RESEARCH ARTICLE

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Classification of Green Pitcher Plant (*Sarracenia oreophila* (Kearney) Wherry) Communities in the Little River Canyon National Preserve, Alabama

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ABSTRACT: Pitcher plant bogs of the Little River Canyon National Preserve in northern Alabama contain the federally endangered green pitcher plant (*Sarracenia oreophila* (Kearney) Wherry). Multivariate analysis of the bog vegetation and environmental variables revealed three communities with unique species compositions and soil characteristics. The significant soil characteristics were percent A-horizon sand and A-horizon depth. A blackgum (*Nyssa sylvatica* Marsh.)-yellow-poplar (*Liriodendron tulipifera* L.)-azalea (*Rhododendron canescens* (Michx.) Sweet) type was found on sites bisected by ephemeral streams with a closed canopy. A scarlet oak (*Quercus coccinea* Muenchh.)-flowering dogwood (*Cornus florida* L.)-sweet goldenrod (*Solidago speciosa* Nutt. var. *erecta* (Pursh) MacM.) type was found on upland sites close to the canyon rim and along perennial streams sites. A smooth yellow false foxglove (*Aureolaria flava* (L.) Farw.)-pale-spike lobelia (*Lobelia spicata* Lam.)-violet lespedeza (*Lespedeza violacea* (L.) Pers. type was found on relatively flat sites away from the canyon rim. The results can be used to locate potential sites for restoration of green pitcher plant bogs. Survival of the bogs is threatened by encroachment of over and midstory vegetation.

Index terms: Alabama, classification, fire, green pitcher plant, ordination, species composition

INTRODUCTION

Populations of the federally endangered green pitcher plant (*Sarracenia oreophila* (Kearney) Wherry) are found in scattered moist upland bogs in northern Alabama, northern Georgia, and western North Carolina. It is a fire dependent carnivorous plant that previously occurred in the Alabama and Georgia Piedmont and Coastal Plain and one site in the Cumberland Plateau of eastern Tennessee (Troup and McDaniel 1980). There are 35 extant populations, 32 of them occurring in northeast Alabama. The greatest threats to green pitcher populations are residential and industrial development, agriculture, silviculture (Troup and McDaniel 1980), impoundment of streams (Folkerts 1977), collection of plants by botanists and commercial dealers (Troup and McDaniel 1980), fire suppression and subsequent encroachment by vegetation, and changes in hydrology (U.S. Fish and Wildlife Service 1994).

According to green pitcher plant habitat descriptions, populations are typically found on moist upland and sandy riverbank sites. The U.S. Fish and wildlife Service (1994) indicated that there were differences in soil characteristics of moist upland areas supporting green pitcher plant populations but provided only a general habitat categorization as mixed oak, seepage bog types, and streamside habitats. Bell (1949) reported that green pitcher plants did not occur in bogs but in sandy habitats along stream banks in association with *Kalmia* L. and *Rhododendron* L. rather than other carnivorous plants such as *Drosera* L. or *Pinguicula* L. McDaniel (1971) indicated that the species often occurs in heavily wooded areas. According to Schnell (1980), the best habitats for green pitcher plants are near Boaz, Alabama, located on Sand Mountain, and the ridges of Lookout Mountain above Fort Payne, Alabama. This optimum habitat was on gently sloping open bogs adjacent to small branches or ponds. The soil was usually a silt-clay-sand mixture. According to Folkerts (1977), green pitcher plants occurred on sites bordering streams, mesic woodlands, and open or shaded depressions. He also noted that some streamside populations were lost with the construction of Weiss Lake (Alabama). Patrick et al. (1995) reported that green pitcher plants were found in poorly drained oak-pine flatwoods and red maple (*Acer rubrum*)-blackgum (*Nyssa sylvatica*) swamps.

Green pitcher plant habitat research has primarily involved the description of the vegetation with no attempts to measure vegetation, soil, and landform variables to identify ecological communities. The objective of this study was to examine differences in bog vegetation structure and relate the differences to soil and landform variables in order to identify diagnostic species and environmental variables. Identification of diagnostic soil and landform variables and the resulting woody and herbaceous vegetation will provide baseline information for identifying sites where restoration is possible and for managing vegetation.

METHODS

Study Site

Green pitcher plants have been reported in the Little River Canyon area, Dekalb County, Alabama, as early as 1901 (Mohr 1901) along the banks of the Little River. The Little River Canyon National Preserve near Ft. Payne, Alabama, currently has eight bogs with populations of green pitcher plants. The bogs vary in the amount of sunlight reaching the pitcher plants. Some sites have a dense midstory and canopy while others have an open canopy with dense midstory. The Little River Canyon National Preserve is located entirely on Lookout Mountain in the Cumberland Mountain-Plateau Province of northeast Alabama (Hodgkins et al. 1979). The Little River has carved the canyon into the top of Lookout Mountain. Most of the eight pitcher plant bogs are located near the rim of the canyon where the water table is at or near the soil surface.

