Status and Population Fluctuations of the Eastern Prairie Fringed Orchid [*Platanthera leucophaea* (Nutt.) Lindl.] in Illinois

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ABSTRACT

Historically, the federal threatened eastern prairie fringed orchid [*Platanthera leucophaea* (Nutt.) Lindl.] reached its greatest abundance in Illinois, occurring in 33 counties throughout the northern two-thirds of the state. Most Illinois populations now occur in loess soils over glacial till or outwash in both upland and wetland habitats. Over a twelve-year period (1980-91), statewide censuses of all known populations ranged from 4 to 313 flowering plants, with plants appearing more consistently in wetland sites and during years of high rainfall. This suggests that wetland habitat may be critical in maintaining populations, and that long-term monitoring is needed to understand population dynamics better. Twenty-one populations are extant in Illinois, nineteen of which are in six Chicago-region counties. These populations represent a 75% decline in extant county records, and probably a far greater overall decline in total numbers of plants. Using an artificial viability index based on population size, habitat size, community successional stage, legal protection, and management needs, we concluded that only one Illinois population currently has high viability. Several other populations can be made highly viable through management and protection. We suggest that successful long-term management of Illinois populations will depend upon maintenance of late-successional prairie conditions, primarily through burning, and may also require artificial management for regeneration niches. Continued monitoring, both of populations and of individual plants, is needed to understand the interactions between prairie fringed orchids and their environment and to help guide management of this state endangered species.

INTRODUCTION

Monitoring of rare plants has become an important stewardship activity within the last decade as attention has been focused on the status, management needs, and recovery planning for state and federal listed species (Palmer 1987). Although annual census counts lack the precision of demographic techniques, they can gauge short-term and long-term population fluctuations, especially in relation to changing environmental conditions. Here, we summarize 12 years of census data for Illinois populations of the state endangered (Illinois Endangered Species Protection Board 1990) and federal threatened (U.S. Fish and Wildlife Service 1989) eastern prairie fringed orchid (*Platanthera leucophaea*). The 1990-91 data were gatherered in conjunction with fieldwork for the preparation of the federal recovery plan for this species, which provides range-wide recovery guidelines based on population and habitat status and management needs.

A primary objective of recovery planning was to catalog extant populations of *Platanthera leucophaea*, project their likelihood for long-term survival, and provide recommendations for increasing the viability of populations. We provide this information for Illinois populations and examine the relationship between precipitation, hydrology, and flowering over time in Illinois. The appearance of flowering

prairie fringed orchids is erratic, and reportedly related to precipitation, fire frequency, site hydrology, and plant community successional stage (Sheviak 1974, Bowles 1983). We therefore sought to determine if wetland sites consistently have more flowering plants than upland sites, and if growing season precipitation levels correlate over time with fluctuating numbers of flowering plants.

BACKGROUND

Distribution and status

Platanthera leucophaea and its western species pair *P. praeclara* are characteristic orchids of the tallgrass prairie region of eastern North America (Sheviak and Bowles 1986). *Platanthera leucophaea* ranged from the immediate Mississippi River drainage eastward across the Wisconsinan till plain in a narrowing pattern corresponding to the prairie peninsula of Transeau (1935). Disjunct populations occurred farther north and east in southern Canada, Maine, New Jersey, and Virginia wetland habitats (the species' range is mapped in Bowles 1983 and Sheviak and Bowles 1986). Illinois probably supported larger and more extensive presettlement populations of this orchid than any other state. Originally the species was known from tallgrass prairie in 33 counties across the northern two-thirds of the state, an area now almost completely converted to agriculture (Sheviak 1974, Bowles and Kurz 1981). Twenty-one prairie fringed orchid populations now remain in eight Illinois counties, a 75% decline in extant county records based on voucher specimens (Figure 1). The overall decline of numbers of plants in Illinois since settlement, however, probably reflects the loss of prairie habitat, of which less than .007% remains (White 1978).

Life history and ecology

When flowering, *Platanthera leucophaea* is one of the showiest prairie plants. Inflorescences of 30 or more fragrant white flowers usually overtop the prairie canopy, and pollination is by nocturnal hawkmoths (Family Sphingidae) as they ingest nectar from the flowers' long nectar spurs. Terrestrial orchids are well known for periodic dormancy, apparently during unfavorable conditions or environmental uncertainty (Calvo 1990). The irregular flowering of *P. leucophaea* may result from avoidance of drought stress or impact from grazing in its grassland habitat (Bowles 1983). Often many plants in *P. leucophaea* populations are vegetative (*i.e.*, without flowers), and some may be entirely dormant in an undergroud state. During periods of reduced growth or dormancy, especially during environmental stress, the plants may be supported by mycorrhizal nutrition. Plants develop flowering primordia during the growing season prior to flowering, thus dormancy or reduced vigor one year can have a carry-over effect on numbers of flowering plants in subsequent years. The orchid mycorrhizal relationship begins with seed germination, allowing the development of a chlorophyll-free protocorm that requires fungal nutrition for several years until a vegetative stage is reached; mycorrhizae are apparently maintained throughout the plant's life (Stoutamire 1974, Sanford 1974).

