THE FLORISTIC AND COMMUNITY ECOLOGY OF SEASONALLY WET LIMESTONE GLADE SEEPS OF TENNESSEE AND KENTUCKY

Kimberly Norton Taylor[1] and Dwayne Estes

Austin Peay State University
Department of Biology
and Center of Excellence for Field Biology
Clarksville, Tennessee 37044, U.S.A.
knorton@brit.org, estesl@apsu.edu

ABSTRACT

An open, seasonally wet seep community supporting herbaceous vegetation occurs within the limestone cedar glade complex of the southeastern United States. The purpose of this study is to describe the floristic composition of these limestone glade seeps. A floristic inventory of 9 seasonally wet sites in central Tennessee and south-central Kentucky was performed, documenting 114 species and infraspecific taxa in 91 genera and 43 families. Vegetation analysis identified the dominant taxa as *Eleocharis bifida* (% IV 20.3), *Sporobolus vaginiflorus* (% IV 11.94), *Hypericum sphaerocarpum* (% IV 5.97), *Allium* aff. *stellatum* (% IV 4.71), *Clinopodium glabellum/arkansanum* (% IV 4.15), *Schoenolirion croceum* (% IV 3.89), *Juncus filipendulus* (% IV 3.89), and *Carex crawei* (% IV 3.84). *Gratiola quartermaniae* and *Isoëtes butleri* are also important members of the community and may serve as indicator species. A wetland assessment of the seep community was performed according to the U.S. Army Corps of Engineers Wetland Delineation Manual and appropriate regional supplements. Wetland vegetation requirements are satisfied in 8 of the 9 seasonally wet sites sampled. The limestone glade seeps appear to represent a previously unclassified seasonal wetland type.

RESUMEN

Una comunidad abierta, húmeda estacionalmente por filtración, compuesta por vegetación herbácea se da en el complejo de pantanos calcáreos de cedro del sureste de los Estados Unidos. El propósito de este estudio es describir la composición florística de estos pantanos calcáreos de filtración. Se realizó un inventario florístico de 9 lugares húmedos estacionalmente en el centro de Tennessee y centro-sur de Kentucky, documentándose 114 especies y taxa infraspecíficos de 91 géneros y 43 familias. El análisis de vegetación identificó como taxa dominantes a *Eleocharis bifida* (% IV 20.3), *Sporobolus vaginiflorus* (% IV 11.94), *Hypericum sphaerocarpum* (% IV 5.97), *Allium* aff. *stellatum* (% IV 4.71), *Clinopodium glabellum/arkansanum* (% IV 4.15), *Schoenolirion croceum* (% IV 3.89), *Juncus filipendulus* (% IV 3.89), y *Carex crawei* (% IV 3.84). *Gratiola quartermaniae* y *Isoëtes butleri* son también miembros importantes de la comunidad y pueden server como especies indicadoras. Se realizó un informe de la comunidad de humedal de acuerdo con el U.S. Army Corps of Engineers Wetland Delineation Manual y los suplementos regionales apropiados. Los requerimientos de la vegetación de humedal se satisfacen en 8 de los 9 lugares estacionalmente húmedos que se muestrearon. Los pantanos calcáreos de filtración parecen representar un tipo de humedal estacional que no se había clasificado previamente.

INTRODUCTION

The limestone cedar glade complex is one of the most botanically unique ecosystems in the southeastern United States, supporting a distinct array of vascular plants including many rare and endemic taxa (Somers et al. 1986). The cedar glade complex is composed of a matrix of woodland vegetation, dominated by *Juniperus virginiana*, with areas of thin soil supporting herbaceous vegetation interspersed throughout (Quarterman 1989). While the cedar-woodland is an important component of the complex, the term "cedar glade" refers specifically to the open herb-dominated areas (Baskin & Baskin 2004). These openings are characterized by thin soil and an abundance of exposed Lebanon, Ridley, or Ste. Genevieve/ St. Louis limestones (Harper 1926; Quarterman 1950; Noger 1988).

Impermeable limestone bedrock near the surface, combined with increased winter and spring precipitation, lead to saturated conditions throughout most of the winter and early spring. A decrease in rainfall and increase in temperature from late spring through summer have a drying effect on the thin soil, resulting in drought-like conditions (Harper 1926; Quarterman 1989; Baskin & Baskin 2003). The unique assemblage of plants within the cedar glade community is directly influenced by this shift in moisture extremes (Harper 1926; Quarterman 1989).

[1]Present Address: Botanical Research Institute of Texas, 1700 University Dr., Fort Worth, Texas 76107-3400, U.S.A.

Spring saturation is highly variable within the cedar glade system. Lateral seepage from adjoining limestone strata surfaces at lower slope positions and pools overtop the limestone bedrock (NatureServe 2011). Spring saturation across the glades is therefore not uniform, resulting in glade seeps with varying degrees and length of inundation. The increased saturation within seepage areas restricts the assemblage of species that can survive, and thus a unique flora is expected within these communities.

The vascular flora and community associations within the drier phases of the cedar glades have been well-documented with several classification systems applied to glade vegetation (Picklesimer 1927, Baskin & Baskin 1996; Freeman 1933; Quarterman 1950; Somers et al. 1986; Rollins 1997). The presence of a unique seep community is suggested by Freeman (1933), Quarterman (1950), and Rollins (1997), who identify cedar glade community types dominated by species typical of wetter conditions (Baskin et al. 2007). NatureServe (2011) also identifies three cedar glade associations characterized by seasonal saturation (Table 1). The Limestone Seep Glade association (CEGL004169) of Tennessee, Alabama, and Georgia and the similar Kentucky Glade Seep (CEGL004669) are described as zonal components of limestone cedar glades characterized by seasonal seepage. The Limestone Glade Streamside Meadow association (CEGL 004292) is also characterized by seasonal saturation, but the source of saturation is overflow from proximal ephemeral streams. Dominant taxa, including many of the same taxa as those noted by Freeman (1933), Quarterman (1950), and Rollins (1997), are listed for each NatureServe association but the complete floristic composition within these associations is not indicated.

With sufficient length of saturation, the limestone glade seeps are expected to support primarily hydrophytic vegetation. The purpose of this study is to determine the vascular plant species composition and abundance within seasonally wet limestone glade seeps, and to evaluate the glade seeps in relation to current wetland delineation requirements.

METHODS

To identify potential study sites, cedar glades with seeps, wet swales, or ephemeral streams were visited in Bedford, Davidson, Decatur, Giles, Lincoln, Marshall, Maury, Meigs, Rutherford, and Wilson counties in Tennessee; Colbert, Franklin, and Lawrence counties in Alabama; and Simpson County, Kentucky. In addition to our own reconnaissance, we also consulted with staff from the Tennessee Natural Heritage Program, Drs. Jerry and Carol Baskin (University of Kentucky), Milo Pyne (NatureServe), Deborah White (Kentucky Nature Preserves Commission), and Dr. David Webb (Tennessee Valley Authority) to identify other high-quality examples of wet glades. Glades with evidence of extreme or continuing disturbance such as tire marks, livestock activity, or large amounts of debris as well as glades adjacent to roads or with other evidence of altered hydrology were excluded. Some high-quality sites located on private property were also excluded because we could not be sure that the study sites would not be disturbed during the duration of the study period.

