COMMUNITY ANALYSIS OF PITCHER PLANT BOGS OF 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.

INTRODUCTION

Populations of the federally-endangered green pitcher plant are found in scattered moist upland bogs in northern Alabama, northern Georgia, and western North Carolina. 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. McDaniel (1971) indicated that the species often occurs in heavily wooded areas. According to Schnell (1980), the best habitats for green pitcher plants are 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. Patrick and others (1995) reported that green pitcher plants were found in poorly drained oak-pine flatwoods and red maple-blackgum swamps.

Previous 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.

SITES

The Little River Canyon National Preserve near Fort Payne, AL, has eight bogs with populations of green pitcher plants. The Little River Canyon is located entirely on Lookout Mountain in the Cumberland Mountain-Plateau Province of northeast Alabama (Hodgkins and others 1979). The canyon has been carved into the top of Lookout Mountain by the Little River. 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.

PROCEDURES

In the summer of 2003, a 10 x 30 m plot was placed in each of the 8 bogs. Plots were located near the center of the bogs and away from roads and power lines. Tree, sapling, seedling, and herbaceous strata were sampled following the Carolina Vegetation Survey protocol (Peet and others 1998). Tree (>11.4 cm d.b.h.) and sapling (>5 cm d.b.h.) diameters were measured throughout the plot while seedling (<5 cm d.b.h.) and herbaceous cover were estimated in 2 10 x 10 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 per acre). Landform variables sampled included slope gradient, aspect, terrain shape index (TSI), and landform index (LFI) (McNab 1989, 1992).

Plant communities were delineated through ordination and cluster analysis of vegetation and environmental data. Species occurring in more than one stratum (e.g., red maple as a tree, sapling, and seedling) were considered separate species. Importance values (IVs) were calculated and used in the initial analysis. Detection of communities was difficult with IVs, thus they were replaced with presence/absence data. The mere presence or absence of a species proved to be more important than its relative IV for community classification. The ordination methods employed were Canonical correspondence analysis (CCA) and Detrended correspondence analysis (DCA). Two-way indicator species analysis (TWINSPAN) (Hill 1979) was the cluster analysis employed.

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

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Citation for proceedings: Connor, Kristina F., ed. 2006. Proceedings of the 13th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–92. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 640 p.

The environmental variables significantly ($p = 0.20$) related to the communities were determined by stepwise discriminant analysis with 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 AND DISCUSSION

Three green pitcher plant communities were identified. One community only contained one plot but was accepted because of its unique structure and species composition. Discriminant analysis revealed that percent A horizon sand and depth of the A horizon were significantly (p=0.20) related to the plant communities. 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 percent for each community. Classification success with cross-validation analysis was 63 percent.

Green Pitcher Plant Communities

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

A blackgum-yellow poplar-azalea type was found in broad swales bisected by an ephemeral stream with a mean slope of 3 percent. The mean percent A-horizon sand was 46.25 while the A horizon depth was 22.78 cm (table 1). 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/ha (190), but the trees were larger in diameter and height than those of other communities. The sapling density was 4,940 stems/ha. The overstory was dominated by *A. rubrum*, *Nyssa sylvatica* Marsh., and *Liriodendron tulipifera* L. The sapling stratum was characterized by *Liriodendron tulipifera* and *Rhododendron canescens* Michx., while the seedling stratum was primarily *Liriodendron tulipifera*, *P. taeda*, and *Ilex verticillata* (L.) Gray. Common herbaceous species included *Hexastylis shuttleworthii* (Britten & Baker) Small and *Solidago erecta* Pursh (table 2). *Sarracenia oreophila* density was 5.81 stems/m^2.

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 1). This community had an open tree canopy (386 stems/ha); however, little sunlight reached the ground due to a dense midstory of saplings (5,040 stems/ha). Prescribed fire was likely intense enough to reduce the overstory but not intense enough to prevent the development of a dense midstory. *Q. coccinea* Münchh. was found in the overstory while the sapling stratum was characterized by *Q. coccinea*, *Q. velutina* Lam., *Cornus florida* L., *Castanea pumila* (L.) P. Mill., *Rhus glabra* L., and *Sassafras albidum* (Nutt.) Nees. Common seedling species were *Rhus glabra*, *Rhus 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 2). *Sarracenia oreophila* density was 7.76 stems/m^2.

A smooth yellow false foxglove-pale-spike lobelia- violet lespedeza type was found on convex sites with a slope of 4.25 percent and TSI of -1.875 (table 1). The tree density was still

Table 1—Mean and range (in parentheses) 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	12.29	9.12
	(10.75-11.38)	(8.12-13.88)	(9.12)
TSI	2.83	8.5	-1.18
	(1.63-4.63)	(0.13-10.25)	(-1.18)
% slope	12.00	6.00	4.25
	(3-28)	(3-11)	(4.25)
A-horizon depth (cm)[a]	22.78	24.73	15.00
	(12.5-28.5)	(11.33-38.25)	(15.00)
B-horizon depth (cm)	79.58	62.22	75.37
	(46.5-111.00)	(53.00-81.00)	(75.37)
A-horizon % sand[a]	46.25	55.31	38.75
	(43.75-46.25)	(50-61.25)	(38.75)
B-horizon % sand	51.25	55.00	41.25
	(42.5-58.75)	(46.25-57.5)	(41.25)

[a] Statistically significant (p=0.20)

Table 2—Constancy and mean importance value [constancy (%): importance value] of diagnostic species in green pitcher plant bogs of the Little River Canyon National Preserve

Species[a]	Community type: 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	00:6	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 gronovii 4			100:6
Ludwigia alternifolia 4			100:4
Lespedeza violacea 4			100:11

[a] 1, 2, 3, and 4 following species names indicates tree, sapling, seedling, and herb, respectively.

relatively high (240 stems/ha), but the sapling density was the lowest of the communities (2,280 stems/ha). Fire intensity was great enough to reduce the overstory and midstory density permitting many herbaceous species to become established. This community lacked many woody species common in the other two communities. The A-horizon sand was 15 percent while the A-horizon depth was 38.75 cm (table 1). *Q. stellata* Wang. and *Q. velutina* were found in the overstory while common sapling species included *Q. stellata*, *Q. velutina*, *Q. alba* L., *Vaccinium arboreum*, *P. taeda*, and *Carya tomentosa* (Poir. in Lam.) Nutt. The seedling stratum was characterized by *Q. stellata*, *Q. coccinea*, and *Sassafras albidum*. The herbaceous stratum included *Lobelia spicata* Lam., *Aureolaria flava* (L.) Farw., *Ludwigia alternifolia* L., and *Hieracium gronovii* L. (table 2). *Sarracenia oreophila* was present in the plot but absent from the herbaceous subplot; thus, it does not have an IV. *Sarracenia oreophila* density was 20.46 stems/m^2.

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 black swamps of Patrick and others (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 and others (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 communities described by Patrick.

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 *Q. 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

The sites in the Little River Canyon National Preserve are suffering from overstory encroachment due to infrequent fire. If a more frequent fire regime is restored, the fire could interact with environmental variables to change the species composition. 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.

ACKNOWLEDGMENTS

This research was supported by the Little River Canyon National Preserve, National Park Service, and Jacksonville State University.

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