The eastern prairie fringed orchid requires full sunlight for optimum growth and flowering. Throughout much of its range, it inhabits mesic to wet circumneutral to calcareous tallgrass prairies (Sheviak 1974, Bowles 1983). Most extant Illinois populations occur in soils derived from loess deposits over glacial till or outwash, which characterize the Grand Prairie Natural Division of Illinois (Schwegman *et al.* 1973). In these habitats, populations occupy a continuum extending from mesic upland prairie to wet prairie along the borders of prairie potholes and watercourses. Plants in upland habitats appear to flower infrequently, probably only during seasons of relatively high precipitation. Secondary habitats include sand deposits of the Lake Michigan lake plain and sedge meadows, which are essentially restricted to the Northeastern Morainal Natural Division of Illinois (Schwegman *et al.* 1973).

Under stable conditions, *Platanthera leucophaea* appears to be long-lived. Case (1987) reported that plants survived and produced seeds for up to 30 years in a garden, and several extant Illinois populations survived for decades in cemetery prairies under mowing regimes that probably prevented reproduction by removing inflorescences or seed capsules. However, high population densities can occur in early- to mid-successional habitats compared to late-successional habitats (Bowles 1983). As these communities undergo succession, populations may decline and disappear. Prairie

fringed orchids have been introduced from seed into formerly grazed successional prairie habitat in the Chicago region (Packard 1991), with flowering plants appearing five years after seed dispersal.

METHODS

Population and environmental data

In 1980, the senior author began to census annually flowering plant numbers in Illinois populations of *P. leucophaea*; more recently, populations also have been censused by volunteers coordinated through The Nature Conservancy. These census data were compiled for 1980-1990; all known Illinois *Platanthera leucophaea* localities were revisited during July 1991 and examined for successional changes since previous visits, along with other management needs. Locations of plant populations that had been previously mapped or marked, along with other potential habitats, were searched for flowering plants.

For comparing effects of hydrology on flowering, sites were divided into three classes along a **mesic** (n = 4 sites), **wet-mesic** (n = 5 sites), and **wet** (n = 3 sites) hydrological gradient. These sites were differentiated by field inspection according to their topographic position and characteristic vegetation types (*sensu* White 1978). The proportions of years with or without flowering populations were compared between mesic, wet-mesic, and wetland habitats by goodness of fit tests. The monthly precipitation for April-July of each year and their deviations from the 30-year norm were obtained from National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center monthly summary reports for northeastern Illinois, where most of the orchid populations occur. April-July rainfall was chosen because it represents the period during which soil moisture levels might effect emergence and growth of *Platanthera leucophaea*. As this orchid flowers by late June or early July, July precipitation would be more critical for perennating bud development and flowering during the subsequent season. Sequential nonrandomness in precipitation was tested for with the mean squared successive difference (MSSD) test (Ghent 1971). A Kendall rank correlation test was used to test for a significant relationship between total annual census numbers and departures of April-July rainfall from the 30-year norm. For this test, July rainfall was omitted from the 1991 data set, as it would not affect flowering during 1991.

Demographic data were collected from the largest Illinois population (~200 plants), which occurs in wetland habitat. Since 1985, flowering plants in this population have been permanently marked and their fates subsequently monitored. Only during the 1988 drought, when no flowering plants appeared, were the conditions of previously marked plants not monitored. Because unmarked vegetative orchids cannot easily be found, initial cohort data included primarily flowering plants. Development of a more precise assessment of population structure, including flowering, vegetative, and dormant states, will require long-term monitoring and differentiation between dormancy and mortality.

Estimating population viability

For the federal recovery plan, the likelihood of long-term survival was estimated by developing an **Artificial Viability Index (AVI)**. The index is calculated from the formula **AVI** = $[\Sigma_{i=n} A_i + B_i + C_i + D_i + E_i]/15$. A-E represent population size, habitat size, degree of disturbance, protection status, and management needs, respectively. Appendix I presents the criteria for establishing the values for each variable. A and D range from 0-3; B,C, and E range from 1-3. Dividing by 15 adjusts the index range from 0.2-1.0. **Low AVI** values are <0.5, **moderate AVI** values range from 0.5-0.75, and **high AVI** values are 0.75-1.0. In most cases, management, protection, or restoration measures can be used to increase the value of each variable, and thus the **AVI**.

RESULTS

Hydrology and precipitation: effects on flowering

Site hydrology as interpreted by topographic position had a significant effect on flowering; wet sites had proportionally more (X^2=21.4, P<.001) years with flowering plants than either mesic or wet-mesic sites. Flowering plants were present 89% of the time in wet sites, but less than 40% of the time in both mesic and wet-mesic sites (Figure 2).

April-July precipitation appeared to an important factor affecting flowering plant census numbers

between 1980 and 1991 (Figure 3). Precipitation was nonrandom and cyclic over time ($Z = 5.73$, $P<.0001$). High levels occurred in 1981-1983 and in 1990, intermediate levels occurred in 1980, 1984, 1987, and 1991, and low levels occurred in 1985-1986 and 1988-1989. The most severe growing-season drought in 50 years occurred in 1988. Flowering among orchid populations followed a similar pattern, with total census numbers ranging from 4 in 1988 to 313 in 1987 (Figure 3). There was an overall significant ($P = .0397$) Kendall rank correlation test between annual orchid census numbers and departures from mean rainfall. Census numbers were lowest in years corresponding to low precipitation, which suggests that low precipitation levels had immediate effects on flowering. This was most evident during the 1988 drought, which apparently affected the numbers of flowering plants for three years, even though precipitation was high during 1990. Less severely dry years appeared to affect the numbers of flowering plants in those years only, without the impact carrying over into subsequent years. For example, the highest annual census occurred in 1987, a year of moderate rainfall following two consecutive years in which precipitation and numbers of flowering plants were low, but not as severely low as in 1988.