Of the approximately 30 sites visited, nine of the highest-quality sites were selected for study, including seven sites in central Tennessee and two sites in south-central Kentucky (Fig. 1). An additional dry glade was included in south-central Kentucky (site 3) for comparison purposes. All sites were located in state parks, state forests, or on state natural areas. With the exception of site 3, at least a portion of the area of all sites was covered by a glade seep. Additionally, sites 4, 6, 7, 8, 9, and 10 also had a dry glade component. Most sites included the entire open region with the cedar-woodland edge serving as the site boundary. In cases of large open glades, an artificial boundary was selected and marked with GPS coordinates to include all seep portions of the glade and at least an equal amount of the adjacent dry glade.

Each site was visited one or more times during each of the following sampling periods: May 8–26, 2009; August 12–24, 2009; September 25–October 14, 2009; March 8–April 15, 2010; and May 18–31, 2010. The start of the May 2010 sampling period was postponed from early May to mid May due to torrential flooding in the region. The boundary of each site and the boundary of the glade seep portion within the site were mapped using ArcMap 9.2 (ESRI 2009). There was a clear differentiation in vegetation between dry and saturated areas at most sites. The line representing this shift in vegetative cover combined with the presence of persistent standing

TABLE 1. Dominant vegetation and characteristic species of three seasonally wet limestone cedar glade associations according to NatureServe (2011). All species in the Limestone Seep Glade and Kentucky Glade Seep Communities were documented during this study.

NatureServe Community	Dominant and Characteristic Species
Limestone Seep Glade	*Eleocharis bifida*[1], *Schoenolirion croceum*[1], *Carex crawei*[1], *Allium cernuum*[1], *Nothoscordum bivalve, Isoëtes butleri*[1], *Hypoxis hirsuta*
Kentucky Glade Seep	*Eleocharis bifida*[1], *Nothoscordum bivalve, Isoëtes butleri*[1], *Hypoxis hirsuta*
Limestone Glade Streamside Meadow[2]	*Mecardonia acuminata, Dalea foliosa, Mitreola petiolata, Rudbeckia triloba, Ludwigia microcarpa*

[1]-Determined to be characteristic of glade seep habitat in this study.
[2]-No examples of this community type were surveyed in this study.

water, saturated soil, or other hydrologic indicators (U.S. Army Corps of Engineers 2010) provided a boundary for the glade seep habitat. Each area was assigned a habitat code to indicate a "dry," or typical cedar glade (DG), a limestone glade seep (GS), or the border vegetation (BV) including the ecotone between open glade and adjacent cedar-woodland.

A floristic inventory was conducted of all vascular plants growing at each site, with nomenclature following Chester et al. (2009). Voucher specimens are deposited at the Austin Peay State University Herbarium (APSC). A complete annotated checklist of the seep flora was compiled (Appendix 1), organized by plant family within the four major plant groups (Pteridophytes, Gymnosperms, Angiosperms: Dicots, and Angiosperms: Monocots). Each entry in the checklist includes the scientific name, common name, site number(s) where found, habitat code (DG, GS, or BV), statement of abundance, USACE wetland indicator status code, geographical affinity, and collection number of specimens retained at APSC. Endemic, rare, and exotic species are also noted. Wetland indicator status codes follow the current consensus for the revised USACE wetland plant list, Eastern Mountains and Piedmont Region (Lichvar & Kartesz 2009). For geographical affinity, taxa with an intraneous distribution are those in which their center of distribution includes Tennessee; extraneous taxa are those in which their center of distribution does not include Tennessee; and disjunct taxa are those in which their distribution is not continuous (Kartesz 2003).

During the May 2010 sampling period, 15-meter transects were established in each GS and DG habitat at each of the 10 sites. Twelve GS transects and 7 DG transects were established. Sites 4, 6, 8, 9, and 10 had one DG and one GS transect each; site 7 had two GS transects and one DG transect; sites 1 and 5 had two GS transects each; site 2 had one GS transect; and site 3 had one DG transect. Transects were randomly placed within the boundary of the habitat. Five 0.5-m × 1-m quadrats were randomly selected and placed on alternating sides of each transect with the short edge perpendicular to the transect axis. Quadrat size was chosen so that all quadrats fitted entirely within the boundary of the often-narrow seep habitat. Percent cover values were visually estimated for all vascular plants using the Daubenmire (1959) cover class system as modified by Bailey and Poulton (1968): class 1, 0 to 1%; class 2, >1 to 5%; class 3, >5 to 25%; class 4, >25 to 50%; class 5, >50 to 75%; class 6, >75 to 95%; and class 7, >95 to 100%. Mean percent cover values were determined for each taxon using the mid-point value for each cover class. Percent Importance Values (% IV) [(relative cover + relative frequency)/2] × 100 were calculated for each taxon at each site. Mean across-site % IVs were also calculated for each taxon occurring within each habitat type. All % IVs given indicate the mean across-site % IV unless otherwise noted.

RESULTS

Study Sites.—The mean area of the 10 study sites was 0.37 ha and that of the seep component was 0.12 ha (Table 2). All sites in Kentucky were underlain by Ste. Genevieve/St. Louis Limestones, while all sites in Tennessee were underlain by Lebanon Limestone with the exception of Overbridge Glade State Nature Preserve which was underlain by Ridley Limestone (Noger 1988; Greene & Wolfe 2000). All sites were located at an elevation between 150 and 200 m.

Fig. 1. Locations of study sites in southern Kentucky and central Tennessee. **1, 2, 3**-Flatrock Glade Nature Preserve Glades **1, 2** and **3,** Simpson Co., KY; **4**-Couchville Cedar Glade State Natural Area, Davidson Co., TN; **5**-Cedars of Lebanon State Natural Area Glade S46, Wilson Co., TN; **6**-Cedars of Lebanon State Forest Glade 139, Wilson Co., TN; **7**-Cedars of Lebanon State Forest Glade 137, Wilson Co., TN; **8**-Cedars of Lebanon State Forest Glade 138, Wilson Co., TN; **9**-Sunnybell Glade State Natural Area, Rutherford Co., TN; **10**-Overbridge Cedar Glade State Natural Area, Rutherford Co., TN.

TABLE 2. Summary of study site characteristics including site number, site name, county and state, elevation, bedrock type, and site area. GS=area of glade seep habitat; Total =area of GS and dry glade habitats combined; % Total=percent of total site belonging to the GS habitat.

