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William M. Shepherd
Arkansas Natural Heritage Commission

Charles R. Preston
University of Arkansas at Little Rock

Robert Steinauer
The Arkansas Nature Conservancy

FIVE-YEAR STUDY OF *GEOCARPON MINIMUM* AT WARREN PRAIRIE NATURAL AREA BRADLEY COUNTY, ARKANSAS

WILLIAM M. SHEPHERD
Arkansas Natural Heritage Commission
Suite 200, The Heritage Center
225 East Markham
Little Rock, AR 72201

CHARLES R. PRESTON*
Department of Biology
University of Arkansas at Little Rock
2801 South University Avenue
Little Rock, AR 72204

ROBERT STEINAUER
The Arkansas Nature Conservancy
300 Spring Building, Suite 717
Little Rock, AR 72201

ABSTRACT

Geocarpon minimum, listed by the U.S. Fish & Wildlife Service as threatened, was monitored at Warren Prairie Natural Area, Bradley County, Arkansas, 1986-90. Selected environmental variables were compared with *Geocarpon* productivity plot by plot. Principal components (PC) analysis generated two eigenvectors that jointly accounted for 30% of the variation among plots. PC-Idescribes an exposure gradient; high-productivity plots had less litter and grass cover, more cryptogamic lip, and more iron nodules lying on the surface than most other plots. PC-II was more useful for separating highly productive plots from all other plots; the highly productive plots lay in close proximity to slicks and remote from low spots where shallow water stands after a rain. *Geocarpon* productivity at Warren Prairie Natural Area peaked in 1987 and has declined steeply and steadily in the following years. Recommendations for further study are offered.

INTRODUCTION

This paper reports results of monitoring *Geocarpon minimum* 1986-90 at Warren Prairie Natural Area, Bradley County, Arkansas. *Geocarpon minimum* (Caryophyllaceae) has been on the U.S. Fish &Wildlife Service's list of threatened species since 16 July, 1987. Warren Prairie Natural Area (302 acres) has been under joint protection by the Arkansas Natural Heritage Commission (301 acres) and the Nature Conservancy (1 acre plus an easement on the remainder) since 11 January 1983. In 1990, the Commission acquired an adjacent tract of 275 acres in Drew County, making a new total of 577 acres. The Natural Heritage Commission is an agency of the Department of Arkansas Heritage.

Study design and data collection in the first year of the study were reported in Bridges (1986). Data collection in the second year and plot-by-plot comparison of 1986 and 1987 data were presented with discussion by Shepherd (1987). Results from 1988 were presented by Shepherd (1988). The present report describes monitoring that was conducted in the spring seasons of 1989 and 1990, draws final conclusions concerning microhabitat factors that make possible predictions concerning the occurrence and abundance of *Geocarpon,* and considers the overall trend of *Geocarpon* abundance on the study site throughout the period of investigation.

GEOCARPON MONITORING IN 1989 AND 1990

Data from 1989 and 1990 were collected according to revised procedures as described in Shepherd (1988), except that less information was recorded from each plot in 1990 and in the second sampling of 1989. The same selected plots run in 1988 were sampled in 1989 on 13 and 14 March and again on 24 and 25 March. (Seven additional plots were run and included in the sample as a precaution against loss of plots to disturbance; these were selected randomly in accordance with the same procedures followed in 1988.) Preliminary sampling was conducted on 6 March 1990, to assess the phenologic status of the *Geocarpon* population, and all 57 selected plots were run on 18 March.

The only information recorded on 24-25 March 1989 was the number of *Geocarpon* plants per plot, the percentage of plants exceeding 1 cm in height, and the total vascular plant cover. Plot information recorded 18 March 1990 was limited to the number of *Geocarpon* plants, percent lichen cover, and percent vascular plant cover.

*Department of Zoology, Denver Museum of Natural History
2001 Colorado Boulevard, Denver, CO 80205

RELATIONSHIP BETWEEN *GEOCARPON* PRODUCTIVITY AND SELECTED ENVIRONMENTAL VARIABLES

1988 Data were analyzed as follows: The number of *Geocarpon* plants per plot was used as a measurement of *Geocarpon* productivity; plots were classified as non-productive (0 plants), slightly productive (1-30 plants), moderately productive (30-50 plants), or highly productive (>50 plants). Principal components analysis (Morrison, 1976; Gauch, 1982) was used to characterize study plots with respect to microhabitat features. (See Table 1 for a description of microhabitat variables included in our analysis. "Slicks" are patches of whitish, almost bare soil with very high concentrations of sodium salts. The "cryptogamic lip" is a shallow ring of mixed soil particles and fibrous material that tends to surround each slick. See Pittman [1988] for further explanation.)

Table 1. Eigenvectors of the first two principal components.