Demographic monitoring revealed an unexpectedly high turnover of flowering plants in the Lake County wetland site (Figure 4). In 1987, there were over 100 flowering plants. The 1988 drought reduced flowering plants to near zero for two years, apparently forcing many into dormancy or vegetative condition. For example, 49 (33%) of the 148 plants found between 1985 and 1987 were relocated in 1989, but only two were flowering. In 1990, 40 (27%) of the 148 plants reappeared, but only four were flowering. Only four new plants were found in 1989, and 32 previously unmarked plants were found in 1990; 32 (88.9%) were flowering. Because flowering plants require about 5 years to appear from seed, these plants apparently had also survived the drought. In 1991, after six years of monitoring, only 30 (16%) of 184 marked plants were found to re-flower, while 100 (54.4%) were not found at all, and were either dormant or had died. Eighty-nine new plants were found in 1991; 70 (78.6%) were flowering, and had also apparently survived the 1988 drought.

Population status and viability

Twenty-one *Platanthera leucophaea* populations are now probably extant in Illinois. Nineteen of these populations occur in six Chicago-region counties, including two Cook County sites at which plants have been restored; single *P. leucophaea* populations occur in cemetery prairies in eastern and west-central Illinois counties. We considered populations in DuPage County and at Illinois Beach State Park as extant, although plants were not observed at either site in 1991 (Note: In order to protect orchid populations, site names will be provided only for Illinois Beach, where plants cannot be located without specific information). Plants were observed in the early 1980's at the DuPage County station, but altered site hydrology may have destroyed or severely reduced this population. Plants were observed at Illinois Beach as early as 1908 (Gates 1912), and have been reported as recently as the late 1970's. This population may now be very small or even ephemeral. A large population that occurs one mile north of Illinois Beach (in Wisconsin) could serve as a seed source for dispersal and periodic recolonization in Illinois. Excluding two sites on the Chicago Lake Plain, and three sites in sedge meadow, all Illinois populations occur in loess soils over glacial drift.

Only one Illinois population, in Lake County, ranks as highly viable (Figure 5). This station is in county ownership, and in part a state nature preserve. It contains a diversity of prairie habitats ranging from mesic to wet, and supports the largest and most extensive Illinois population of prairie fringed orchids. Ten Illinois sites rank moderate viability. One of these sites, also in Lake County, supports a population size similar to that of the highly viable site, but the habitat is smaller and contains only mesic conditions, and orchids appear less frequently. Illinois Beach was ranked moderately viable because of its extensive habitat and legal protection, although the orchid population status is unknown. Only three populations occur in habitats supporting communities ranked as grade "A" by the Illinois Natural Areas Inventory. These sites ranked moderately viable because they are legally protected, but small in size and in population numbers.

Other populations ranked moderate to low viability because of small population and habitat size, early

successional stage, nonbinding protection, or management problems (Figure 6). Small population size was the most frequent problem, with only two of these sites supporting more than 50 plants. Population sizes can only be estimated, and in most of the moderate to low viability sites, especially smaller sites that do not include wetland habitat, far fewer than 50 plants were found. Thirteen of the Illinois populations, all of which are in the Chicago region, occur in formerly disturbed habitats. The long-term stability of these populations is unknown because of their potential to decline with successional change (see discussion). Only six of the Illinois populations, having less than 20% of the Illinois plants, occur on dedicated nature preserves. Most of the Illinois plants are concentrated on two unpreserved Lake County sites; the dedication of these sites as Illinois nature preserves would result in the protection of over 75% of all Illinois plants.

Management problems are the most serious threat to the long-term persistence of orchid populations. Many Illinois prairie or wetland remnants that support orchid populations are threatened by woody invasion fostered by fire suppression (Bowles 1983). Ongoing management, primarily prescribed burning, is needed to maintain all orchid habitats. Invasions by the exotic species purple loosestrife (*Lythrum salicaria*), buckthorn (*Rhamnus frangula*), and teasel *(Dipsacus laciniatus)* pose serious threats to orchid habitats in both Illinois and adjacent Wisconsin (Reinartz *et al.* 1987, Reinartz and Kline 1988, Solecki 1989, Bowles 1991). Although many habitats do not yet have purple loosestrife, its threat to all wetland communities is severe. Buckthorn invasion is also serious. Prescribed burning alone will not control these species; cutting, herbiciding, and pulling are also necessary.

DISCUSSION

Precipitation, hydrology, and flowering

Precipitation during the growing season appears to have a strong effect on the flowering and structure of *Platanthera leucophaea* populations. A severe drought affected even a wetland population, reducing flowering plant numbers to near zero for three successive years. However, some plants survived, and some flowered within two years. The effect of drought is apparently even more significant in upland habitat. Schwegman (1992) could not relocate two marked plants in an upland mesic site after the drought of 1988. A colony of 27 plants surveyed at the same site in 1982 has not reappeared after two drought cycles and, although other orchids occasionally appear at the site, this colony is presumably lost (M. Bowles and R. Nyboer, unpublished data). Because precipitation is stochastic, and the proportions of flowering, reflowering, vegetative, and dormant individuals depend on past climatic conditions and levels of reproduction, orchid populations may be in perpetual disequilibria.

