Endangered Plant Inventory And Monitoring Strategies at Indiana Dunes National Lakeshore

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ABSTRACT: Thirty-five endangered plant taxa were studied at the Indiana Dunes National Lakeshore. Their populations were delineated on park data base maps and quantified from permanent plots. Sampling methods were based on plant life history, growth form, and distribution. A monitoring program was developed, based on population characteristics and on land use. Quanitification of populations was most successful when they were small. Accurate quantification of more common taxa would require more intense data collection, which is controlled by time and budget limitations.

INTRODUCTION

In 1984 the National Park Service contracted with the Morton Arboretum and the Natural Land Institute to determine the status of endangered plant taxa listed by the state of Indiana present in the Indiana Dunes National Lakeshore. Objectives were to locate, describe, and map populations; collect population data from permanent study plots; and develop a plant monitoring program. This study would provide data on the abundance, distribution and habitat status of endangered plants in the national lakeshore, and provide for subsequent determination of management needs through monitoring and data inspection. In this paper we report on development of the methodology and monitoring program, summarize results of the study, and provide an example of data recorded for one state-listed endangered species of the national lakeshore.

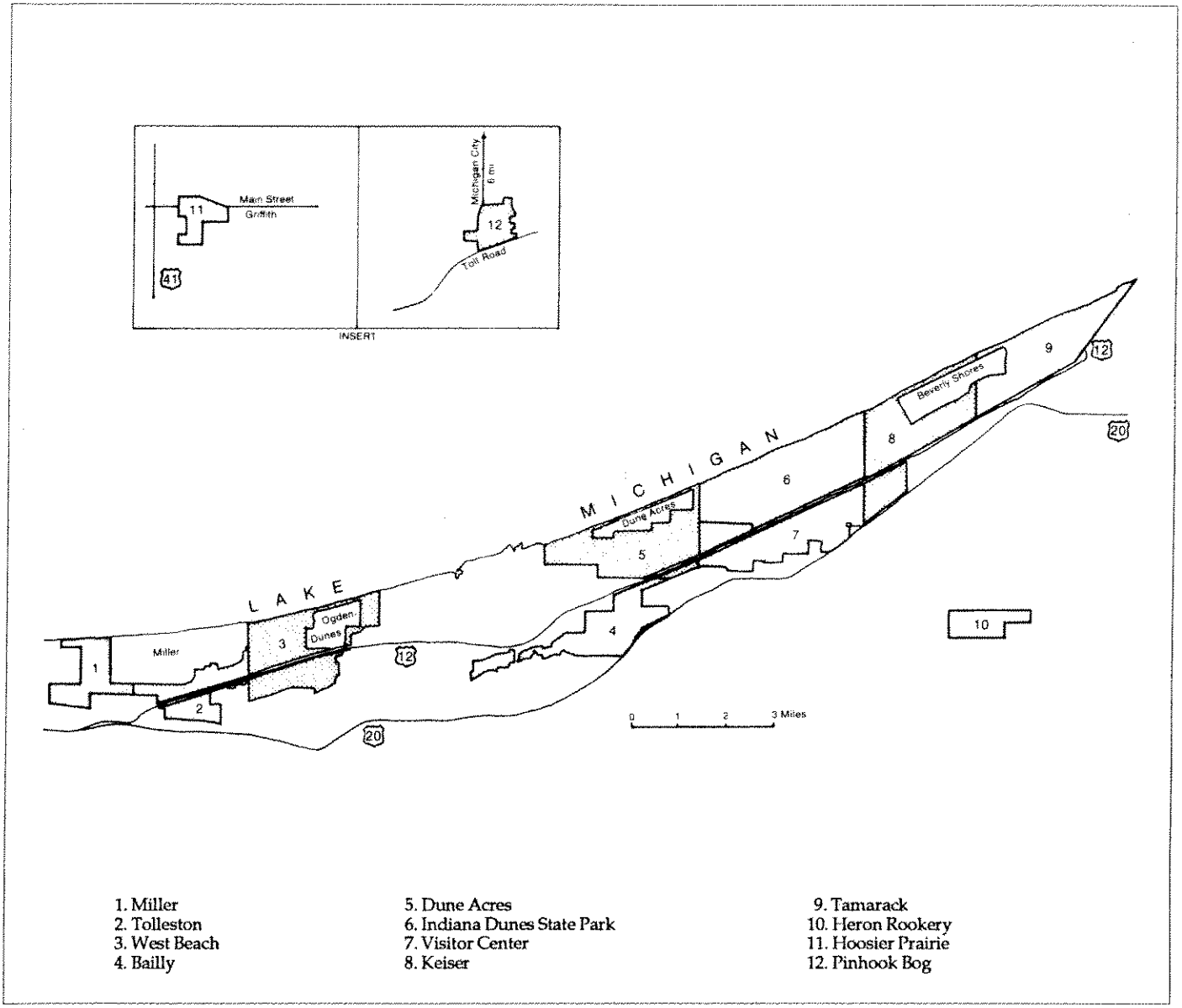
STUDY AREA

The Indiana Dunes is a sand-derived physiognomic unit on the southern tip of Lake Michigan in Lake, Porter, and LaPorte counties of northern Indiana. It originally encompassed more than 120,000 acres and supported a diverse and distinctive flora having Atlantic Coastal Plain affinities, boreal relicts, and many species near their limits of distribution (Babcock 1872, 1873; Highley and Raddin 1891; Peattie 1930). Almost 90 percent of the original Indiana Dunes landscape has been affected by industry, agriculture, logging, drainage, housing development, protection from natural fires, subsequent unnatural burning and invasion by an Eurasian flora (Wilhelm 1980). As a result of these impacts and the limited distribution of dune habitat in Indiana, many of Indiana's endangered plant taxa (Bacone and Hedge 1980) are known from the dunes region. Wilhelm (1980) reported fifty-two endangered plant taxa from the 13,000-acre Indiana Dunes National Lakeshore, which contains most of the remaining natural areas of the dunes region (Figure 1).