*VARIABLES	PC - I	PC - II
L	-0.485	-0.070
B	0.112	-0.077
FE	0.260	0.239
LIP	0.374	0.326
LCH	-0.027	0.176
NOS	0.245	-0.335
MOSS	-0.003	-0.244
LWORT	0.098	0.154
AB	-0.161	-0.198
HA	0.232	-0.286
HD	-0.227	-0.065
PH	0.045	0.417
R	0.297	-0.375
SK	-0.190	0.007
TP	-0.066	0.399
UG	-0.456	-0.001

*L = litter, B = bare ground, FE = iron nodules lying on soil surface, LIP = cryptogamic lip (defined in Pittman [1988]), LCH = unidentified lichens, NOS = *Nostoc* spp., MOSS = unidentified mosses, LWORT = unidentified liverworts, AB = *Ambrosia bidentata*, HA = *Hedyotis australis*, HD = *Hypericum drummondii*, PH = *Plantago hybrida*, R = *Ranunculus* spp., SK = *Scirpus koilolepis*, TP = *Talinum parviflorum*, UG = unidentified grasses.

The first principal component (PC-I) accounted for 17% of the variation among plots and described a gradient of increasing iron nodules and cryptogamic lip and decreasing litter and unidentified grasses. Therefore, PC-I describes an exposure gradient; in high-productivity plots there was less litter and grass cover, more cryptogamic lip, and more iron nodules lying on the surface.

The second principal component (PC-II) accounted for an additional 13% of the environmental variation and described a gradient of increasing cryptogamic lip, ***Plantago hybrida***, and ***Talinum parviflorum;*** and decreasing *Nostoc* and *Ranunculus* sp. In habitat terms high values of PC-II indicate close proximity to slicks and remoteness from low spots where shallow water stands after a rain. (The lip develops near slicks; *Plantago hybrida* and *Talinum parviflorum* tend to grow close to slicks; *Nostoc* grows in standing water; and *Ranunculus* sp. tends to grow in or near standing water.) Highly productive *Geocarpon* plots were characterized by medium to high values of PC-I and high values of PC-II, i.e. highly productive plots were located near slicks, in plots with relatively well developed cryptogamic lip and high iron content. Non-productive, slightly productive, and moderately productive plots were generally indistinguishable with respect to PC-I and PC-II axes (Fig. 1).

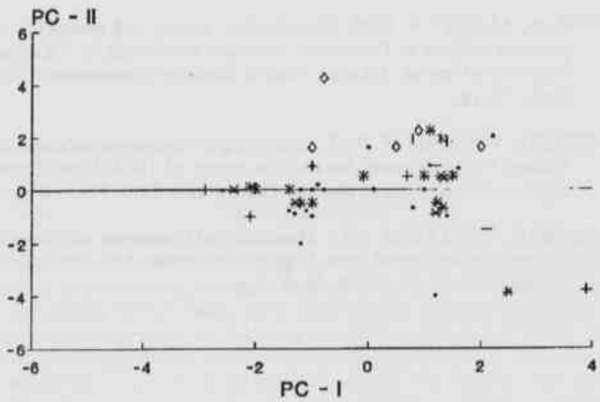

Figure 1. Ordination of study plots with respect to the first two principal components.

■ Plots with no *Geocarpon* plants
* Plots with 1 - 30 *Geocarpon* plants
\+ Plots with 31 - 50 *Geocarpon* plants
◇ Plots with more than 50 *Geocarpon* plants

Jointly, PC-I and PC-II accounted for only 30% of the variation among plots. Thus there may be other, more important variables that were not measured or included in the study.

In summary, our PCA yielded a partial description of *Geocarpon* microhabitat that is consistent with Pittman's (1988) qualitative description. In general, *Geocarpon* grows in well drained spots close to slicks, and its closest associate is *Plantago hybrida*. However, our analysis failed to enable us to discriminate clearly among groups of plots on the basis of productivity. Alarger sample size, with a better balance between the highly productive plots and the less productive ones, would be valuable for evaluating further the relationship between geocarpon productivity and microhabitat variables.

We believe multivariate analytic techniques show promise for guiding habitat-management for rare plants and possibly also for guiding searches for populations of rare plants. As the habitat of *Geocarpon* is extremely patchy, even within the treeless parts of Warren Prairie Natural Area, so that distances of even a few centimeters often mark the difference between good habitat and unsuitable habitat, we want to emphasize that using the most appropriate scale for habitat analysis is absolutely essential to any hope of obtaining meaningful results. In the present case, where a very small scale is required, higher correlations might have been obtainable if 25cm^2 **cells** rather than 0.1m^2 or 0.04m^2 **plots** had been compared.

TREND OF PRODUCTIVITY IN *GEOCARPON* 1986-90

Figure 2 charts the productivity of *Geocarpon* in the reduced sample of 57 selected plots 1986-90. The figure used for 1990 should be viewed with special caution.