Because drought years can limit flowering and reproduction, especially in drier sites, they can affect future population demography, and possibly cause local population extinction in homogeneous landscapes. If upland populations that decline or go extinct during droughts are adjacent to lowland populations that can survive droughts, the upland sites have a greater likelihood of being recolonized. Although long-term census data cannot explain the demography of such population dynamics, it can track population fluctuations in relation to precipitation cycles.

Orchid populations: management uncertainty in successional communities

Sheviak (1983) suggested that *Platanthera leucophaea* was extremely rare in the Chicago region, having not exploited prairie remnants in this area's low degree of agricultural activity. However, by the early 1980's, almost twenty populations had been discovered in a range of successional conditions, suggesting a dynamic state of colonization. Most populations are in prairie or wetlands that have been degraded by past overgrazing; orchids may have colonized these sites following grazing, or in some cases may have survived and spread after grazing.

The successional status of these populations presents a paradox and management challenge. As with many orchid species, prairie fringed orchids occur more frequently and with higher densities in successional communities, where they often decline as succession proceeds (Bowles 1983, Case 1987, Sheviak 1990). Although management for orchid species with early-successional conditions may maintain higher orchid

numbers (Sheviak 1990), prairie management is most feasible and cost effective when it directs succession toward stable late-successional conditions, using prescribed burning to maintain climax species equilibria. The persistence of low-density orchid populations in late-successional presettlement prairie would have been facilitated by orchid longevity, the constancy and long-distance flights of hawkmoth pollinators, wind-dispersed seeds, and colonization of stochastic patch disturbances.

Small preserves often cannot maintain landscape disturbance regimes (Noss 1987) or populations of habitat-size-restricted vertebrates that may create regeneration niches (*sensu* Platt 1975). As a result, on smaller preserves artificial management may be needed to create regeneration niches for low-density plant species such as orchids. Where possible, land acquisition and community restoration should be used to build units that are large enough to support endogenous disturbances and that are more likey to be exposed to exogenous disturbances.

CONCLUSIONS

Although eastern prairie fringed orchid population dynamics may be complex, a strong correlation appears to exist between cyclic precipitation and the appearance of flowering plants. Likely, extreme drought suppresses flowering by inducing dormancy, and this effect carries over into subsequent years. However, long-term demographic monitoring and experimentation is needed to interpret the reactions of individual plants, and the effects of site hydrology, heterogeneity, and management on population viability. Two other factors, fire and reproduction, may also affect the appearance of flowering plants and were not assessed in this study. It is likely that prescribed burning enhances the appearance of flowering plants (Sheviak 1974, Bowles 1983); however, the effect may occur during years of intermediate to high precipitation, but not during drought years. Reproduction is known to have a carry-over effect on some orchids, with the cost of heavy fruit-set limiting plant vigor in subsequent years (*e.g.* Snow and Whigham 1989, but see Case 1987). As a result, heavy flowering and seed production in *Platanthera leucophaea* could interact with rainfall cycles and burning, either further reducing flowering in drought years, or damping flowering during years of high rainfall and prescribed burns.

Assessment of habitat viability through an artificial viability index (**AVI**) may be useful in guiding the preservation and management of orchid populations, and in selecting sites that represent the diversity of communities and habitats used by *Platanthera leucophaea* in Illinois.

Managing for the persistence of *Platanthera leucophaea* may be complex. Only a few Illinois populations now exist on essentially undisturbed prairie habitats, and these small populations may decline with attrition. Many Illinois populations occur at higher densities in early-successional communities, but populations in these habitats may also decline with advancing succession. This presents a management paradox for *P. leucophaea*. Prairies are usually managed for succession toward stable climax conditions, but disturbance and successional conditions seem best to promote high orchid densities. In addition, small preserves do not afford landscape disturbance processes. These dilemmas may be best resolved by managing for regeneration niches in small preserves, or increasing preserve sizes.

ACKNOWLEDGMENTS

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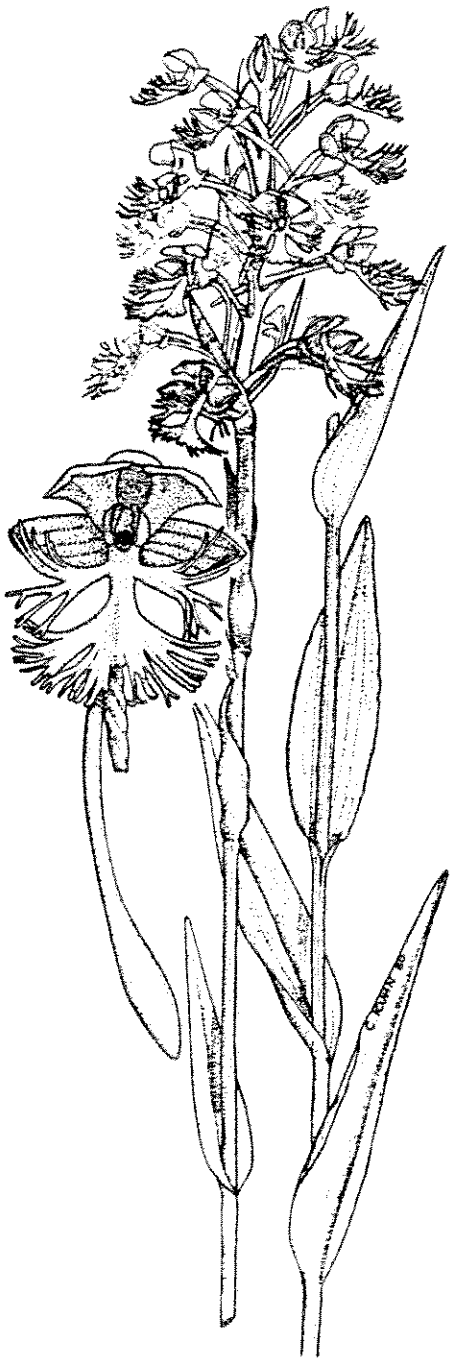

Platanthera leucophaea (Nutt.) Lindl.
Illustration reproduced by permission from R.S. Mitchell and C.J. Sheviak. 1981. *Rare plants of New York State.* Bulletin No. 445 of the New York State Museum.