Field and Laboratory Procedures

In the summer of 2003, one 10-m x 30-m plot was placed in each of the eight bogs. Plots were located near the center of the bogs and away from roads and power lines. Canopy trees, sapling and seedling (both tree and shrub), and herbaceous strata were sampled following the Carolina Vegetation Survey protocol (Peet et al. 1998). Tree (>11.4 cm dbh) and sapling (>5 cm dbh) diameter was measured throughout the plot while seedling (<5 cm dbh) and herbaceous cover were estimated in two 10-m x10-m subplots. Vines were recorded as part of the herbaceous strata. Soil samples were collected by horizon (A and B) from four locations within the plot to determine soil horizon depth. The soil was retained for texture analysis and chemical analysis including pH, percent N and C, and total P, K, CA, and Mg (tons/acre). Landform variables sampled included slope gradient, aspect, terrain shape index (TSI), and landform index (LFI). Landform index was derived from the mean of eight measurements taken with a clinometer in percent scale at forty-five degree spacing from plot center to the surrounding horizon (McNab 1992). A positive landform index indicates lower protected slope positions, while a negative index indicates upper slope positions and exposed landforms. Terrain shape index was derived from the mean of 8% slope measures taken from plot center to plot perimeter at 45-degree intervals. A positive terrain shape index indicates concave shape while a negative value indicates convexity (McNab 1989).

Data Analysis

Communities were delineated through ordination and cluster analysis of vegetation and environmental data. Species occurring in more than one stratum [e.g., red maple (*Acer rubrum* L.) as a tree, sapling, and seedling] were considered separate species. Importance values (IV) were calculated and used in the initial analysis. Detection of communities was difficult with importance values; thus, they were replaced with presence/absence data. The mere presence or absence of a species proved to be more important than its relative importance value for community classification.

Ordination is a multivariate technique that arranges sampling units in ordination space along axes on the basin of species composition data (Jongman et al. 1995). Ordination diagrams are based on weighted averaging scores and the axes are not labeled (McCune and Grace 2002). Sample units' relationships to these axes reveal biological and environmental factors that may influence the structure of ecological communities. Clustering vegetatively similar plots together and separating dissimilar plots in ordination space achieves this. It is then possible to search for the underlying factors that may be responsible for the pattern (Ludwig and Reynolds 1988). The ordination methods employed were Canonical Correspondence Analysis (CCA) and Detrended Correspondence Analysis (DCA).

Cluster analysis (classification) was used in conjunction with ordination to avoid subjectivity in the delineation of communities. Two-way indicator species analysis (TWINSPAN; Hill 1979) was the cluster analysis employed. It uses species importance values or presence/absence data to divide sample plots into successively smaller clusters of similar species composition (Gauch 1982). The TWINSPAN results were used to determine community boundaries on ordination diagrams.

A process involving six steps was followed to identify plant communities (Carter 1999). First, an initial cluster analysis (TWINSPAN) was performed with the data set. Next, ordination was performed with CCA using all the environmental variables and DCA. A comparison was made between the cluster analysis and the DCA and CCA ordinations to search for similar groupings of plots. If the groupings tended to agree, discriminant analysis ($p \leq 0.20$) was performed on the environmental variables for each group identified with cluster analysis to identify diagnostic variables for each group. CCA ordination was then repeated using only the diagnostic variables identified with discriminant analysis. When extraneous environmental variables are removed from a data set, CCA should agree with DCA (Jongman et al. 1995). When the same groups were identified by TWINSPAN, CCA, and DCA, the groups were accepted.

In order to characterize the species composition of each community, constancy and importance values were calculated for each community. Constancy for a single species was calculated by dividing the number of plots of occurrence in a land unit by the total number of plots within the community, expressed as a percentile. Species with a constancy of 50% or greater were considered to be diagnostic for a community. Species with the highest constancy and importance value were used to give each community a name (e.g., longleaf pine-shiny blueberry-wiregrass type).

The environmental variables significantly ($p = 0.20$) related to the communities were determined by stepwise discriminant analysis with SYSTAT (SYSTAT 2004). Discriminant functions were created for each community with the significant environmental variables and tested by resubstitution and cross-validation to determine their predictive efficacy.