METHODS

Locating Populations

Priorities for locating and studying plant populations were based on time of anthesis, sporulation, fruiting, or other distinctive periods when the taxa were most easily detected and identified. We obtained information about plant locations from studies and local floras (Deam 1940; Peattie 1930; Swink and Wilhelm 1979; Wilhelm 1980), herbaria of the Morton Arboretum and Indiana Dunes National Lakeshore, the national lakeshore science staff, and the many botanists who are familiar with the Indiana Dunes flora. Once known populations were located, we searched similar habitats for new populations.



1. Miller
2. Tolleston
3. West Beach
4. Bailly
5. Dune Acres
6. Indiana Dunes State Park
7. Visitor Center
8. Keiser
9. Tamarack
10. Heron Rookery
11. Hoosier Prairie
12. Pinhook Bog

Figure 1. Special vegetation survey units of Indiana Dunes National Lakeshore.

MAPPING AND DESCRIPTION

The locations of all endangered plant populations (or the typical communities for widespread taxa) and study plots were field surveyed and delineated on U.S.G.S. 1:24000 scale topographic maps, and on 1:2400 scale topographic maps specific to the national lakeshore. The latter are to be digitized as part of the park natural resource database. When an endangered taxon occurred in different natural community types, we selected a study population from each type. But due to time and budget limitations we could not study all populations of each taxon in detail. In cases where a taxon was represented by large or widely scattered populations within a natural community type or different survey units, we subjectively chose one or more study sites, giving emphasis to features such as size, potential threats, critical locations, or uniqueness. Each study population was characterized. Its natural community was identified based on the Indiana Division of Nature Preserves natural community classification system and Wilhelm (1980) and described by developing lists of dominant and associated plant taxa. Population size, density, vigor and reproductive status were qualitatively described. Management and protection needs were assessed, based on community successional stages, population characteristics, and biological or anthropogenic threats.

