The Vegetation of Pulliam Prairie, Chickasaw County, Mississippi: a Significant remnant of Pre-Columbian Landscape in the Black Belt

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Vegetation types are described and mapped at Pulliam Prairie, in Chickasaw County, Mississippi. This site is a significant remnant of pre-Columbian landscape in the Black Belt of Upper East Gulf Coastal Plain. Its ca. 250 acres [100 ha] lie mostly on gentle calcareous slopes between bottomlands of Sakatonchee Creek and (on the west side) uplands transitional to the Pontotoc Ridge. Most vegetation is native grassland, or old fields and plowed plots that are reverting to largely native composition. Also, there are narrow riparian woods, transitional thickets, and upland oak woods in various conditions. Vegetation types are conceptually organized based on subdivisions along two gradients: (1) from alluvial lowlands, to chalky slopes, to more acid uplands; (2) from deeper woods to more open areas, with xerohydric vertisols and eroding or bare surfaces at open extremes. Potential complexities in (2) include relationships to disturbance regime and management. Pulliam Prairie can become an important center for restoration of the region's native vegetation.

The Black Belt of Mississippi and Alabama is a distinctive calcareous section of the Upper East Gulf Coastal Plain in the southeastern U.S.A. It is largely underlain by Upper Cretaceous sediments that are mostly "chalk and marly chalk containing fewer impurities than underlying and overlying formations" (Moore, 1985). There has been a substantial recent increase in research on the native vegetation of this region during recent years (Peacock and Schauwecker, 2003; Barone, 2005; Barone and Hill, 2007; Schotz and Barbour, 2009; Campbell and Seymour, 2011a). Much attention has focused on remnants of the characteristic native grasslands or 'prairies' of this region, but it has been difficult to describe the full pattern of varied grassland and woodland types that existed on the landscape before first European contact. Because of general agricultural conversion, individual study-sites rarely allow insight to the broader patterns. This paper describes vegetation at the Pulliam Prairie in eastern Chickasaw County, Mississippi, a tract of ca. 250 acres [100 ha] with much evidence of the original gradients in composition related to topography and soils.

Most good remnants of Black Belt prairie are only 5–20 acres [3–12 ha] in size, but a few cover up to 500 acres [200 ha] if adjacent thickets and open woodlands are included (Wiygul et al., 2003; Barone and Hill, 2007; Schotz and Barbour, 2009). In Mississippi, the Tombigbee National Forest has begun to restore significant remnants within ca. 500 acres [200 ha] of Pontotoc County (Wiygul et al., 2003), a few miles north of Pulliam Prairie, and there is potential for a much broader effort in this neighborhood, given the several nearby pastures and roadsides with variously degraded remnants of the original grassland (based on our personal observations). The Osborn Prairie ("Sixteenth Section Prairie") includes ca. 178 acres [72 ha] of grassland in Oktibbeha County, and is currently leased and managed by Friends of the Black Belt in cooperation with Mississippi State University (Wiygul et al., 2003; Hill and Selzer, 2007). A smaller remnant—the Morton Hill Prairie—occurs at Noxubee National Wildlife Refuge (Noxubee County), where restoration is also proceeding (Hill, 2004).

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In recent years, there has been increasing focus on conservation in the Black Belt involving several governmental, academic and non-profit partners (Wiygul et al., 2003; Schotz and Barbour, 2009; D. Coggin and J. Hill, pers. comm.). In addition to supporting healthy populations of deer and turkey, marginal farmlands and old fields in the Black Belt form a prioritized region for recovery of quail in Mississippi. These efforts will clearly benefit from more detailed understanding of what the native vegetation was, where the best remnants are, and how they can be restored under current conditions.

The Pulliam Prairie offers special insight to the original landscape since it includes varied soils and native vegetation types. Also, there are several nearby woods and fields with some degree of natural quality, covering 100s of additional acres for extended study in the future. In addition to extensive grassland on the more calcareous slopes and adjacent uplands, there are strips of wooded riparian zones and patches of woods on the broader ridges. Although much of the area has been farmed to some extent, there has been little persistent cropping on the uplands, and diverse native species have recovered in many areas. According to local history, the Pulliam family purchased land in this neighborhood from the Chickasaw tribe during the 1820s. In recent years, they have consolidated some of the tracts. They have used the areas with native grassland primarily for hunting, and have applied fire to maintain the open character.