RESULTS

Ordination and Classification

Three green pitcher plant communities were identified through ordination and cluster analysis. One community only contains one plot but was accepted because of its unique structure and species composition (Figures 1 and 2). DCA ordination (Figure 1) revealed a pitcher plant population gradient along the x-axis from low (IV = 0, plot 3) to high (IV = 14.44, plot 6; IV = 13.78, plot 7). The y-axis reflects a tree density gradient from highest (plot 2 = 510 trees/ha) to lowest (plot 8 = 0 tress/ha). Plot 8 had no trees or saplings within the plot although the site was shaded by a hardwood overstory. This gradient is likely the result of fire intensity interacting with site environmental variables. In general, DCA revealed more of a successional or vegetative gradient. However, the plants are still responding to soil characteristics. This is reflected by dominance of *Liriodendron tulipifera*, a species preferring moisture, in the blackgum (*Nyssa sylvatica* Marsh.)-yellow-poplar (*Liriodendron tulipifera* L.)-azalea (*Rhododendron canescens* (Michx.) Sweet) community and *Quercus coccinea*, a xeric preferring species, in the scarlet oak (*Quercus coccinea* Muenchh.)-flowering dogwood (*Cornus florida* L.)-sweet goldenrod (*Solidago speciosa* Nutt. var. *erecta* (Pursh) MacM.)community. The y-axis of the CCA ordination (Figure 2) reflects an A-horizon depth gradient from Plot 1 (38.25 cm) to Plot 8 (11.33 cm). The x-axis (Figure 2) reflects A-horizon percent sand from Plot 3 (38.75%) to Plot 8 (61.25). The clear environmental gradient in the CCA ordination is due to the inclusion of environmental variables in the ordination analysis. Thus, DCA revealed information on vegetative and community characteristics while CCA showed the influence of environmental variables on the communities.

Community statistics

There were differences in species richness and diversity between communities. The smooth yellow false foxglove (*Aureolaria flava* (L.) Farw.)-pale-spike lobelia (*Lobelia spicata* Lam.)-violet lespedeza (*Lespedeza violacea* (L.) Pers. -pale-spike lobelia-violet lespedeza community had the lowest species richness (S=44), species diversity (Table 1), and low tree and sapling density (Table 2). The small sample size likely contributed to low species richness and diversity. The scarlet oak-flowering dogwood-sweet goldenrod community, located in the center of Figure 1, had the highest tree and sapling density (Table 2) and highest species richness (S=121) and species diversity (Table 1). The blackgum-yellow-poplar-azalea community to the left had an intermediate species richness (S=96) and species diversity (Table 1). According to Jaccard Similarity Index, the blackgum-yellow-poplar-azalea community and scarlet oak-flowering dogwood-sweet goldenrod community were the most similar while blackgum-yellow-poplar-azalea community and pale-spike lobelia-smooth yellow fox glove community were the least similar (Table 3).

Green Pitcher Plant Communities

All pitcher plant bogs shared certain species in common including *Sarracenia oreophila*, *Acer rubrum* L., *Liquidambar styraciflua* L., *Oxydendrum arboretum* (L.)DC., *Pinus taeda* L., *Quercus falcata* Michx., *Vaccinium arboretum* Marsh., *Smilax rotundifolia* L., *S. glauca* Walt., and *Vitis rotundifolia* Michx. Most tree species were sapling size, although *O. arboretum*, *P. taeda*, and *Q. falcata* were tree sized.

Table 1. Species richness and diversity indices of green pitcher plant communities of the Little River Canyon National Preserve.

	Community Type		
Characteristic	Blackgum-Yellow-poplar-Azalea	Scarlet oak-Flowering Dogwood-Sweet goldenrod	Smooth yellow false foxglove-Pale-spike lobelia-Violet lespedeza
Species Richness	96	121	44
Shannon-Weiner Diversity Index	4.01	4.15	3.78
Simpson's Diversity Index	0.982	0.984	0.977

Table 2: Mean stem density/hectare for trees and saplings in green pitcher plant bogs of the Little River Canyon National Preserve.

	Community Type		
Variable	Blackgum-Yellow-poplar-Azalea	Scarlet oak-Flowering Dogwood-Sweet goldenrod	Smooth yellow false foxglove-Pale-spike lobelia-Violet lespedeza
Trees/ha	190	386	240
Saplings/ha	4940	5040	2280