Site #	Site Name	County, State	Elevation (m)	Bedrock Type	Area (ha)		
					GS	Total	% Total
1	Flatrock Glade State Nature Preserve 1	Simpson Co., KY	180	Ste. Genevieve/ St. Louis Limestones, undivided[1]	0.08	0.08	100
2	Flatrock Glade State Nature Preserve 2	Simpson Co., KY	180	Ste. Genevieve/ St. Louis Limestones, undivided	0.11	0.11	100
3	Flatrock Glade State Nature Preserve 3	Simpson Co., KY	180	Ste. Genevieve/ St. Louis Limestones, undivided	0.00	0.11	0
4	Couchville Cedar Glade State Natural Area	Davidson Co., TN	200	Lebanon Limestone[2]	0.07	0.38	18.4
5	Cedars of Lebanon State Natural Area, S46	Wilson Co., TN	154	Lebanon Limestone	0.4	0.4	100
6	Cedars of Lebanon State Forest Glade 139	Wilson Co., TN	170	Lebanon Limestone	0.07	0.19	36.8
7	Cedars of Lebanon State Forest Glade 137	Wilson Co., TN	167	Lebanon Limestone	0.1	0.57	17.5
8	Cedars of Lebanon State Forest Glade 138	Wilson Co., TN	158	Lebanon Limestone	0.15	0.48	31.3
9	Sunnybell Glade State Nature Preserve	Rutherford Co., TN	174	Lebanon Limestone	0.35	1.14	30.7
10	Overbridge Glade State Nature Preserve	Rutherford Co., TN	181	Ridley Limestone[2]	0.06	0.21	28.6

[1]-Mississippian in age
[2]-Ordovician in age

Floristic Study.—A total of 114 species and infraspecific taxa were documented from the nine limestone glade seeps, representing 91 genera and 43 families (Appendix 1). The 114 seep taxa were distributed among 2 pteridophytes, 1 gymnosperm, and 111 angiosperms divided into 38 monocots and 73 dicots (Table 3). Of these, 20 taxa were found exclusively in the limestone glade seep habitat and were absent from the surrounding dry glade. Poaceae and Asteraceae were the largest families with 18 and 12 taxa, respectively, followed by Cyperaceae (8), Euphorbiaceae (8), and Fabaceae (6). The largest genus was *Carex* with 4 taxa followed by *Hypericum* and *Dichanthelium* each with 3 taxa. Seven non-native taxa were documented, representing 6 percent of the total flora. Three of these are listed as invasive in Tennessee, Kentucky, or both (Kentucky Exotic Pest Plant Council 2008; Tennessee Exotic Pest Plant Council 2009). Of the 107 native taxa, 63 had an intraneous distribution with 11 of these endemic to cedar glades. A total of 37 taxa had extraneous distributions with 21 extraneous to the west, 11 to the north, and 5 to the south. Seven additional taxa were disjunct from the west, resulting in 24.6 percent of the seep flora having western affinities.

Vegetation Study.—The limestone glade seep community was dominated by *Eleocharis bifida*, which occurred in 55% of the quadrats sampled, with a percent relative cover of 32.7% and a mean across site % IV of 20.3 (Table 4). *Sporobolus vaginiflorus* (% IV 11.94), *Hypericum sphaerocarpum* (% IV 5.97), *Allium* aff. *stellatum* (% IV 4.71), *Clinopodium arkansanum/glabellum*. (% IV 4.15), *Schoenolirion croceum* (% IV 3.89), *Juncus filipendulus* (% IV 3.89), and *Carex crawei* (% IV 3.84) were also important components of the spring seep flora. The dry glade transects were dominated by *Dalea gattingeri* (% IV 23.26), *Sporobolus vaginiflorus* (% IV 19.60), *Diodia teres* (% IV 7.58), *Hypericum sphaerocarpum* (% IV 7.29), *Minuartia patula* (% IV 7.06), and *Pediomelum subacaule* (% IV 6.26).

DISCUSSION

Floristics and Vegetation.—The unique nature of the glade seep flora can be seen by the presence of 14 rare taxa, 11 endemic taxa, and 7 disjunct taxa. Of the 14 rare taxa documented, *Schoenolirion croceum, Carex crawei, Isoëtes*

Table 3. Summary of taxa documented within limestone glade seeps.

Group	Families	Genera	Taxa
Pteridophytes	2	2	2
Gymnosperms	1	1	1
Angiosperms:			
Monocots	8	26	38
Dicots	32	62	73
Total	43	91	114

Table 4. Frequency, relative cover, and mean across site percent importance values of taxa occurring along limestone glade seep and dry glade transects. Frequency- (number quadrats taxon occurs in/total number of quadrats) × 100; Relative Cover- (total cover for taxon/total cover for all taxa) × 100; Mean %IV- (sum %IVs from all sites)/number of sites.

Taxon	Glade Seep			Dry Glade		
	Freq. (%)	Relative Cover (%)	Mean % I V	Freq. (%)	Relative Cover (%)	Mean % I V
Eleocharis bifida	55.00	32.66	20.30	—[1]	—	—
Sporobolus vaginiflorus	20.00	19.45	11.94	70.00	15.31	19.60
Hypericum sphaerocarpum	35.00	4.61	5.97	36.67	6.56	7.29
Allium aff. *stellatum*	30.00	8.83	4.71	23.33	3.49	5.79
Clinopodium arkansanum/glabellum	22.22	2.34	4.15	—	—	—
Schoenolirion croceum	30.00	6.56	3.89	20.00	3.47	3.53
Juncus filipendulus	23.33	4.18	3.89	—	—	—
Carex crawei	16.67	4.48	3.84	—	—	—
Chrysanthemum leucanthemum	21.67	2.79	3.63	—	—	—
Diodia teres	21.67	4.59	3.43	40.00	5.23	7.58
Scutellaria parvula	18.33	1.68	3.43	—	—	—
Ruellia humilis	25.00	1.72	2.95	23.33	0.60	2.71
Leucospora multifida	20.00	1.87	2.69	—	—	—
Lobelia appendiculata var. *gattingeri*	20.00	0.43	2.21	23.33	0.27	2.50
Houstonia purpurea var. *calycosa*	15.00	0.76	2.04	3.33	0.13	0.38
Muhlenbergia schreberi	16.67	3.18	2.02	13.33	4.67	4.04
Dalea gattingeri	18.33	2.36	2.00	96.67	16.91	23.26
Sisyrinchium albidum	46.67	0.79	1.36	—	—	—
Erigeron strigosus var. *calcicola*	6.67	0.84	1.28	23.33	3.07	3.59
Symphyotrichum priceae	5.00	0.70	1.08	10.00	0.93	1.45
Nostoc commune	6.67	1.62	1.07	6.67	3.34	2.91
Leavenworthia spp.	6.67	1.17	0.87	—	—	—
Isoetes butleri	6.67	0.69	0.79	—	—	—
Nothoscordum bivalve	15.00	0.21	0.67	23.33	4.14	4.83
Croton spp.	6.67	0.10	0.61	30.00	0.76	3.98
Sedum pulchellum	0.00	0.16	0.48	6.67	0.16	0.63
Chamaecrista fasciculata	3.33	0.08	0.48	—	—	—
Carex granularis	1.67	0.35	0.34	—	—	—
Chamaesyce spp.	3.33	0.14	0.26	—	—	—
Hypericum dolabriforme	5.00	0.07	0.25	—	—	—
Delphinium carolinianum ssp. *calciphilum*	1.67	0.07	0.18	—	—	—
Minuartia patula	0.00	0.07	0.18	43.33	2.58	7.06
Ophioglossum engelmannii	1.67	0.01	0.11	—	—	—
Dichanthelium acuminatum	—	—	—	6.67	0.80	0.94
Oenothera macrocarpa	—	—	—	16.67	4.34	4.13
Opuntia humifusa	—	—	—	3.33	1.67	1.08
Packera anonyma	—	—	—	3.33	0.02	0.35
Pediomelum subacaule	—	—	—	33.33	5.07	6.26
Plantago virginica	—	—	—	10.00	2.00	1.80
Verbena simplex	—	—	—	10.00	0.18	0.94

[1]-taxon not documented within any quadrats for the indicated habitat.

butleri, and *Juncus filipendulus* are characteristic members of the glade seeps (Kentucky Rare Plant Database 2006; Crabtree 2008). *Schoenolirion croceum* is restricted to four study sites in Tennessee but is typically locally dominant. *Carex crawei* and *Juncus filipendulus* are often dominant in these communities as well, occurring at all but two sites. *Isoëtes butleri* was less abundant, occurring at only two sites, but it was restricted to the glade seeps. The federally endangered *Dalea foliosa*, found at only one site, did not occur in the wettest portions of glades but was found in close proximity. Due to the time of sampling and major flooding during spring 2010, this study may not have captured the full diversity of winter annuals or early spring ephemerals, including *Leavenworthia* spp. *Gratiola quartermaniae*, and *I. butleri*.