SITE CONTEXT: TOPOGRAPHY AND SOILS

The Pulliam Prairie lies within the western side of the Black Belt region (Fig. 1), mostly on relatively gentle topography (Fig. 2). It drains into Sakatonchee [or Chuquatonchee] Creek, a major tributary of the Tombigbee River. The broad ridge west of these slopes is connected to the southern terminus of the Pontotoc Ridge (Lowe, 1921; Harper, 1943), which is an extension of the "Northern Hilly Gulf Coastal Plain" that has been mapped as an ecological region here and across much of north-central Mississippi (Chapman et al., 2004). Elevation around the Pulliam Prairie ranges from about 250 feet [76 m] above sea level along Sakatonchee Creek to 400 feet [122 m] on ridges west of the study area. The Pulliam tract itself is mostly at 260–310 feet [85–95 m], and the mile-long corridor along the access road from the closest paved road extends up to about 340 feet [105 m].

Campbell and Seymour (2011a, their Fig. 1) have outlined the overall patterns of variation among soil series of the Black Belt. Soils of this region (USDA, 2010a), and at the Pulliam Prairie or nearby, can be arranged conceptually along two largely independent gradients (or 'catenas'). There is an elevation-related gradient, from alluvial lowlands, to the chalky soils on gentle side slopes, to the overlying clays and sands on broader ridges. And there is a drainage-related gradient, from poorly drained flats with generally deeper soils, to better drained slopes with generally shallower soils. Most soil series on the chalk itself are classed as vertisols—with expansive 'shrink-swell' clays, and 'self-mulching' of organic matter into deep A horizons. More local soils include entisols (especially on more recent colluvium or alluvium), inceptisols (especially on deep, damp colluvium or alluvium), mollisols (presumably with more stable grass, cane or cedar cover), and alfisols (on more weathered loamy uplands with more woodland history just above the chalk). In contrast, loamy ultisols (with generally less base saturation) predominate above the chalky soils, on more sandy uplands or on high terraces with a history of woodland.

Soil series mapped by USDA (2010b) at the Pulliam Prairie or nearby cover the full range of catenas illustrated for the region by Campbell and Seymour (2011a), except that the shallowest soils on chalk (Binnsville and Sumter series) and the ultisols on more sandy ridges are not documented here. Several intervening soil series along the catenas are not mapped here, but these may still be present to a limited extent. Within three miles of our study area, a more complete range of soils is represented, including sandy transitions to the Pontotoc Ridge.