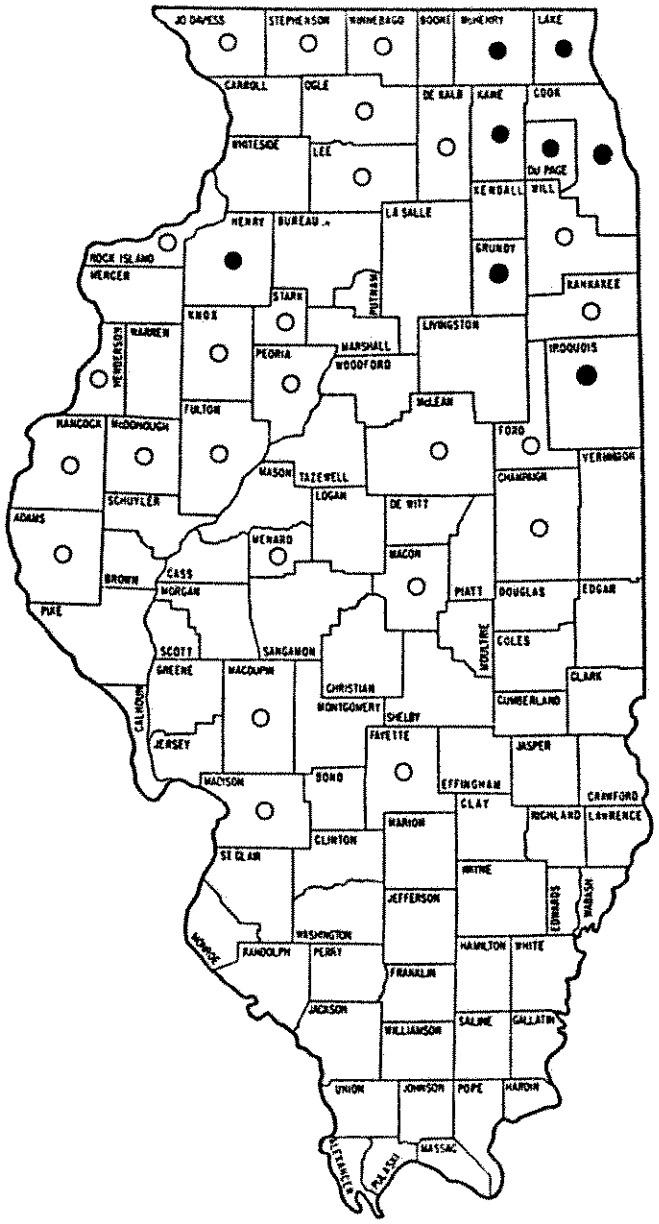

Figure 1. Illinois distribution of *Platanthera leucophaea* by counties. Closed circles indicate one or more extant populations. Open circles indicate historic records for which populations can no longer be found.