The unique flora of the cedar glades has interested botanists for many years, dating back to the botanical surveys conducted by Gattinger in the mid- to late 19th century (Gattinger 1901). As a result, these areas have been well studied and the vegetation and community structure characterized extensively. Our results on the dominant dry glade taxa agree closely with those described in previous vegetation studies (Freeman 1933; Quarterman 1950, 1989; Somers et al. 1986; Rollins 1997). In particular, the abundance of *Dalea gattingeri* (% IV 23.26, freq. 96.7%) and *Sporobolus vaginiflorus* (% IV 19.60, freq. 66.7%) was consistent with prior studies (Freeman 1933; Quarterman 1950, 1989; Somers et al. 1986; Rollins 1997).

Sporobolus vaginiflorus, a summer annual, which germinates in early spring, had a high % IV in both dry and seep transects (Baskin & Baskin 1973). This suggests it is capable of tolerating a wide range of hydrological conditions. Conversely, the taxa which are primarily restricted to glade seeps require the additional moisture to survive. It is these taxa that characterize the glade seep community and differentiate it from other glade communities: *Eleocharis bifida*, *Allium* aff. *stellatum*, *Clinopodium glabellum/arkansanum*, *Schoenolirion croceum, Juncus filipendulus, Carex crawei*, *C. granularis, Gratiola quartermaniae, Leucospora multifida,* and *Isoëtes butleri*. All of them, with the exception of *Allium* aff. *stellatum,* are spring dominants and many disappear by early summer. Though the glade seeps lose much of their floristic uniqueness during summer, the presence of *A.* aff. *stellatum* and the persistence of dead *E. bifida* culms aids in identification of the community during the drier summer months.

The characteristic seep taxa identified by this study are consistent with prior studies. Several of them were identified as important components of glades sampled by Rollins (1997) including *Eleocharis bifida* (=*E. compressa*), *Carex crawei*, and *Clinopodium glabellum* (=*Calamintha glabella*). Baskin et al. (2007) note that some glades may be wet enough to support several "moisture-loving plants" including *E. bifida, Isoëtes butleri, C. crawei*, and *Schoenolirion croceum*. Quarterman (1950) identified glade regions with spring seep taxa including *Isoëtes butleri* and *S. croceum*. *Isoëtes butleri* was also noted by Freeman (1933).

All species listed in the NatureServe (2011) Kentucky Glade Seep and Limestone Seep Glade associations were documented during our study. Several of our characteristic seep taxa are also listed as dominants within the NatureServe (2011) associations, including *Eleocharis bifida, Carex crawei, Isoëtes butleri, Schoenolirion croceum,* and *Allium* aff. *stellatu*m (identified there as *Allium cernuum*). Additional taxa we found to be characteristic of the glade seeps should be included in the NatureServe Limestone Seep Glade association, including *Juncus filipendulus* and *Gratiola quartermaniae*.

All species in the Limestone Glade Streamside Meadow association, with the exception of *Ludwigia microcarpa,* were documented as well, though none of the taxa was abundant at any site (NatureServe 2011). Therefore, it appears the sites we studied are more characteristic of the Limestone Seep Glade and Kentucky Glade Seep associations and do not represent the Streamside Meadow association. Additional study of Streamside Meadow communities and how the vegetation compares to the seep community is needed.

Wetland Assessment.—The stress on vegetation resulting from saturated conditions is reflected in the increase in importance of hydrophytic vegetation within glade seeps. National wetland indicator status codes are assigned to species known to occur in saturated conditions, indicating how frequently these taxa are encountered in wetlands (Lichvar & Kartesz 2009). In our analysis of the glade seep flora, 42 percent of the taxa, including all of the characteristic taxa noted previously except the summer dominant *Allium* aff. *stellatum*, had a designated wetland indicator status code representing hydrophytic vegetation (FAC, FACW, or OBL). The

prevalence of vegetation recognized as hydrophytic suggests the persistence of water in the glade seep communities is enough to have a controlling influence over the vegetation.

USDA wetland delineation protocols use species abundance and wetland indicator status codes to determine if the vegetation of a site is hydrophytic or not (U.S. Army Corps of Engineers 2010). When these same protocols are used to assess the 9 glade seep communities studied here, 8 of the 9 GS sites satisfy the requirements. Glade 137 appeared "wetter" than a typical dry glade, but lacked most of the taxa determined to be characteristic of the glade seep. Saturation in this site may be more intermittent and thus not have a substantial effect on the vegetation.

In addition to the presence of hydrophytic vegetation the analyses of soils and hydrology are also necessary for a site to receive wetland status. Physical signs of hydrology that may satisfy the requirement were recorded and photographed throughout the study, including the presence of standing water, aquatic fauna (Fig. 2), water marks, sediment deposits, algal mats, and drift deposits (U.S. Army Corps of Engineers 2010). The very nature of the cedar glade system, with thin soils and near-surface bedrock, makes traditional soil analysis difficult. Limestone seep communities in Texas which are dominated by hydrophytic vegetation (Jue 2010) exhibit some characteristics of hydric soils, but Llado (2010) noted that "hydric properties may be impossible to observe year-round due to the nature of the community." Jue (2010) suggests these Texas "Muhly Seeps" be designated as a new wetland type, "seasonally unstable ephemeral wetlands."

We argue that designation of limestone glade seeps as ephemeral wetlands would be correct. If water exerts a controlling influence over the community, the vegetation will indicate this. This suggests that these 8 sites may meet the standards for wetland delineation protocols, and the glade seep community in general may represent a previously unrecognized wetland community type.

Conservation Status.—The glade seep community is limited in geographic range to within the cedar glade complex (Baskin & Baskin 2003). Reconnaissance field work during the site selection process led to the identification of less than 30 examples of seasonally wet sites, with most of these on public land and the rest on private lands in various states of disturbance. Cedar glades have often been viewed as waste areas and have been used to dump trash, as pasture land, and as a source for limestone paving stones and gravel (Harper 1926). All-terrain vehicle use is also high with wet communities being especially vulnerable to this threat. Development of cedar glade lands poses arguably the greatest threat to these communities with the expansion of Nashville and the surrounding urban area. Recognizing glade seeps as a seasonal wetland may hold important implications for conservation of this rare and floristically unique community.

APPENDIX 1. ANNOTATED CHECKLIST

Taxa are arranged alphabetically by family and species within the three major groups of vascular plants (Pteridophytes, Gymnosperms, and Angiosperms). Nomenclature follows Chester et al. (2009). Statement of abundance follows Murrell and Wofford (1987). Collection numbers indicate vouchers deposited at APSC. Taxa not collected due to rarity are indicated by a caret (^).