Study Plot Location and Size

Permanent study plots were established for selected populations of endangered plant taxa. These plots were marked with one-

Objectives
1) Design quadrats compatible with plant life form, population size and population distribution.
2) Collect data on population characteristics that will allow monitoring of specific population changes.

Population size and distribution	Mapping and Quadrat design	Data Collection
Locally rare small woody plants, annual or perennial herbs, or cespitose grasses and sedges.	Map genet distribution by sq. dm, use multiple meter sq. quadrats over entire population.	Ramets/genet, no. flowers or fruit/ramet or genet. Each genet = a data point.
Locally distributed large woody plants or coarse herbs, sedges or grasses.	Map ramets or genets by smallest possible meter sq. unit. Map distance and direction from circular plot center.	Ramets/genet, no. flowers or fruit/ramet or genet. Each ramet or genet = a data point.
Small dense populations of woody plants, sedges or grasses in which mapping and quantification of individuals is not facilitated.	Map cover by smallest usable unit area, limit grid size to 100 sq. m; or map distance and direction from up to 1/10 ha plot centers	Ramet or genet frequency, density, cover-class, or size-class/unit area; no. flowers or fruits/ramet or genet/unit area.
Extensive populations of community dominant woody plants, herbs, grasses and sedges.	Map extent of community type. Sample by stratified random meter sq. quadrats or intercept along transects; or establish study plots at selected points.	Determine relation to community structure. Sample density, cover or size-class/unit area, and flowers or fruits/ramet or genet/unit area.

Figure 2. Quadrat and Data Collection Model

inch diameter conduit stakes and their locations surveyed in relation to the nearest bench mark such as a section corner, road, or other permanent landmark.

An objective (Figure 2) was to situate plots so that they included entire small populations or most of the distribution of somewhat larger populations. We used plots ranging in size from a single square meter to 100 square meters; larger plots of this type were difficult to establish and from which to collect data. With more widely dispersed plants, we employed various sampling techniques. Stratified random quadrats or transect intercepts were established through linear habitats such as beach ridges or anthropogenic corridors. For woody plants and some herbs we used 1/10-hectare circular plots.

Because of the restricted distribution of some plants, conventional community sampling techniques were not always applicable. Alternatively, some plots were specifically located in areas of different population characteristics, sites subjected to disturbance (such as along trails or erosion-prone areas), or sites undergoing plant succession.

Data Collection

A primary objective of data collection was to record baseline information that could be used for subsequent analysis of changes in specific population characteristics. The smallest quadrat unit for deriving data points usually was the square decimeter portion of a square meter. Smaller sub units might have allowed more accurate individual plant locations, but rhizome growth and spread can reposition annual above-ground stems and confound more specific locations. The type of data collected varied with species life form and population distribution (Figure 2). For sparsely distributed herbaceous, cyperoid, or graminoid taxa, we quantified growth form and reproductive effort per plant with information on ramet density/genet and flower or fruit density/ramet or /genet. With larger plants, or with populations having higher densities, we collected data on a per unit area basis rather than an individual plant basis. The smallest unit area was one decimeter, while the largest usually was one meter square. Alternate forms of data collection included presence or percent cover per unit area for plants forming extensive ground cover, and size class distribution per unit area for woody and some perennial herbaceous taxa.

Permanent photographic stations were established coincident with the study quadrats. A 6 cm x 6 cm format camera with wide-angle lens was used and usually positioned one meter above and one meter distant from the quadrats, at the center of circular plots, or at the beginning of transects. The camera position and azimuth were recorded

Plant Population Type	Reconnaissance Monitoring Schedule
Annual, biennial, or rare	1-2 year intervals, search for new populations
Perennial herbs, grasses or sedges	2-3 year intervals, search for population recruits or new populations
Dominant herbs, grasses or sedges	3-4 year intervals, estimate change in population/community structure.
Trees or shrubs	4-5 year intervals, estimate population/community changes.
Plant Population Type	**Quantitative Monitoring Schedule**
All Types	Monitor reconnaissance-detected changes.
All Types	Monitor response to environmental changes, disturbances or management.
Community dominants	Monitor at 5-10 year intervals
Widespread plants not under immediate threat of decline	Monitor at 3-4 year intervals.
Rare, irregularly flowering or declining plants	Monitor at 2-3 year intervals, or after events of reproduction.
Successional	Monitor at 2-3 year intervals or in response to estimated rate of successional change.