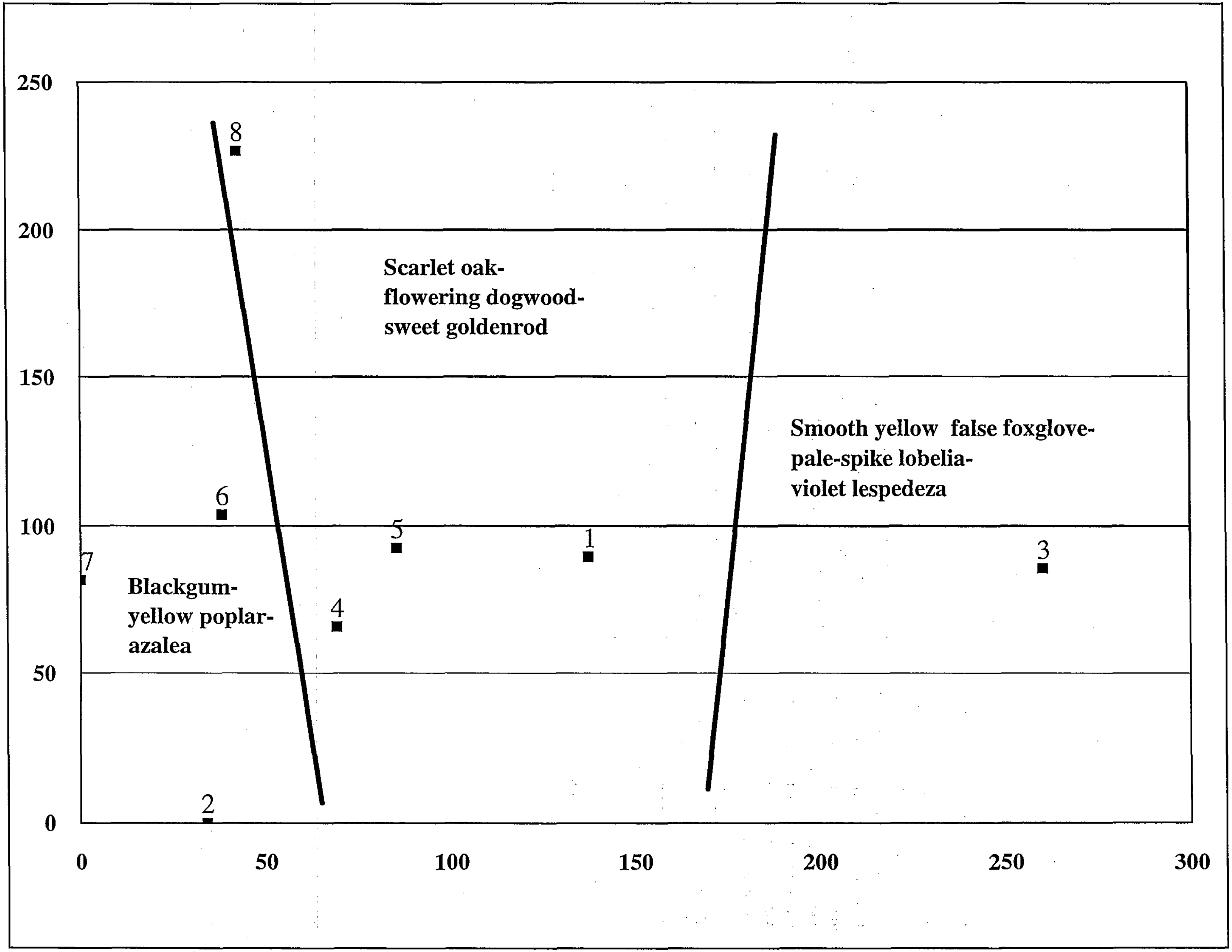

Figure 1. Presence/Absence DCA Ordination of Green Pitcher Plant Bogs of the Little River Canyon National Preserve, Alabama, USA.