The following is a guide to the format and abbreviations associated with each taxon in the checklist. *Taxon* Authority (Common Name)—site numbers where found [habitat code]; statement of abundance; USACE wetland indicator status codes; geographic affinity; (Collector, collection number).

Symbols preceding taxon:

***** Cedar glade endemic/near endemic

† Taxon listed as rare at state (Kentucky or Tennessee) or federal level

Site numbers:

1 Flatrock Glade Nature Preserve Glade 1, Simpson Co., KY

2 Flatrock Glade Nature Preserve Glade 2, Simpson Co., KY

3 Flatrock Glade Nature Preserve Glade 3, Simpson Co., KY

4 Couchville Cedar Glade State Natural Area, Davidson Co., TN

5 Cedars of Lebanon State Natural Area Glade S46, Wilson Co., TN

Fig. 2. **Top** – Site 5, Cedars of Lebanon State Natural Area glade S46, in May 2009. Limestone glade seep community dominated by Schoenolirion croceum and Eleocharis bifida showing the presence of standing water over the near-surface limestone bedrock. **Bottom** – Site 4, Couchville Cedar Glade State Natural Area, in March 2009. The presence of standing water and use by aquatic fauna, serves as two signs of hydrology which may satisfy the hydrology indicator necessary for wetland determination.

6 Cedars of Lebanon State Forest Glade 139, Wilson Co., TN
7 Cedars of Lebanon State Forest Glade 137, Wilson Co., TN
8 Cedars of Lebanon State Forest Glade 138, Wilson Co., TN
9 Sunnybell Glade State Natural Area, Rutherford Co., TN
10 Overbridge Cedar Glade State Natural Area, Rutherford Co., TN

Habitat codes:

BV Border Vegetation **DG** Dry Glade **GS** Glade Seep

Statement of abundance:

V Very rare **R** Rare **S** Scarce **I** Infrequent
O Occasional **F** Frequent **C** Common

Geographical affinities:

INT Intraneous **WEST** Western Extraneous
EAST Eastern Extraneous **NORTH** Northern extraneous
SOUTH Southern Extraneous **D** Disjunct
NON Non-native

PTERIDOPHYTES

Isoëtaceae

†*Isoëtes butleri* Engelm. (Limestone Quillwort)—2,7 [GS]; I; OBL; WEST; (Norton 504).

Ophioglossaceae

Ophioglossum engelmannii Prantl (Limestone Adders Tongue)—1,6 [BV, GS]; R; FACU; WEST; (Norton 435).

GYMNOSPERMS

Cupressaceae

Juniperus virginiana L. (Eastern Red Cedar)—1,2,3,4,5,6,7,8,9,10 [BV, GS]; C; FACU; INT; (Norton 240).

ANGIOSPERMS – Monocots

Agavaceae

Manfreda virginica (L.) Rose (False Aloe)—2,4,6,7 [DG, GS]; S; NI; INT; (Norton 527).

†*Schoenolirion croceum* (Michx.) Wood (Yellow Sunnybell)—5,6,9,10 [BV, DG, GS]; F; OBL; SOUTH; (Norton 399).

Alliaceae

Allium canadense L. (Meadow Garlic)—3,4,10 [DG, GS]; S; FACU; INT; (Norton 471).

†*Allium* aff. *stellatum* Ker-Gawl.—4,5,6,7,8,10 [DG, GS]; C; NI; D-WEST; (Norton 45).

Nothoscordum bivalve (L.) Britt. (False Garlic)—3,4,6,7,8,9 [DG, GS]; C; FAC; INT; (Norton 221).

Amaryllidaceae

Hypoxis hirsuta (L.) Coville (Star-Grass)—1 [BV, GS]; S; FAC; INT; (Norton 341).

Cyperaceae

†*Carex crawei* Dewey (Crawe's Sedge)—1,2,4,5,6,7,9,10 [BV, DG, GS]; F; OBL; WEST; (Norton 414).

Carex glaucodea Tuck. ex. Olney (Blue Sedge)—1,3 [DG, GS]; R; FAC; INT; (Norton 419).

Carex granularis Muhl. ex Willd. (Limestone Meadow Sedge)—4,5 [DG, GS]; S; FACW; NORTH; (Norton 410).

Carex hirsutella Mack. (Fuzzy Sedge)—3,6,8 [GS]; S; FAC; NORTH; (Norton 428).

Cyperus acuminatus Torr. & Hook. (Taperitip Flat Sedge)—1 [GS]; R; OBL; WEST; (Norton 490).

Cyperus squarrosus L. (Bearded Flat Sedge)—2,3,5,9 [DG, GS]; O; OBL; INT; (Norton 116).

**Eleocharis bifida* S.G. Smith (Glade Spike Rush)—1,2,4,5,6,7,8,10 [GS]; C; FACW; INT; (Norton 397).

Scirpus pendulus Muhl. (Rufous Bulrush)—1,2,3,10 [GS]; I; OBL; NORTH; (Norton 473).

Iridaceae

Sisyrinchium albidum Raf. (White Blue-eyed Grass)—4,5,6,7,8,9 [BV, DG, GS]; F; FACU; INT; (Norton 3).

Juncaceae

Juncus brachycarpus Engelm. (Whiteroot Rush)—2 [GS]; R; FAC; INT; (Norton 502).

†*Juncus filipendulus* Buckl. (Ringseed Rush)—1,2,4,5,6,8,9,10 [GS]; C; FAC; D-WEST; (Norton 31).

Orchidaceae

Liparis liliifolia (L.) Rich. ex Lindl (Lilyleaved Tway Blade)—1 [BV, GS]; R; FACU; NORTH; (Norton 185).

†*Spiranthes magnicamporum* Sheviak (Great Plains Ladies'-Tresses)—1, 5 [GS]; R; FACU; WEST; (Norton 214).

Spiranthes lacera (Raf.) Raf. var. *gracilis* (Bigelow) Luer (Northern Slender Ladies'-Tresses)—1 [BV, GS]; R; FAC; INT; (Norton 1307).

Poaceae

Andropogon gerardii Vitman (Big Bluestem)—10 [DG, GS]; S; FAC; INT; (Norton 160).

†*Bouteloua curtipendula* (Michx.) Torr. (Sideoats Grama)—7 [DG, GS]; S; UPL; WEST; (Norton 76).

Bromus commutatus Schrad. (Meadow Brome)—1 [DG, GS]; R; NI; NON; (Norton 478).

Chasmanthium latifolium (Michx.) Yates (Indian Woodoats)—10 [DG, GS]; R; FAC; INT; (Norton 157).

Danthonia spicata (L.) Beauv. ex Roem. & Schult. (Poverty Oat Grass)—1 [DG, GS]; S; NI; NON; (Norton 195).

Dichanthelium acuminatum (SW.) Gould & C.A. Clark (Tapered Rosette Grass)—1,5,6 [DG, GS]; I; FAC; INT; (Norton 402).

Dichanthelium laxiflorum (Lam.) Gould (Open-Flower Rosette Grass)—1 [GS, DG]; F; FAC; INT; (Norton 197).