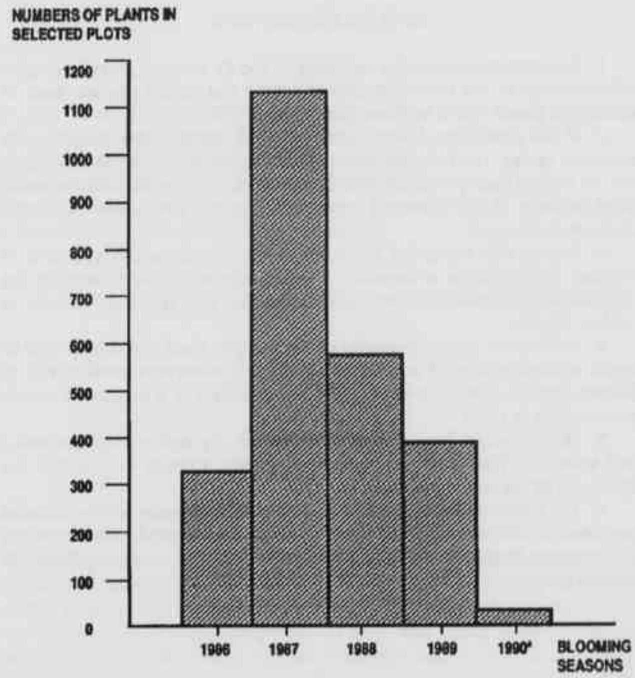

Figure 2. *Geocarpon* productivity in selected plots 1986-1990.
*1990 count conducted after the peak of bloom had passed (see text).

We believe we were fairly successful in timing the annual survey of the geocarpon population to coincide with its peak of bloom 1987-89. However, we know we missed the peak in 1990. On 6 March, 1990, Steinauer made a preliminary survey of 33 four-row plots from the reduced sample. The 33 plots selected for the 6 March, 1990, preliminary survey were all the plots in which *Geocarpon* plants were found in the 1989 survey; and, as demonstrated by Shepherd (1987), year-to-year consistency is strong. On 6 March, 1990, Steinauer counted a total of 39 geocarpon plants in the 33 plots. When all 57 plots in the reduced sample were surveyed 18 March, 1990, only 33 plants were found. Thus it is evident that the number charted (33) is lower than the one that would have been obtained had it been possible to survey the entire set of 57 plots earlier in the month. However, the numerical difference between the totals from the two dates in March, 1990 is small. (Excessive rain, which kept the soil soft and muddy, made it imprudent to attempt a survey 7-17 March, 1990.)

The productivity curve charted here is consistent with the hypothesis that *Geocarpon minimum* is dependent on disturbance in the surface of the soil but peaks in abundance 4 or 5 years after the disturbance takes place, provided there is no further disturbance. (An alternative hypothesis would be that the weather was unfavorable for *Geocarpon* in 1989 and 1990, though frequent rains during the blooming season created an impression of favorableness. We know nothing about possible effects of summer, fall, and early winter weather on *Geocarpon* productivity in March and April. Still another possibility is that the 1990 peak of blooming occurred in February or even January.)

A wheeled vehicle's disturbance of surface soil in the middle of *Geocarpon* transect D on 7 November 1987 created a ready-made experiment for testing the hypothesis that *Geocarpon* responds positively, though belatedly, to disturbance. If the high population of *Geocarpon* in 1987 represented a positive response to disturbance early in 1983, a similar response in plots D-24, D-28, and D-29 may be expected in 1991 or 1992. To prevent further disturbance from clouding the picture, Transect D was surrounded with a well flagged barbed-wire fence in 1989.

RECOMMENDATIONS

1. It is recommended that sampling of the 57 selected plots be continued annually in the late winter/spring until and unless the numbers of geocarpon plants found in those plots exceed 300.
2. If this population level is not reached in another year of apparently adequate spring rainfall, experimental disturbance should be created at one or more fence-protected locations and these plots should be monitored annually in the blooming season for at least 5 years even if no other plots are monitored.
3. Especially since the evidence is equivocal on the question of whether geocarpon is a biennial, a winter annual, or both, monitoring visits should be made in November, December, January, and February as well as March.
4. Studies on the germination of *Geocarpon* seed could help lead to better understanding of annual variation in *Geocarpon* productivity at Warren Prairie. (See Shepherd [1987] for specifics of a proposal to study germination *in situ*.)
5. Have Warren Prairie studied thoroughly by both a geologist and a soil scientist. The latter, in particular, should attempt to describe the dynamics of the surface disturbance cycle.
6. For better understanding of *Geocarpon*'s response to microhabitat variables, establish additional study plots in highly productive locations and conduct further multivariate analysis. Consider using smaller plots for this purpose.

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