Figure 3. Monitoring Model

along with quadrat vegetation data. Exposures were made on black and white film, and archival quality film developing techniques were used. Selected exposures were printed on 100 percent rag paper, prints were archivally processed, labeled and stored in archival binder sleeves.

Monitoring System

Following completion of baseline field surveys, a time-dependent monitoring system was developed to guide comparison of plant populations or quadrat data over time for determination of management and protection needs.

This two-level monitoring system includes a fixed interval quantitative schedule that can be modified by the reconnaissance (non-quantitative) schedule. A model of frequency and intensity of monitoring (Figure 3) over time is based on plant life form and life history characteristics, population size and distribution, habitat conditions, community characteristics, land use and management, intensity of visitor use, and potential threats. Annual or biennial herbs, extremely rare taxa, successional populations, or apparently declining rare species are given priorities for frequent monitoring.

Population and habitat management recommendations will then be derived from changes determined by the monitoring system. These recommendations would include protective measures against natural or anthropogenic threats to populations, evaluations of the potential effect of different park uses on these plants and identification of management practices that should be discontinued, maintained or implemented. The program also will help determine taxonomic and biological research needs concerning these species, and how management practices or natural processes can be used for experimental research.

RESULTS AND DISCUSSION

Data and locational information were presented to the national lakeshore in the form of a report (Bowles, Hess and DeMauro 1985). This document included for each plant a monitoring schedule, description, and discussion of population status and management needs, quadrat summary sheet, data sheet, and distribution map. Appendix I includes this information for two populations of one endangered taxon of the national lakeshore.

This inventory and study of endangered plant taxa of the Indiana Dunes National Lakeshore resulted in the addition of six new taxa to the national lakeshore and a 73 percent success rate in relocating taxa thought to be present (Table 1). We studied thirty five taxa and established seventy-eight permanent plots in populations of these species.

Table 1. Endangered Plants Extant or possibly extant within the Indiana Dunes National Lakeshore: Summary of Results.

TAXA	SURVEY UNIT A	B	C	D	E	F	G	H	I	J	K	L	M	N
Aster furcatus							N							
Betula populifolia	S	S												
Botrychium matricariaefolium								S						
Botrychium multifidum intermedium								L						
*Botrychium oneidense								S						
Buchnera americana							S							
Calla palustris														S
Carex chordorrhiza														S
Carex eburnea					S									
Carex flava fertilis											N			
Carex folliculata		S					S	W	W	S				
Carex howei							W?							
Carex seorsa							S	O	W	S				W
Chrysosplenium americanum								S		S	O			
Cornus canadensis					N		S							
*Corydalis sempervirens													S	
Eleocharis geniculata			S		S									
Eleocharis melanocarpa	S						W							
Equisetum variegatum			S											
Eriophorum spissum														N
Fuirena pumila							N							
*Geranium bicknelli													S	
Glyceria borealis			N								N			
Juncus scirpoides		S	S	S										
Lathyrus japonicus glaber								S						
Linnea borealis americana					N		N							
Lycopodium clavatum							S							
Lycopodium inundatum		S												
Lycopodium obscurum								N						
Lycopodium tristachyum							S							
Malaxis unifolia														W,L
Myosotis laxa		S					S							
Orobanche fasciculata							L							
Oryzopsis asperifolia											S			
Oryzopsis pungens								L						
Oryzopsis racemosa					S									
*Panicum verrucosum							S							
Platanthera hookeri								L						
Polygala paucifolia								S						
Populus balsamifera										?				
Potentilla anserina					S			S			S			
Pyrola secunda					N									
Rhus aromatica arenaria			S		S		O	O		?	?			
Rhynchospora globularis recognita													S	
Scheuchzeria palustris americana														N
Scleria reticularis							S							
Sisyrinchium angustifolium		S					S							
* Sparganium androcladum							S							
Stipa avenacea											S			
Talinum rugospermum					?									
Thuja occidentalis							O							
Utricularia minor			L											
** Utricularia subulata					S								O	
Xyris caroliniana														S