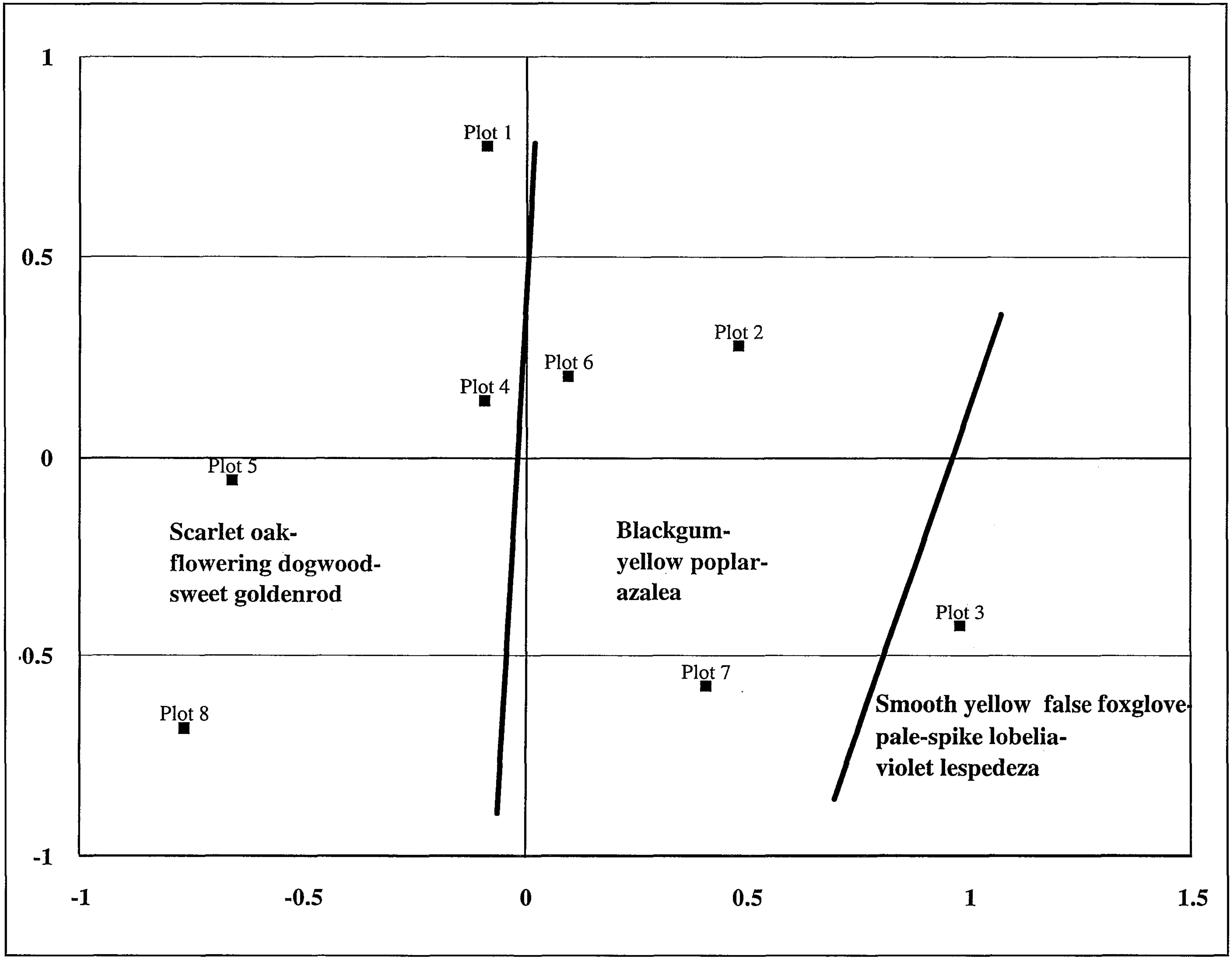

Figure 2. Presence/Absence CCA Ordination of Green Pitcher Plant Bogs of the Little River Canyon National Preserve, Alabama, USA.

Discriminant analysis revealed that percent A horizon sand and depth of the A horizon were significantly (p=0.20) related to the plant communities (Table 4). These variables were used to create discriminant functions for each community. Resubstitution analysis of the discriminant functions revealed that the classification success rate using only the environmental variables was 100% for each community. Classification success with cross-validation analysis was 63%.

A blackgum-yellow-poplar-azalea type was found in broad swales bisected by an ephemeral stream with a mean slope of 3%. The mean percent A-horizon sand was 46.25 while the A horizon depth was 22.78 cm (Table 4). The community had experienced prescribed fires but a closed canopy still persisted. The fire intensity likely was too low due to the ephemeral streams to reduce the canopy cover. It had the lowest number of trees per hectare (Table 2), but the trees were larger in diameter and height than those of other communities. The overstory was dominated by *Acer rubrum*, *Nyssa sylvatica*, and *Liriodendron tulipifera*. The sapling stratum was characterized by *Liriodendron tulipifera*, and *Rhododendron canescens*, while the seedling stratum was primarily *Liriodendron tulipifera*, *Pinus taeda*, and *Ilex verticillata* (L.) Gray. Common herbaceous species included *Hexastylis shuttleworthii* (Britten & Baker) Small and *Solidago erecta* Pursh (Table 5). *Sarracenia oreophila* density was 5.81 stems/m^2 (pers. comm., National Park Service).

A scarlet oak-flowering dogwood-sweet goldenrod type was found on upland seepage bogs close to the canyon rim and along perennial streams. The mean slope was 7.5 and these sites were the most concave (TSI = 8.5) of all communities. The mean percent A-horizon sand was 24.73 and the A-horizon depth was 27.73 cm (Table 4). This community had an open tree canopy; however, little sunlight reached the ground due to a dense midstory of saplings (Table 2). Prescribed fire was likely intense enough to reduce the overstory but not intense enough to prevent the development of a dense midstory. *Quercus coccinea* was found in the overstory while

Table 3. Jaccard community similarity index (%) of green pitcher plant communities of the Little River Canyon National Preserve.

	Community Type		
Community Type	Blackgum-Yellow-poplar-Azalea	Scarlet oak-Flowering Dogwood-Sweet goldenrod	Smooth yellow false foxglove-Pale-spike lobelia-Violet lespedeza
Blackgum-Yelllow-poplar-Azalea	*	25	15
Scarlet oak-Flowering Dogwood-Sweet goldenrod	*	*	18

Table 4. Mean and range of environmental variables of green pitcher plant bogs of the Little River Canyon National Preserve.