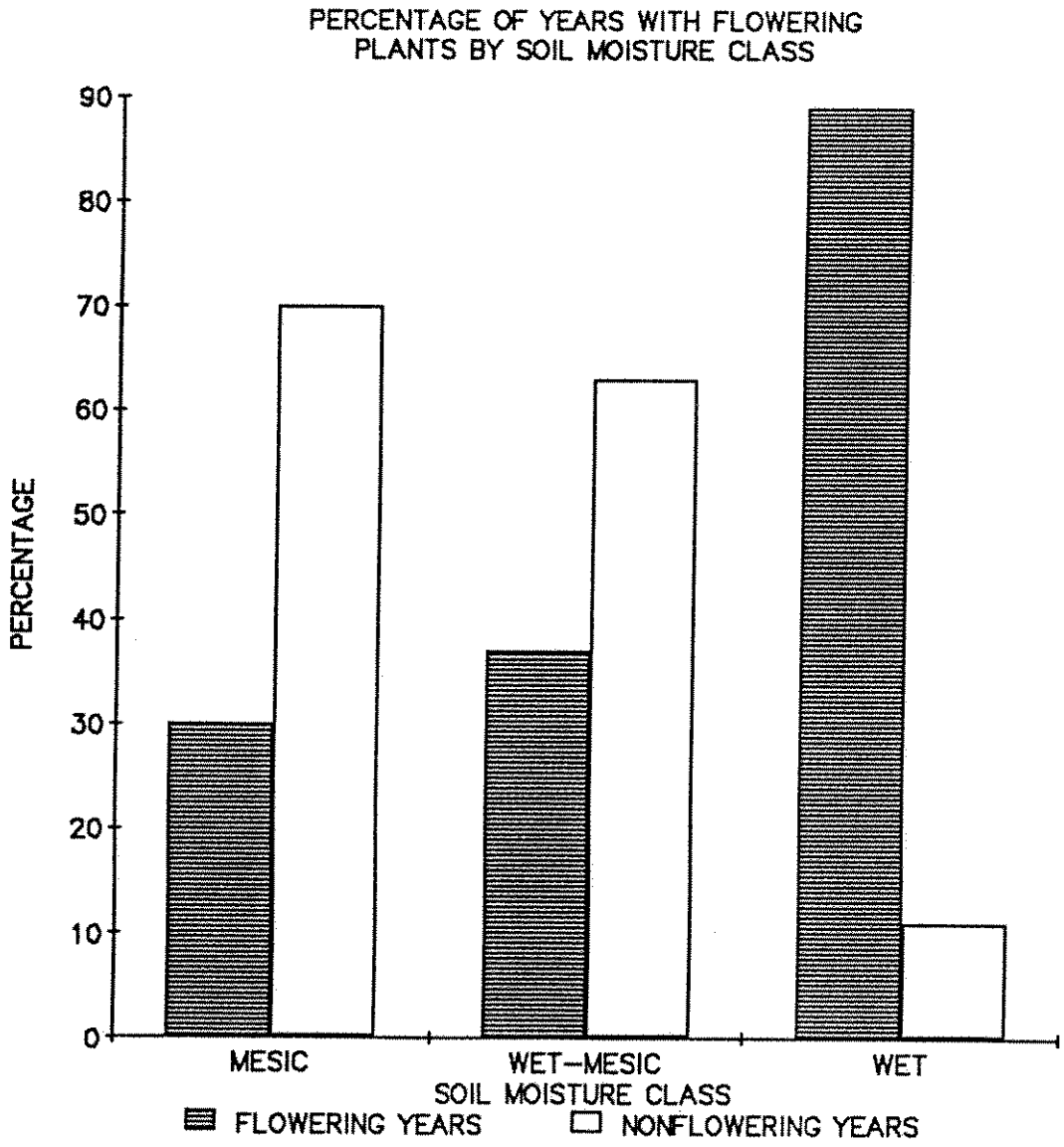

Figure 2. Percentage of years between 1980-1991 in which flowering *Platanthera leucophaea* populations were censused in **mesic** (n = 4 sites), **wet-mesic** (n = 5 sites), and **wet** (n = 3 sites) habitats. See text for habitat classification methods.