Survey Units

A=NIPSCO Ponds
B=NIPSCO Row
C=Miller
D=Tolleston
E=West Beach
F=Bailly
G= Dune Acres
H=Dunes St. Pk
I=Visitor Center
J=Keiser
K= Tamarack
L=Heron Rookery
M=Hoosier Prairie
N=Pinhook Bog

S= Sampled by permanent quadrat
O= Observed, not sampled
W= Observed by Wilhlem (1980)
L=Likely present, not observed
?= Questionable presence
N= Not seen recently, historic collection
* New to the National Lakeshore
** New to Indiana

Various populations appeared to have remained stable under natural conditions, declined or disappeared with habitat alteration or destruction, declined from fire protection and subsequent community succession, became restricted to sites with a recent or current anthropogenic disturbance history, or declined for unknown reasons.

Our success in collecting usable information about endangered plant taxa depended upon the size and extent of each population and the amount of time we could allocate to each taxon. We were able to map and quantify all occurrences of 34 percent of the taxa examined. Primarily, these were species with limited distribution, which were of utmost concern to the national lakeshore. We mapped the total distribution and quantified 10-50 percent of the occurrences of an additional 22 percent of the taxa studied, which had somewhat limited distributions. The remaining 44 percent were widespread or had large populations, and were of less immediate concern to the national lakeshore. Within this group we quantified less than 10 percent of the populations but accurately mapped most population distributions. We feel that improvements to this inventory and monitoring program would require greater time and money allocations. However, these commodities are limited resources to most natural area managers, and their budgeting results in various tradeoffs. For example, our data collection for some locally rare species could have been improved by the more detailed but time consuming discriminating of ramets from genets, sampling of density rather than frequency, or quantifying of seed production as opposed to fruit production. For more widespread taxa, increasing the number or size of quadrats could have better estimated population distribution and variation.

The use of random sampling and proper experimental design is necessary for most useful statistical data analysis and determination of population changes. In order to hedge against subsequent statistical problems, we quantified entire small populations whenever possible. For larger populations, quadrats often were established with a bias toward sites with potential managment problems. These plots may provide useful data but will not reflect total population trends or allow powerful statistical analysis. When sites or populations were not adequately sampled, it appears important that their data sets should be added to over time by additional sampling. Research and monitoring of populations of endangered taxa in response to future use of the national lakeshore, including visitor use, development, management regimes and experimental manipulations will be critical for maintaining these special elements of the Indiana Dunes flora.

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APPENDIX I. Study Plot Information Collected for *Stipa avenacea* L. at Indiana Dunes National Lakeshore.

Stipa avenacea L. (Black Oat Grass) POACEAE

DESCRIPTION

Perennial; loosely cespitose, 5 to 10 dm tall; leafy at the base, sheaths shorter than the internodes; blades 1 to 2 mm wide; slightly involute, mostly glabrous; panicle 1 to 2 dm long, loose, open and few-flowered, the slender, divergent branches each with 1 to 2 spikelets; glumes 9 to 13 mm long, abruptly short-acuminate; lemmas dark brown, 7.5 to 11 mm long, villous basally, glabrous in the middle, scabrous distally; awns scabrous, 4 to 7.5 cm long, twice geniculate near the middle.

GENERAL DISTRIBUTION AND HABITAT

Dry woods and openings from Massachusetts south to Florida, west to Kentucky, Arkansas and Texas, and in northern Indiana and southern Michigan.