Dichanthelium malacophyllum (Nash) Gould (Soft Leaved Panic Grass)—1,5,7 [DG, GS]; O; NI; WEST; (^).

Eragrostis frankii C.A. Mey ex Steud (Sandbar Love-Grass)—1,8 [DG, GS]; I; FACW; NORTH; (Norton 133).

Leersia virginica Willd. (White Grass)—1 [GS, DG]; O: FACW; INT; (Norton 199).
Muhlenbergia schreberi J.F. Gmel. (Nimbleweed)—1 [GS]; R; FAC; INT; (Norton 200).
Panicum flexile (Gatt.) Scribn. (Wiry Panic Grass)—1,3,5,7,8,9,10 [BV, DG, GS]; C; FAC; INT; (Norton 201).
Panicum gattingeri Nash (Gattinger's Panic Grass)—1,2,3,4,5,9 [DG, GS]; C; FAC; NORTH; (Norton 202).
Paspalum setaceum Michx. (Thin Paspalum)—1 [DG, GS]; R; FAC; INT; (Norton 203).
Setaria parviflora (Poir.) Kerguélen (Marsh Bristle Grass)—4,5,8,10 [GS]; O; FAC; INT; (Norton 54).
Setaria pumila (Poir.) Roem. & Schult. (Yellow Bristle Grass)—4, 5, 8, 10 [GS, DG]; O; FAC; NON; (Norton 55).
Sporobolus vaginiflorus (Torr. ex A. Gray) Alph. Wood (Poverty Dropseed)—1,2,3,4,5,6,7,8,9,10 [DG, GS]; C; UPL; INT; (Norton 56).
Tridens flavus (L.) Hitchc. (Purpletop Tridens)—1,8 [GS]; S; FACU; INT; (Norton 137).

ANGIOSPERMS – Dicots

Acanthaceae
Ruellia humilis Nutt. (Fringeleaf Wild Petunia)—1,4,5,6,7,8,9,10 [DG, GS]; C; FACU; WEST; (Norton 151).

Apiaceae
Daucus carota L. (Queen Anne's Lace)—4,8,9 [DG, GS]; S; NI;NON; (Norton 97).

Asclepiadaceae
Asclepias verticillata L. (Whorled Milkweed)—4,5,10 [DG, GS]; I; FACU; INT; (Norton 508).

Asteraceae
Ageratina altissima (L.) R.M. King & H. Rob. (White Snakeroot)—1,4,7,8,10 [DG, GS]; O; FACU; INT; (Norton 192).
Ambrosia artemisiifolia L. (Annual Ragweed)—1,3,4,5,7,8,9,10 [DG, GS]; F; FACU; INT; (Norton 246).
Conoclinium coelestinum (L.) DC. (Blue Mistflower)—1, 2 [GS, DG]; O; FAC; INT; (Norton 208).
**Erigeron strigosus* Muhl. ex Willd. var. *calcicola* J.Allison (Limestone Fleabane)—1,3,4,5,7,8,9,10 [DG, GS]; C; FAC; INT; (Norton 256).
Eupatorium serotinum Michx. (Lateflowering Thoroughwort)—1 [BV, DG, GS]; R; FAC; INT; (Norton 194).
Grindelia lanceolata Nutt. (Narrowleaf Gum Weed)—4,10 [DG, GS]; S; NI; WEST; (Norton 241).
Helenium autumnale L. (Common Sneezeweed)—4 [DG, GS]; R; FACW; INT; (Norton 228).
Leucanthemum vulgare Lam. (Oxeye Daisy)—1,3,4,5,8,10 [BV, DG, GS]; F; UPL; NON; (Norton 416).
Packera anonyma (Wood) Weber & A. Löve (Small's Ragwort)—1,4,5,6,7,8,10 [DG, GS]; C; FACU; INT; (Norton 430).
Ratibida pinnata Barnh. (Pinnate Prairie Coneflower)—10 [GS]; R; NI; WEST; (Norton 475).
†*Symphyotrichum priceae* (Britt.) G.L. Nesom (Lavender Old Field Aster)—1,4,10 [DG, GS]; S; FACU; INT; (Norton 88).
Verbesina virginica L. (White Crownbeard)—9 [BV, DG, GS]; R; FACU; SOUTH; (Norton 1308).

Balsaminaceae
Impatiens capensis Meerb. (Jewelweed)—10 [GS]; R; FACW; INT; (Norton 146).

Boraginaceae
Heliotropium tenellum (Nutt.) Torr. (Pasture Heliotrope)—4,5,7,8,9,10 [DG, GS]; C; NI; WEST; (Norton 155).

Brassicaceae
**Leavenworthia stylosa* A. Gray (Cedar Glade Cress)—4,5,7,8,9 [DG, GS]; O; NI; INT; (Norton 264).
*†*Leavenworthia torulosa* A. Gray (Necklace Glade Cress)—1 [DG, GS]; R; OBL; INT; (^).

Campanulaceae
*†*Lobelia appendiculata* A. DC. var. *gattingeri* (A. Gray) McVaugh (Gattinger's Lobelia)—1,4,5,6,7,8,9,10 [DG, GS]; C; FAC; INT; (Norton 37).
Lobelia inflata L. (Indian-Tobacco)—1 [GS]; V; FACU; INT; (Norton 181).
Triodanis perfoliata (L.) Nieuwl. var. *perfoliata* (Clasping Venus' Looking Glass)—1,4 [DG, GS]; S; FACU; INT; (Norton 479).

Caryophyllaceae
Minuartia patula Michx. (Pitcher's Sandwort)—4,5,6,7,8,9 [DG, GS]; F; FAC; WEST; (Norton 10).

Clusiaceae
Hypericum dolabriforme Vent. (Straggling St. Johnswort)—1,2 [DG, GS]; R; NI; INT; (Norton 176).
Hypericum gentianoides (L.) B.S.P (Orangegrass)—2 [GS]; R; FACU; INT; (Norton 210).
Hypericum sphaerocarpum Michx. (Roundseed St. Johnswort)—1,2,3,4,5,6,7,8,9,10 [DG, GS]; C; FACU; WEST; (Norton 60).

Crassulaceae
Sedum pulchellum Michx. (Widowscross)—1,4,5,7,8,9 [DG, GS]; F; UPL; D-WEST; (Norton 406).

Ebenaceae
Diospyros virginiana L. (Persimmon)—6,10 [BV, GS]; S; FACU; INT; (Norton 1309).

Euphorbiaceae
Acalypha gracilens A.Gray (Slender Three Seed Mercury)—7 [DG, GS]; S; FAC; INT; (Norton 69).
Acalypha virginica L. (Virginia Three-Seed-Mercury)—1[GS, DG]; O; FACU; INT; (Norton 175).
Chamaesyce maculata (L.) Small (Spotted Sandmat)—1,3 [DG, GS]; R; FACU; INT; (Norton 1310).
Chamaesyce nutans (Lag.) Small (Eyebane)—5,7,8,10 [DG, GS]; O; FACU; INT; (Norton 74).
Chamaesyce prostrata (Ait.) Small (Prostrate Sandmat)—1,8,9 [DG, GS]; S; FAC; NON; (Norton 184).
Croton capitatus Michx. (Hogwort)—1,2,3,4,5,7,8,9,10 [DG, GS]; C; NI; WEST; (Norton 166).
Croton monanthogynus Michx. (Prairie Tea)—1,2,3,4,5,6,7,8,9 [DG, GS]; C; NI; WEST; (Norton 247).
Euphorbia dentata Michx. (Toothed Spurge)—1,3,5,8,9 [DG, GS]; F; NI; WEST; (Norton 518).