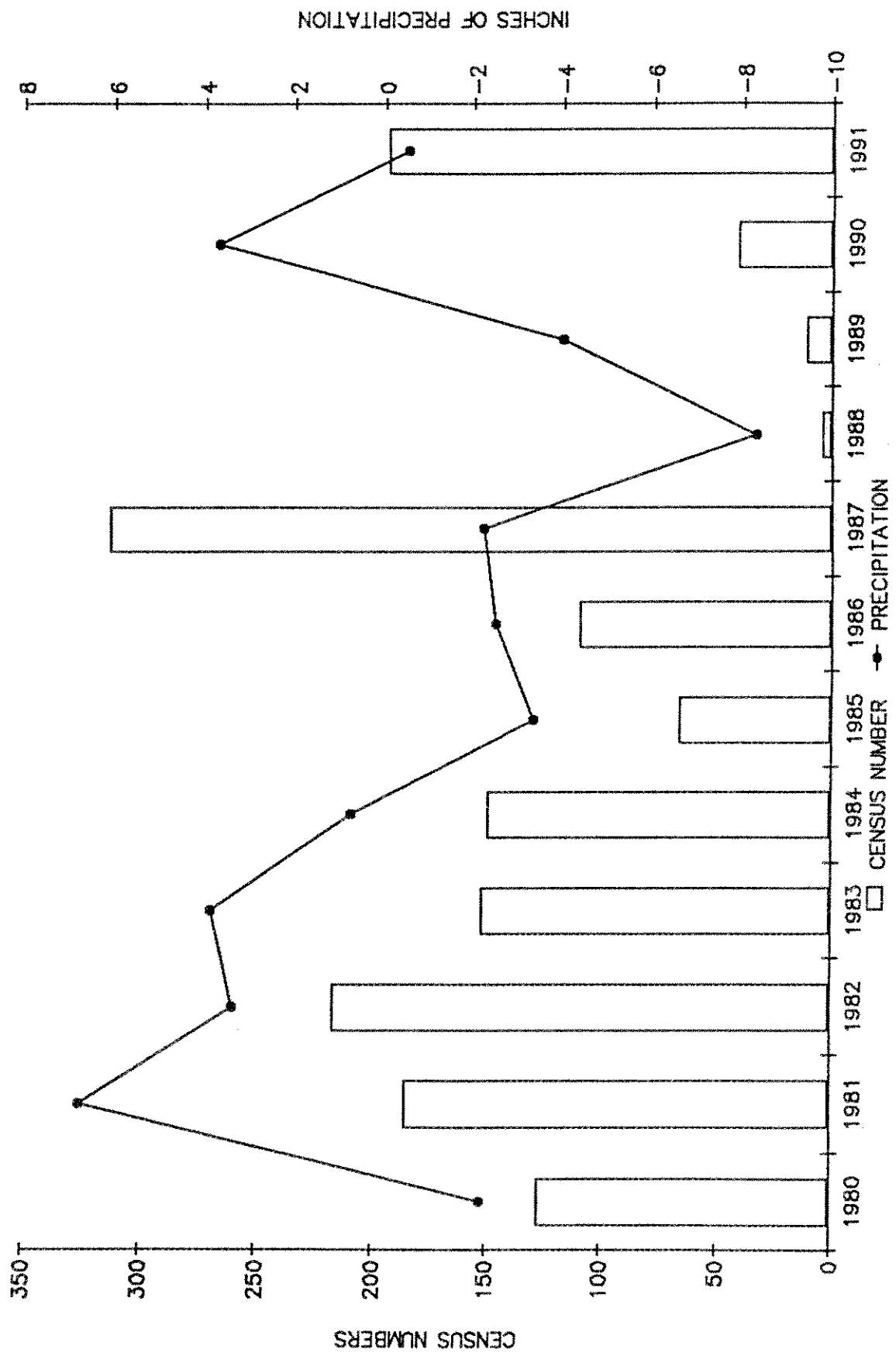

Figure 3. Relationship between precipitation and flowering among 19 *Platanthera leucophaea* populations over time. Inches of rainfall represent the April-July annual departure from the 30-year norm established by the National Oceanic and Atmospheric Administration.

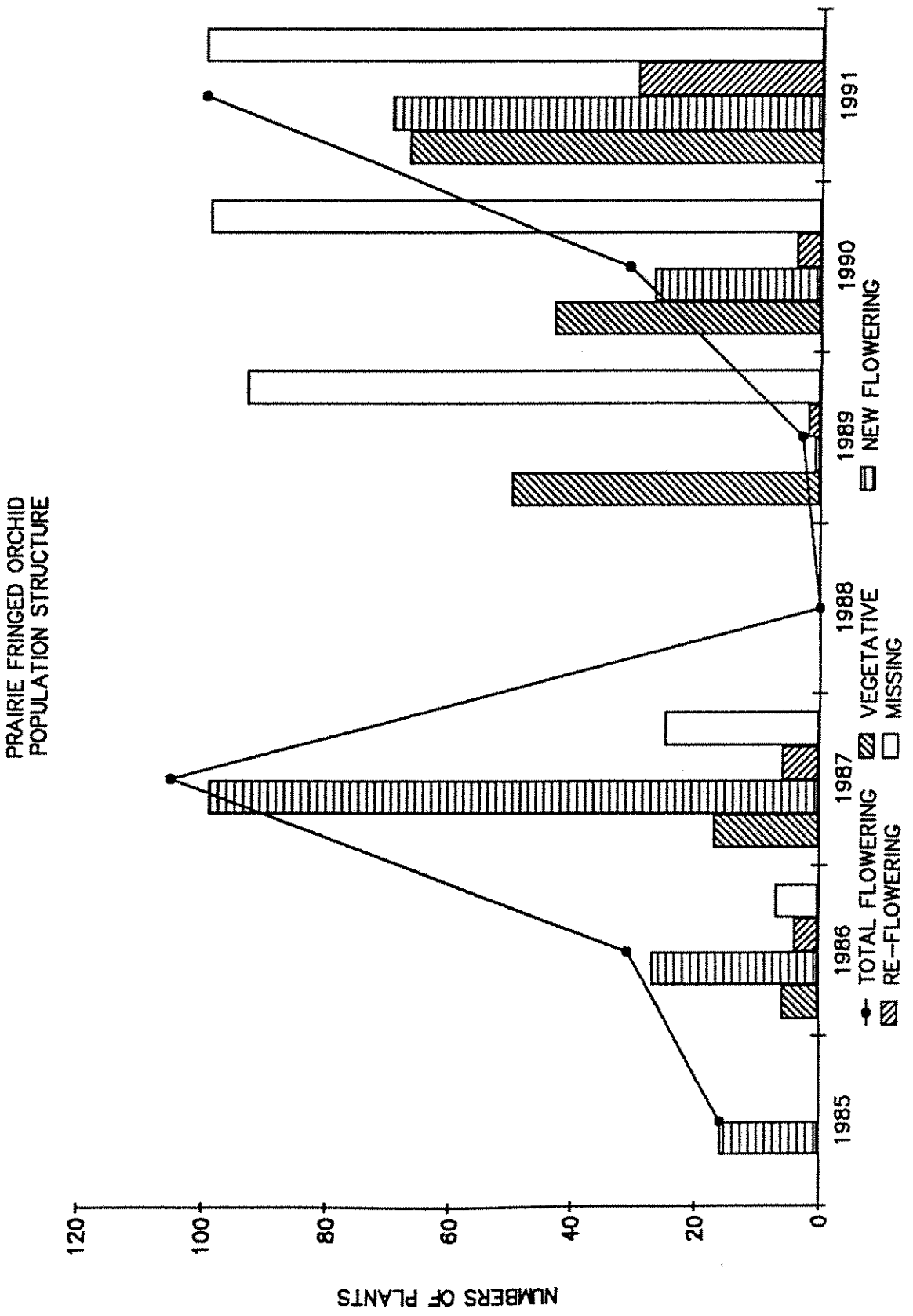

Figure 4. Comparisons of *Platanthera leucophaea* population structures before and after severe drought. Only flowering plants were monitored in 1988. Data collected from wetland habitat in Lake Co., IL.