SALIENT IDENTIFICATION FEATURES

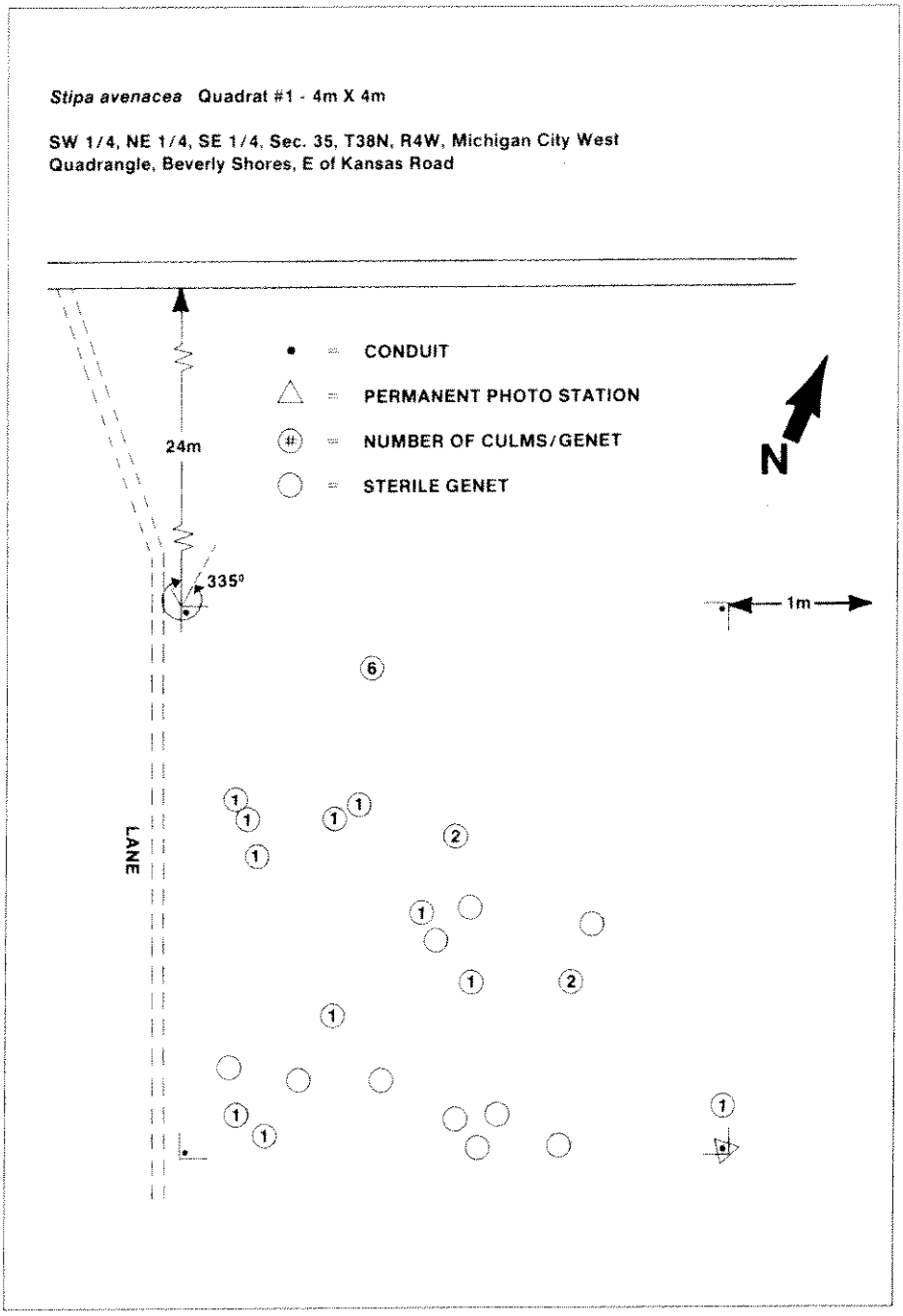
This is the only *Stipa* in the Lakeshore with awns that are less than 8 cm long and blumes that are less than 15 mm long.