Fabaceae
Chamaecrista fasciculata (Michx.) Greene (Partridge Pea)—6,8,10 [BV, DG, GS]; I; FACU; INT; (Norton 120).
*†*Dalea foliosa* (A. Gray) Barneby (Leafy Prairie Clover)—5 [DG, GS]; R; NI; INT; (^).
**Dalea gattingeri* (A. Heller) Barneby (Purpletassels)—4,5,6,7,8,9,10 [BV, GS]; R; NI; INT; (Norton 398).
Desmanthus illinoensis (Michx.) MacMill. ex B.L. Rob. & Fern. (Prairie Bundle Flower)—4,10 [DG, GS]; S; FAC; WEST; (Norton 90).
Lespedeza cuneata (Dum.Cours.) G. Don (Chinese Lespedeza)—5,10 [BV, GS]; S; UPL; NON; (Norton 141).
**Pediomelum subacaule* (Torr. & A. Gray) Rydb. (Indian Breadroot)—4,6,7,8,9,10 [DG, GS]; C; NI; INT; (Norton 346).

Lamiaceae

Blephilia ciliata (L.) Benth (Downy Pagoda Plant)—4 [DG, GS]; R; NI; INT; (Norton 455).

Clinopodium arkansanum (Nutt.) House (Limestone Calamint)—6,7,9,10 [DG, GS]; O; FACW; D-WEST; (Norton 472).

Clinopodium glabellum (Michx.) Kuntze (Ozark Calamint)—4,5,8,9 [DG, GS]; O; FACW; INT; (Norton 83).

Isanthus brachiatus (L.) B.S.P (Fluxweed)—1,4,7,10 [DG, GS]; O; NI; NORTH; (Norton 177).

Scutellaria parvula Michx. (Small Scullcap)—1,2,3,4,5,6,7,8,9 [BV, GS]; C; FACU; INT; (Norton 9).

Loganiaceae

Mitreola petiolata (J.F. Gmel.) Torr. & A. Gray (Lax Hornpod)—10 [GS]; R; FACW; SOUTH; (Norton 507).

Lythraceae

Cuphea viscosissima Jacq. (Blue Waxweed)—1,3,7,10 [DG, GS]; O; FACW; NORTH; (Norton 71).

Malvaceae

Malvastrum hispidum (Pursh) Hochr. (Hispid False Mallow)—1,3 [DG, GS]; S; NI; D-WEST; (Norton 173).

Montiaceae

*†*Phemeranthus calcaricus* (S. Ware) Kiger (Limestone Fameflower)—3,4,5,7,9 [DG, GS]; F; NI; INT; (Norton 101).

Oleaceae

†Forestiera ligustrina (Michx.) Poir. (Upland Swamp Privet)—1,2,3,4,5,6,7,8,9,10 [BV, GS]; C; FAC; SOUTH; (Norton 213).

Onagraceae

Gaura longiflora Spach (Longflower Beeblossom)—10 [DG, GS]; R; NI; WEST; (Norton 138).

†Oenothera macrocarpa Nutt. (Bigfruit Evening Primrose)—10 [DG, GS]; R; NI; D-WEST; (Norton 142).

Plantaginaceae

Leucospora multifida (Michx.) Nutt. (Narrowleaf Paleseed)—1,4,5,7,8,9,10 [DG, GS]; F; OBL; WEST; (Norton 150).

Mecardonia acuminata (Walt.) Small (Axilflower)—1,4,7,8,10 [DG, GS]; O; FACW; SOUTH; (Norton 158).

**Gratiola quartermaniae* D. Estes (Limestone Hedge Hyssop)—6 [GS]; R; FAC; INT; (Norton 342).

Penstemon calycosus Small (Long Sepal Beard Tongue)—10 [BV, DG, GS]; R; FACU; NORTH; (Norton 474).

Plantago virginica L. (Virginia Plantain)—1,3,6,7 [DG, GS]; O; FACU; INT; (Norton 488).

Polygalaceae

Polygala verticillata L. (Whorled Milkwort)—1,7,10 [BV, DG, GS]; I; UPL; INT; (Norton 485).

Portulacaceae

Portulaca oleracea L. (Little Hogweed)—1 [GS]; R; FACU; NON; (^).

Primulaceae

Dodecatheon meadia L. (Shooting Star)—1,7,9,10 [BV, DG, GS]; O; FACU; WEST; (Norton 421).

Ranunculaceae

Aquilegia canadensis L. (Red Columbine)—6,9 [DG, GS]; O; FAC; NORTH; (Norton 437).

**†Delphinium carolinianum* Walt. ssp. *calciphilum* Warnock (Carolina Larkspur)—4,6,9,10 [BV, GS]; F; NI; INT; (Norton 451).

Rosaceae

Potentilla simplex Michx. (Common Cinquefoil)—5,7,8,9 [BV, DG, GS]; F; FACU; INT; (Norton 13).

Rubiaceae

Diodia teres Walt. (Poorjoe)—1,2,6,7,8,10 [BV, GS]; F; FACU; INT; (Norton 494).

Galium virgatum Nutt. (Southwestern Bedstraw)—6 [DG, GS]; S; NI; D-WEST; (Norton 434).

Hedyotis nigricans (Lam.) Fosberg (Diamond Flowers)—4,6,7,8,10 [DG, GS]; F; NI; WEST; (Norton 510).

Houstonia purpurea L. var. *calycosa* A. Gray (Venus' Pride)—1,4,5,6,7,8,9,10 [DG, GS]; C; NI; INT; (Norton 12).

Solanaceae

Physalis pubescens L. (Husk Tomato)—1 [GS]; R; UPL; INT; (Norton 186).

Solanum ptycanthemum Dunal (West Indian Nightshade)—1 [GS]; R; FACU; INT; (Norton 180).

Urticaceae

Pilea pumila (L.) A. Gray (Canadian Clearweed)—1 [BV, GS]; S; FACW; INT; (Norton 183).

Verbenaceae

Verbena simplex Lehm. (Narrowleaf Vervain)—1,4,5,6,10 [DG, GS]; F; NI; INT; (Norton 439).

ACKNOWLEDGMENTS

The authors acknowledge Roger McCoy and Todd Crabtree (Tennessee Natural Heritage Program), Jerry and Carol Baskin (University of Kentucky), Milo Pyne (NatureServe), Deborah White (Kentucky Nature Preserves Commission), and David Webb (Tennessee Valley Authority) for their assistance in site identification; The Tennessee State Parks and Forestry and Kentucky State Natural Areas for permits; Carol Baskauf and Floyd Scott for their assistance and encouragement; and the Austin Peay State University Biological Sciences Department and Center for Excellence in Field Biology for funding. We also thank Theo Witsell and Roger McCoy for their helpful suggestions to improve the manuscript and Jerry Baskin and one anonymous reviewer for helpful suggestions.

REFERENCES

Baskin, J.M. and C.C. Baskin. 1973. Observations on the ecology of *Sporobolus vaginiflorus* in cedar glades. Castanea 38:25–35.

