENDIX II

LIST OF REVIEWERS

LIST OF REVIEWERS

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