DISCUSSION

The ecology of *Stipa avenacea* sppears to be fire-related. We found this grass in level "pockets" near the 620-foot contour line between foredunes. These sites support dry-mesic sand forest or dry-mesic sand savanna. The savanna community appeared to have been opened in response to a severe fire in 1979 (evidenced by charcoaled *Quercus velutina* stumps and sprouts.) *Stipa avenacea* density was 13.5 culms/square meter in the

***Stipa avenacea* Quadrat No. 2, Photo Station No.2**

***Stipa avenacea* Quadrat No. 1, Photo Station No. 1**



Stipa avenacea Quadrat No. 1, Photo Station No. 1

savanna vs. 1.3 culms/square meter in the forest community. In the former, this grass occurred in full sun, while it occurred in openings or under *Pteridium aquilinum* or brush in the dune forest. Similar habitats occur throughout Beverly Shores and should be searched for the presence of this grass.

Deam (1940) reported *Stipa avenacea* from Porter and LaPorte Counties but did not indicate whether these sites were in the lakeshore area. Pepoon (1927) wrote that this taxon was present at the extreme eastern border of the lakeshore; however, Peattie (1930) did not list it from the lakeshore area. Wilhelm (1980) reported *Stipa avenacea* along the north side of trail 10 in a savanna-like community of Indiana Dunes State Park, but we were unable to relocate this population.