	Community Type		
Variable	Blackgum-Yellow-poplar-Azalea	Scarlet oak-Flowering Dogwood-Sweet goldenrod	Smooth yellow false foxglove-Pale-spike lobelia-Violet lespedeza
LFI	11.92 (10.75-11.38)	12.29 (8.12-13.88)	9.12 (9.12)
TSI	2.83 (1.63-4.63)	8.5 (0.13-10.25)	-1.18 (-1.18)
Percent Slope	12 (3-28)	6 (3-11)	4.25 (4.25)
A-Horizon* Depth (cm)	22.78 (12.5-28.5)	24.73 (11.33-38.25)	15.00 (15.00)
B-Horizon Depth (cm)	79.58 (46.5-111.00)	62.22 (53.00-81.00)	75.37 (75.37)
A-Horizon* Sand (%)	46.25 (43.75-46.25)	55.31 (50-61.25)	38.75 (38.75)
B-Horizon Sand (%)	51.25 (42.5-58.75)	55 (46.25-57.5)	41.25 (41.25)

*Statistically significant (p=.20)

Table 5. Constancy and mean importance value (constancy (%) – importance value) of diagnostic species in green pitcher plant bogs of the Little River Canyon National Preserve. 1, 2, 3, and 4 following species names indicates tree, sapling, seedling, and herb, respectively.

	Community Type		
Species	Blackgum-Yellow-poplar-Azalea	Scarlet oak-Flowering Dogwood-Sweet goldenrod	Smooth yellow false foxglove-Pale-spike lobelia-Violet lespedeza
Sarracenia oreophila 4	100 : 10.94	100 : 5.12	100 : 0
Nyssa sylvatica 1	100 : 3		
Liriodendron tulipifera 3	66 : 2		
Rhododendron canescens 1,2	66 : 10		
Rhododendron canescens 3	100 : 6	100 : 4	
Hexastylis shuttleworthii 4	66 : 7		
Solidago speciosa var. *erecta* 4	66 : 7	25 : 2	
Ilex verticillata 3	66 : 4	25 : 5	
Sassafras albidum 2	33 : 12	75 : 2	
Arundinaria gigantea 4	33 : 7	75 : 10	
Rubus argutus 4	33 : 4	75 : 6	
Rhus copallina 3	33 : 3	100 : 6	
Cornus florida 2		75 : 3	
Solidago odora 4		100 : 5	
Quercus velutina 2		75 : 2	100 : 2.35
Quercus coccinea 2		75 : 2	100 : 9
Rhus copallina 2		75 : 7	100 : 15
Quercus stellata 2		50 : 2	100 : 3
Lobelia spicata 4			100 : 9
Aureolaria flava 4			100 : 14
Hieracium gronivii 4			100 : 6
Ludwigia alternifolia 4			100 : 4
Lespedeza violacea 4			100 : 11

the sapling stratum was characterized by *Quercus coccinea*, *Q. velutina* Lam., *Cornus florida*, *Castanea pumila* (L.) P. Mill., *Rhus glabra* L., and *Sassafras albidum* (Nutt.) Nees. Common seedling species were *Rhus glabra*, *R. copallina* L., and *Castanea pumila*. The herbaceous stratum was characterized by *Rubus argutus* Link, *Solidago odora* Ait., and *Arundinaria gigantea* (Walt.) Muhl. ssp. *tecta* (Walt.) McClure (Table 5). *Sarracenia oreophila* density was 7.76 stems/m^2 (pers. comm., National Park Service).

A smooth yellow false foxglove-pale-spike lobelia-violet lespedeza type was found on convex sites with a slope of 4.25% and TSI of -1.875 (Table 4). The tree density was still relatively high but the sapling density was the lowest of the communities (Table 2). Fire intensity was great enough to reduce the overstory and midstory density permitting many herbaceous species to become established. Therefore, this community lacked many woody species common in the other two communities (Tables 5 and 6). The percent A-horizon sand was 15 while the A-horizon depth was 38.75 cm (Table 4). *Quercus stellata* Wang. and *Q. velutina* were found in the overstory while common sapling species included *Quercus stellata*, *Q. velutina*, *Q. alba* L., *Vaccinium arboretum*, *Pinus taeda*, and *Carya tomentosa* (Poir. in Lam.) Nutt. The seedling stratum was characterized by *Quercus stellata*, *Q. coccinea*, and *Sassafras albidum*. The herbaceous stratum included *Lobelia spicata*, *Aureolaria flava*, *Ludwigia alternifolia* L., and *Hieracium gronovii* L. (Table 5). *Sarracenia oreophila* was present in the plot but absent from the herbaceous subplot; thus, it does not have

Table 6. Constancy and mean importance value (constancy (%) – importance value) of common species in green pitcher plant communities of the Little River Canyon National Preserve. 1, 2, 3, and 4 following species names indicates tree, sapling, seedling, and herb, respectively.