Baskin, J.M., D.H. Webb, and C.C. Baskin. 1995. A floristic plant ecology study of the limestone glades of northern Alabama. Bull. Torrey Bot. Club 122:226–242.

Baskin, J.M. and C.C. Baskin. 1996. Bessey Picklesimer's little-known quantitative study on the vegetation of a cedar glade in the Central Basin of Tennessee. Castanea 6:25–37.

Baskin, J.M. and C.C. Baskin. 2003. The vascular flora of cedar glades of the southeastern United States and its phytogeographical relationships. J. Torrey Bot. Soc. 130:101–118.

Baskin, J.M. and C.C. Baskin. 2004. History of the use of "cedar glades" and other descriptive terms for vegetation on rocky limestone soils in the Central Basin of Tennessee. Bot. Rev. 70:403–424.

Baskin, J.M., E. Quarterman and C.C. Baskin. 2007. Flow diagrams for plant succession in the middle Tennessee cedar glades. J. Bot. Res. Inst. Texas 2:1131–1140.

Bailey, A.W. and C.E. Poulton. 1968. Plant communities and environmental relationships in a portion of the Tillamook burn, northwestern Oregon. Ecology 49:1–13.

Catling, P.M. and V.R. Brownell. 1999. Alvars of the Great Lakes Region. In: R.C. Anderson, J.S. Fralish, and J.M. Baskin, eds. Savannas, Barrens, and rock outcrop plant communities of North America. Cambridge University Press, Cambridge, UK. Pp. 375–391.

Chester, E.W., B.E. Wofford, D. Estes, and C. Bailey. 2009. A fifth checklist of Tennessee vascular plants. Botanical Research Institute of Texas Press, Fort Worth, Texas.

Crabtree, T. (ed.). 2008. Tennessee Natural Heritage Program rare plant list. Tennessee Division of Natural Areas. Tennessee Department of Environment and Conservation, Nashville.

Daubenmire, R.K. 1959. A canopy-coverage method of vegetation analysis. Northw. Sci. 43:43–64.

ESRI (Environmental Systems Resource Institute). 2009. ArcMap 9.2. ESRI Inc., Redlands, California.

Estes, D. and R.L. Small. 2007. Two new species of *Gratiola* (Plantaginaceae) from Eastern North America and an updated circumscription for *Gratiola neglecta*. J. Bot. Res. Inst. Texas 1:149–170.

Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 16+ vols. New York and Oxford.

Freeman, C.P. 1933. Ecology of the cedar glade vegetation near Nashville, Tennessee. J. Tennessee. Acad. Sci. 8:143–255.

Gattinger, A. 1901. The flora of Tennessee and a philosophy of botany. Press of the Gospel Advocate Publ. Co. Nashville, Tenn.

Greene, D.C. and W.J. Wolfe. 2000. Superfund GIS – 1:250,000 Geology of Tennessee. U.S. Geological Survey, Nashville, Tennessee.

Harper, R.M. 1926. The cedar glades of middle Tennessee. Ecology 7:48–54 plus 1 plate.

Harper, R.M. 1939. Granite outcrop vegetation in Alabama. Torreya 39:153–159.

Hill, S.R. 2003. Botanical survey of dolomite prairie remnants, natural plant communities, and threatened and endangered plants at the Interstate 55 (FAI 55) – Arsenal Road interchange project, Channahon, Will, County, Illinois. Center for Biodiversity Technical Report 2003 (37). Prepared for Bureau of Design and Environment, Illinois Department of Transportation, Springfield, by the Illinois Natural History Survey, Campaign, Submitted 31 Dec 2003.

Houle, G. 1987. Vascular plants of Arabia Mountain, Georgia. Bull. Torrey Bot. Club 114:412–418.

Jones, R.L. 2005. Plant life of Kentucky: an illustrated guide to the vascular flora. The University Press of Kentucky, Lexington.

Jue, M.L. 2011. Vegetative analysis of Muhly hillslope seeps in North Central Texas. Master's Thesis. Texas Christian University, Fort Worth, Texas.

Kartesz, J.T. 2003. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. Second Edition. In: Kartesz, J.T. Synthesis of the North American flora, Version 2.0.

Kentucky Rare Plant Database. 2006. Kentucky State Nature Preserves Commission. http://eppcapp.ky.gov/nprareplants/index.aspx, Accessed May 2010.

Kentucky Exotic Pest Plant Council. 2008. http://www.se-eppc.org/ky/lists.htm. Accessed May 2010.

Lichvar, R.W. and J.T. Kartesz. 2009. North American digital flora: National Wetland Plant List, version 2.4.0 https://wetland_plants.usace.army.mil U.S. Army Corps of Engineers, Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, NH, and BONAP, Chapel Hill, NC.

Llado, L.E. 2011. Soil moisture dynamics of Muhly seeps in a hillslope hollow during low flow and storm conditions. Master's Thesis. Texas Christian University, Fort Worth, Texas.

McVaugh, R. 1943. The vegetation of the granitic flat-rocks of the southeastern United States. Ecol. Monogr. 13:119–166.

NatureServe. 2011. Natureserve Explorer: an online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed: January 30, 2012).

Noger, M.C. (compiler). 1988. Geologic map of Kentucky: sesquicentennial edition of the Kentucky Geological Survey: U.S. Geological Survey and the Kentucky Geological Survey, scale 1:500,000.

Perkins, B.E. 1981. Vegetation of sandstone outcrops of the Cumberland Plateau. Master's Thesis. University of Tennessee, Knoxville, Tennessee.

Picklesimer, B.C. 1927. A quantitative study of the plant succession of the cedar glades of middle Tennessee. Master's Thesis. George Peabody College for Teachers, Nashville, Tennessee.

Quarterman, E. 1950. Major plant communities of Tennessee cedar glades. Ecology 31:234–254.

Quarterman, E. 1989. Structure and dynamics of the limestone cedar glade communities in Tennessee. J. Tennessee Acad. Sci. 64:155–158.

Reed Jr., P.B. (compiler). 1997. Revision of the National List of plant species that occur in wetlands. In Cooperation with the National and Regional Interagency Review Panels: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, and Natural Resources Conservation Service. Department of Interior, U.S. Fish and Wildlife Service, Washington, DC, USA.

Rollins, S.C. 1997. Calcareous glade communities in the Central Basin of Tennessee. Master's Thesis, Univ. North Carolina, Chapel Hill.

Smith, S.G. 2001. Taxonomic innovations in North American *Eleocharis* (Cyperaceae). Novon 11:241–257.

Somers P., L.R. Smith, P.B. Hamel, and E.L. Bridges. 1986. Preliminary analysis of plant communities and seasonal changes in cedar glades in middle Tennessee. A.S.B. Bull 33:178–192.

Tennessee Exotic Pest Plant Council. 2009. http://www.tneppc.org/invasive_plants. Accesed May 2010.

U.S. Army Corps of Engineers. 2010. Interim regional supplement to the Corps of Engineers wetland delineation manual: Eastern Mountains and Piedmont Region, ed. J.S. Wakeley, R.W. Lichvar, C.V. Noble, and J.F. Berkowitz. ERDC/EL TR-10-9. U.S. Army Engineer Research and Development Center, Vicksburg, MS.