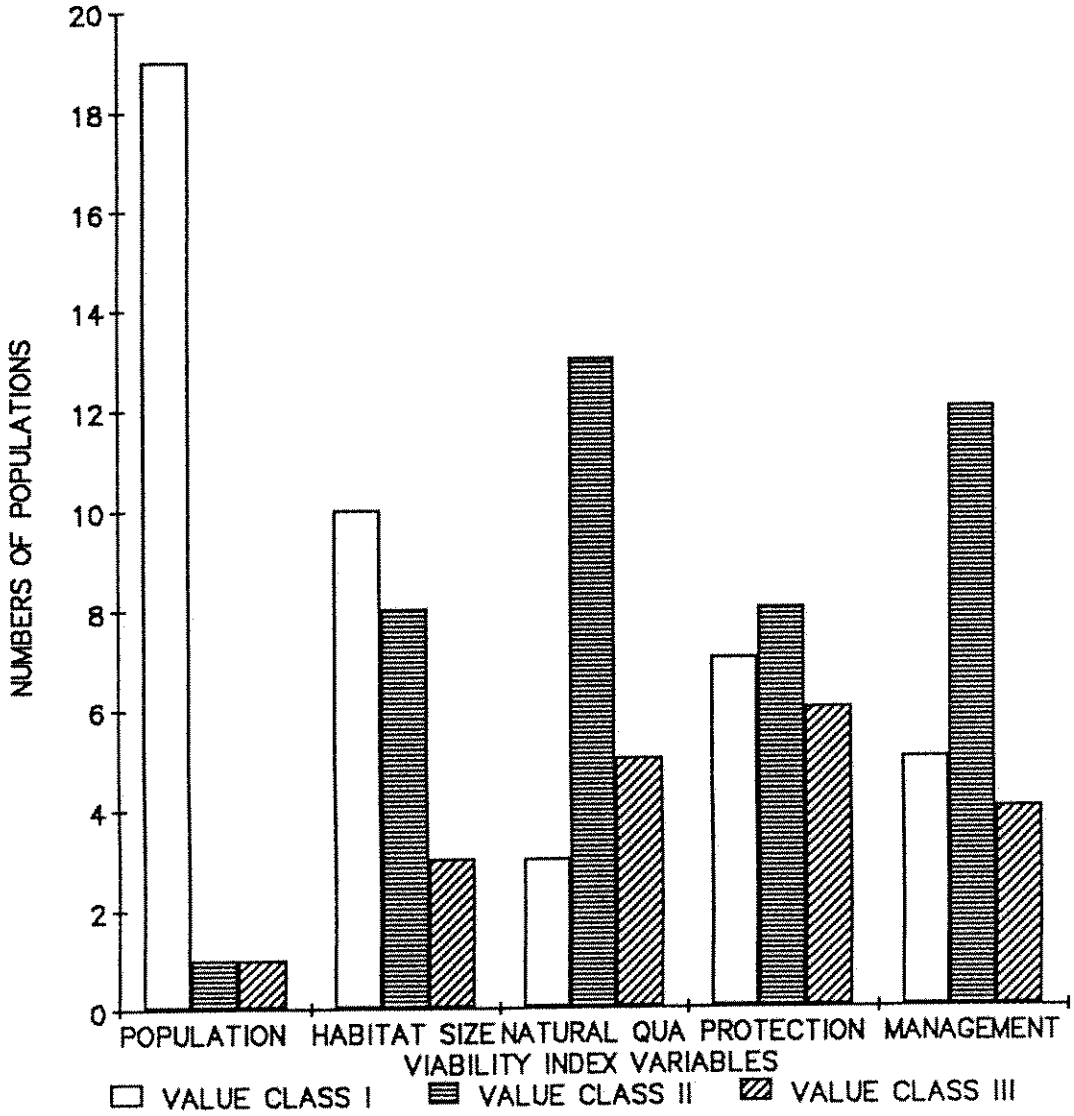

Figure 6. Distribution of 21 Illinois *Platanthera leucophaea* populations in relation to the five variables used to calculate Artificial Viability Index (**AVI**) scores. See Appendix I for methods used to quantify each value class.

Appendix I. Determination of Artificial Viability Index (AVI). AVI = $[\Sigma_{i-j} A_i + B_i + C_i + D_i + E_i]/15$. AVI ranges from 0.2-1.0, and is arbitrarily divided into three groups. Low viability = <0.5; moderate viability = >0.5-0.75; high viability = >0.75-1.0.

Variable	VALUE (0^1-1^4)	(2)	(3)
A. Population size[1]	small <50 plants	medium >50-100 plants	large >100 plants
B. Habitat size[2]	small <2 hectares (<5 acres)	medium >2-20 hectares (>5-50 acres)	large >20 hectares (>50 acres)
C. Degree of past disturbance/successional stage of natural community[3]	heavy/early-successional	moderate/mid-successional	light/late successional
D. Protection/status[4]	none/informal	formal	legal
E. Management needs[5]	severe	moderate	low

[1]Based on recent census data and current habitat conditions. These data represent flowering plants only, and may represent <100% of total populations. Values of 0 are given to small populations that appear in jeopardy or have not been relocated.

[2]Habitat size takes into account only those areas of the site that support, or have the potential to support, prairie fringed orchid populations.

[3]Assumes that populations may not be maintained at existing levels as succession advances from recently or severely disturbed to late-successional plant communities.

[4]None = private ownership with no protection (value = 0); informal = private ownership, without legally binding protection; formal = private or public ownership with formal but not legal protection; legal = private or public ownership with legally binding protection.

[5]Includes threats such as exotic species invasion (*e.g.* glossy buckthorn and purple loosestrife), surrounding land use (*e.g.* drainage, development, pollution), development threats (on private tracts), and fire protection/brush invasion.