	Community Type		
Species	Blackgum-Yellow-poplar-Azalea	Scarlet oak-Flowering Dogwood-Sweet goldenrod	Smooth yellow false foxglove-Pale-spike lobelia-Violet lespedeza
Acer rubrum 1, 2	100 : 21	50 : 15	
Arundinaria gigantea ssp. *tecta* 4		75 : 10	100 : 7
Bromus pubescens Muhl. ex Willd. 4	33 : 3	50 : 3	
Carya alba (L.) Nutt. ex Ell. 2	100 : 2	50 : 3	100 : 4
Castanea pumila (L.) P. Mill. 3	33 : 3	75 : 4	
Chasmanthium laxum (L.) Yates 4	66 : 5	75 : 5	100 : 4
Iris verna L. 4	66 : 7	100 : 4	
Eupatorium album L. 4	100 : 7	75 : 8	
Eupatorium rotundifolium L. 4	100 : 8	75 : 6	
Liquidambar styraciflua 1, 2	83 : 12	55 : 12	100 : 4
Liquidambar styraciflua 3	100 : 7	75 : 5	
Lyonia ligustrina (L.) DC. 3	66 : 7	100 : 7	
Lysimachia quadrifolia L. 4	33 : 3	100 : 5	100 : 4
Osmunda cinnamomea L. 4	66 : 19	75 : 8	
Oxydendrum arboreum 1, 3	100 : 11	75 : 17	
Oxydendrum arboreum 2	100 : 11	75 : 26	100 : 33
Photinia pyrifolia (Lam.) Robertson & Phipps 3	66 : 2	75 : 3	
Pinus taeda 1	100 : 12	75 : 32	100 : 61
Pinus taeda 2			100 : 3.27
Pinus virginiana P. Mill. 3	33 : 2	75 : 5	
Piptochaetium avenaceum (L.) Parodi 3	66 : 7	100 : 5	
Pteridium aquilinum (L.) Kuhn 4	66 : 9	100 : 7	
Quercus alba L. 3	66 : 4	75 : 3	
Quercus falcata 1, 2	66 : 6	63 : 14	100 : 11
Quercus falcata 3	66 : 2	50 : 4	
Quercus stellata Wangenh. 3	33 : 7	100 : 3	100 : 13
Quercus velutina Lam. 3	66 : 3	50 : 2	
Smilax glauca 4	100 : 4	100 : 6	
Smilax rotundifolia 4	100 : 8	75 : 6	100 : 25
Thaspium barbinode (Michx.) Nutt. 4		75 : 3	100 : 3
Vaccicnium arbortum 3	100 : 3	75 : 6	
Vaccinium pallidum Ait. 3	66 : 4	100 : 5	
Vitis rotundifolia Michx. 3	100 : 6	100 : 4	100 : 13

an IV. *Sarracenia oreophila* density was 20.46 stems/m^2 (pers. comm., National Park Service).

DISCUSSION

Relationship to Previous Studies

The bogs of the Little River Canyon seem to be similar to the poorly drained oak-pine flatwoods and red maple blackgum swamps of Patrick et al. (1995) or seepage bogs noted by Schnell (1980). The seepage bogs were reported to be located on moderately to steeply sloping sites with low-density canopies. The smooth yellow false foxglove-pale-spike lobelia-violet lespedeza type seems to fit Schnell's seepage bog description. Patrick et al. (1995) reported that green pitcher plants were found in poorly drained oak-pine flatwoods and red maple-blackgum swamps. The blackgum-yellow-poplar-azalea type and scarlet oak-flowering dogwood seem to fit the communities described by Patrick et al.

No previous research has quantitatively examined soil and landform properties and vegetative structure of green pitcher plant bogs and attempted to classify communities. The inclusion of soil and landform properties into community classification provides a more ecologically based classification. Possible sites for restoration can then be located based on soil and landform properties. It also reduces the possibility of a classification being a reflection of successional communities. The communities identified in this research each have unique soil properties that have influenced the vegetation. This is reflected in dry site species such as *Quercus coccinea* in the scarlet oak-flowering dogwood-sweet goldenrod type and moister site species such as *Liriodendron tulipifera* in the blackgum-yellow-poplar-azalea type.