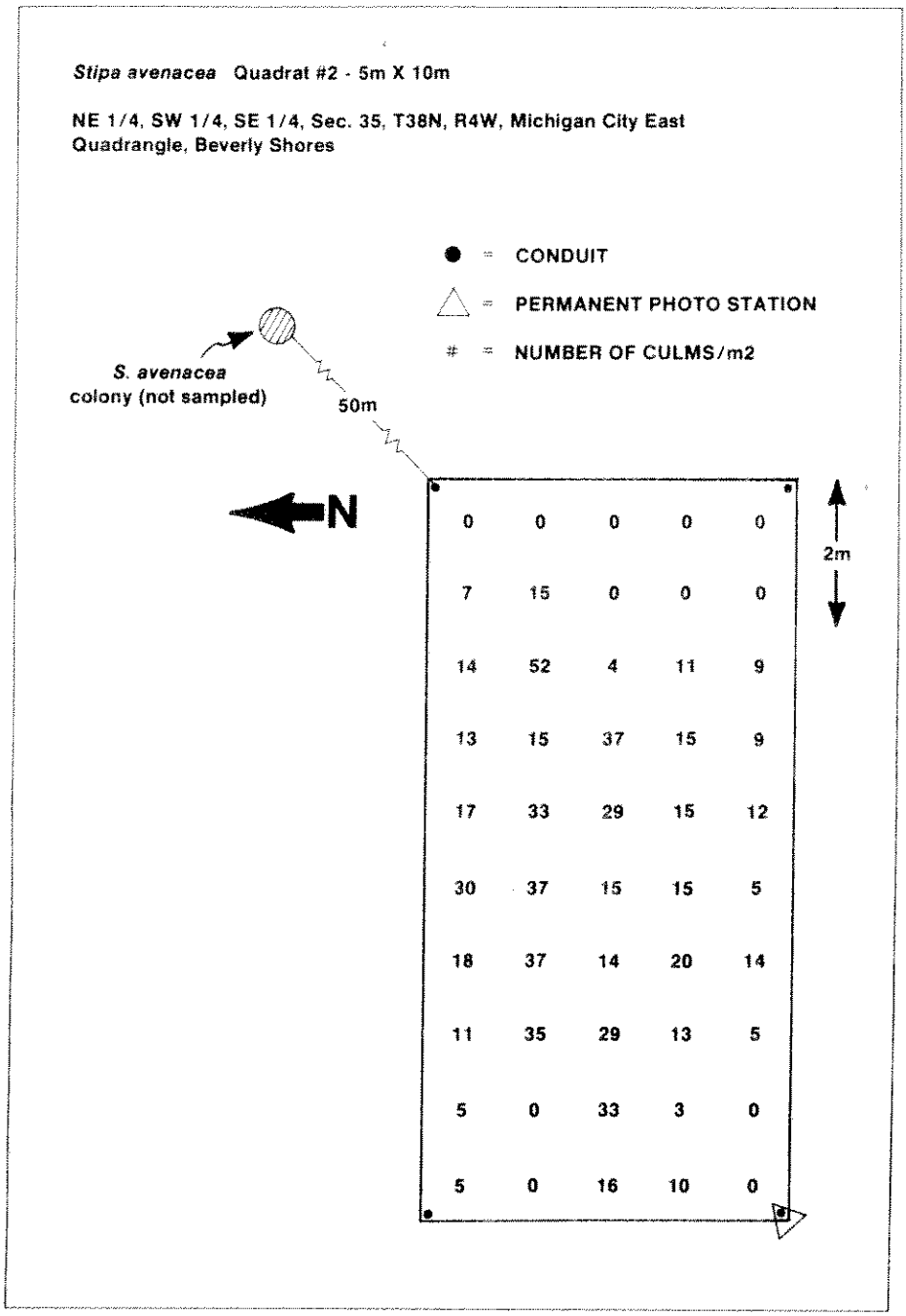
MANAGEMENT RECOMMENDATIONS

The populations of *Stipa avenacea* should be quantitatively monitored at three- or four-year intervals, or after an ecological disturbance such as fire. Results should help determine the effect of woodland encroachment on these populations. Prescribed burns, partricularly at the site of Quadrat No. 1, should be used to open forest canopy and allow an increase in plant density and flowering frequency.

LOCATION, COMMUNITY AND QUADRATS

1) TAMARACK SURVEY UNIT. In dry mesic sand forest east of Kansas Road.
LOCAL DOMINANTS: *Quercus alba, Q. velutina, Sassafras albidum.*
SPECIFIC ASSOCIATES: *Carex pensylvanica, Comandra richardsiana, Lactuca sp., Prunus serotina, Pteridium aquilinum, Smilacina racemosa, Solidago* sp.
SOILS: Sand with poorly developed humus.
SLOPE: 0° to 5° southwest.
QUADRAT: No. 1; Photo Station No. 1.
SURVEY DATE: June 18, 1984.
LOCATION: NE1/4 SW 1/4 SE 1/4 Sec. 35, T38N, R4W, Michigan City West Quadrangle, Porter County.
SIZE OF POPULATION: Approximately 5m x 10m.
QUADRAT SIZE: 16 square meters.
VARIABLE MEASURED: Mapped location and number of culms/genet.
DENSITY: 1.5 genets/square meter, x=0.9 culms/genet (10 plants were sterile), 1.3 culms/square meter.

2) TAMARACK SURVEY UNIT. In dry mesic sand savanna west of



Stipa avenacea Quadrat No. 2, Photo Station No. 2

Kansas Road. A second colony was located 50 meters northeast of this site but was not sampled.

LOCAL DOMINANTS: *Gaylussacia baccata, Quercus velutina, Sorghastrum nutans, Vaccinium angustifolium.*

SPECIFIC ASSOCIATES: *Carex pensylvanica, Comandra richardsiana, Euphorbia corollata, Helianthemum canadense, Melampyrum lineare, Pteridium aquilinum.*

SOILS: sand with poorly developed humus.

SLOPE: None.

QUADRAT: No. 2; Photo Station No. 2.

SURVEY DATE: June 18, 1984.

LOCATION: NE 1/4 SW1/4 SE 1/4 Sec. 35, T38N, R45W, Michigan City West Quadrangle, Porter County.

SIZE OF POPULATION: Two colonies, each approximately 100 m^2.

QUADRAT SIZE: 5m x 10m (50% of colony).

VARIABLE MEASURED: Number of culms/square meter.

DENSITY: 13.5 culms/ square meter.