Fire and Fire Suppression

Pitcher plant bogs represent a fire subclimax (Folkerts 1982) or fire type (Eleuterius and Jones 1969). The absence of fire leads to a decline in bog species (Folkerts 1982) due to their dependence on fire to reduce the canopy cover (Schnell 2002). Fire suppression and subsequent encroachment has degraded many green pitcher plant bogs (U.S. Fish and Wildlife Service 1994). Reduction of fire frequency results in rapid invasion by shrubby species (Walker and Peet 1983, Folkerts 1982). Wooded sites, usually dominated by *Quercus* spp., were not considered optimal for green pitcher plants by Schnell (1980). Schnell noted a negative relationship between *Sarracenia* L. and *Quercus*. These wooded sites were adjacent to streams and likely were open bogs at one time. Patrick et al. (1995) recommended control of woody vegetation by prescribed burning. The sites in the Little River Canyon National Preserve are suffering from overstory encroachment (Table 2) due to infrequent fire. If a more frequent fire regime is restored, the fire could interact with environmental variables to change the species composition. The species richness and diversity of all the communities will likely increase with increased sunlight reaching the ground. Sites experiencing fire suppression consistently have lower species richness (Walker and Peet 1983). Research is needed to access the influence of fire on the communities and the green pitcher plant populations. Each community is likely to respond to fire differently and may require unique management regimes.

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LITERATURE CITED

Bell, C.R. 1949. A cytotaxonomic study of the Sarraceniaceae of North America. Journal of the Elisha Mitchell Science Society 65:37-166.

Carter, R.E. 1999. Ecological land classification in the Southern Loam Hills of south Alabama: longleaf pine ecosystems. Ph.D. diss., Auburn University, Auburn, Ala.

Eleuterius, L.N., and S.B. Jones. 1969. A floristic and ecological study of pitcher plant bogs in south Mississippi. Rhodora 71:29-34.

Folkerts, G.W. 1977. Endangered and threatened carnivorous plants of North America. Pp. 301-313 *in* G. Prance and T. Elisa, eds., Extinction is Forever. New York Botanical Garden, New York.

Folkerts, G.W. 1982. The Gulf Coast pitcher plant bogs. American Scientist 70:260-267.

Gauch, H.G. 1982. Multivariate Analysis in Community Ecology. Cambridge University Press. New York.

Hill, M.O. 1979. TWINSPAN: A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, Dept. of Ecology and Systematics, Ithaca, N.Y.

Hodgkins, E.J., M.S. Golden, and W.F. Miller. 1979. Forest habitat regions and types on a photomorphic-physiographic basis: a guide to forest site classification in Alabama-Mississippi. Southern Cooperative Series Number 210. Alabama Agricultural Experiment Station, Auburn.

Jongman, R.H.G., C.J.F. ter Braak, and O.F.R. Van Tongeren. 1995. Data Analysis in Community and Landscape Ecology. Cambridge University Press, New York.

Ludwig, J.A., and J.F. Reynolds. 1988. Statistical Ecology: a Primer on Methods and Computing. J. Wiley, New York.

McCune, B., and J.B. Grace. 2002. Analysis of Ecological Communities. MJM Software Design. Gleneden Beach, Ore.

McDaniel, S.T. 1971. The genus *Sarracenia* (Sarraceniaceae). Bulletin of the Tall Timbers Research Station 9:1-36.

McNab, W.H. 1989. Terrain shape index: quantifying effect of minor landforms on tree height. Forest Science 35:91-104.

McNab, W.H. 1992. A topographic index to quantify the effect of mesoscale and form on site productivity. Canadian Journal of Forest Research 23:1100-1107

Mohr, C.T. 1901. Plant life of Alabama, an Account of the Distribution, Modes of Association, and Adaptations of the Flora of Alabama, Together with a Systematic Catalogue of the Plants Growing in the State. Brown Printing Co. Montgomery, Ala.

Patrick, T.S., J.R. Allison, and G.A. Krakow. 1995. Protected Plants of Georgia. Georgia Department of Natural Resources, Social Circle, Ga.

Peet, R.K., T.R. Wentworth, and P.S. White. 1998. A flexible multipurpose method for recording vegetation composition and structure. Castanea 63:262-274.

Schnell, D.E. 1980. Notes on the biology of *Sarracenia oreophila* (Kearney) Wherry. Castanea 45:166-170.

Schnell, D.E. 2002. Carnivorous Plants of the United States and Canada. Timber Press, Portland, Ore.

SYSTAT. 2004. SYSTAT 11.0 for Windows. SYSTAT Software, Richmond, Calif.

Troup, R.L., and S.T. McDaniel. 1980. Current status report on *Sarracenia oreophila.* U.S. Fish and Wildlife Service, Atlanta, Ga.

U.S. Fish and Wildlife Service. 1994. Green pitcher plant recovery plan. U.S. Fish and Wildlife Service, Jackson, Miss.

Walker, J., and R.K. Peet. 1983. Composition and species diversity of pine-wiregrass savannas of the Green Swamp, North Carolina. Vegetatio 55:163-179.