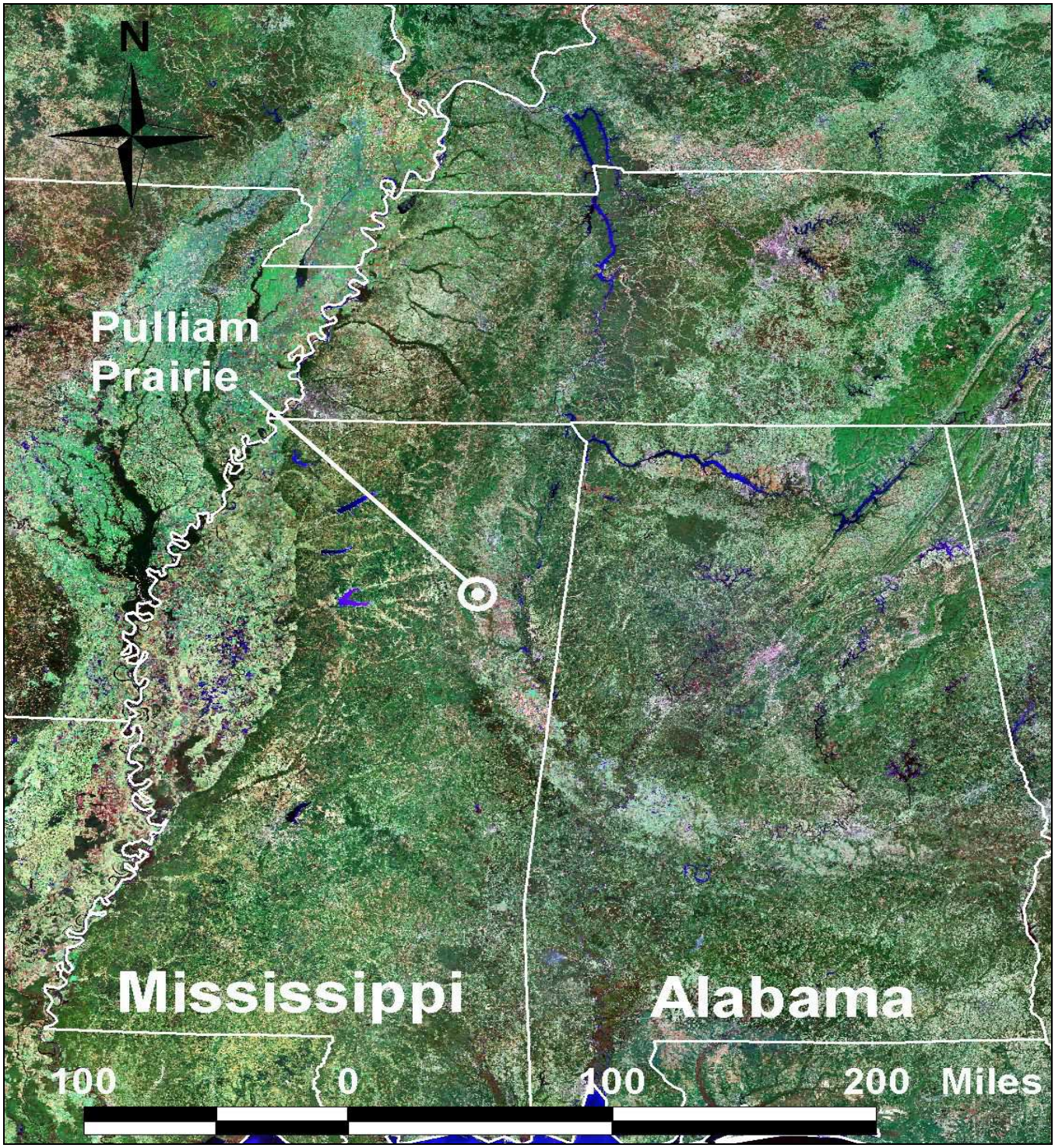

Figure 1. **Location of Pulliam Prairie in relation to Landsat-derived imagery for the region (NaturalVue, 2000)**.

Figure 2 (next page). **Map of site based on aerial photograph from National Agricultural Imaging Program (USDA Farm Service Agency)**. Date of image is 2009, July 2nd; reference code is ortho_1-1_1n_s_ms017_2009_1. Contours in feet are added from MARIS (2009).

Figure 2 (for caption see previous page).

METHODS

We made collecting six trips to Pulliam Prairie in 2009, covering 14 days: April 20–21, June 6–8, July 10–12, August 22–24 (Fig. 4), September 24–25 and October 28. During each trip, except the last, we systematically covered the study area, using an electric Stealth Predator XR vehicle for transport and collection platform for herbarium specimens (Campbell and Seymour, 2011c). On each trip we visited most or all sections of the study area, defined as 15 grid units of 1000 x 1000 feet [305 x 305 m].

We assigned initial codes for habitats at multiple sites within each grid unit, in order to map vegetation and to provide label data for our collected species. These codes were: W1a = Cedar Woods; W1b = Post Oak Woods; W2a = Oak Hickory Woods; W2b = Riparian Mixed Woods; W3a = Green Ash Woods; W3b = Willow Oak / Water Oak Woods; S1 = Dry Scrub; S2 = Seasonally Wet Scrub; S3 = Riparian Scrub; G1 = Grassland on eroded/dry upland soils; G2 = Grassland on moderately dry soils; G3 = Grassland on deeper or damper soils. We eventually converted this system into the vegetation types outlined below; and see Campbell and Seymour (2011c) for a related series of codes to indicate the typical position of each species along ecological gradients.

In addition to our field work, we used recent aerial photographs (from USDA Farm Service Agency), topographic mapping (USGS 1987 7.5 min topographic quadrangle "Buena Vista"), and digitized soil mapping of NRCS (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx) to interpolate our observations over the site. Also, we used our broad regional review of soils (USDA, 2010a) and vegetation in order to refine our definitions of habitat types (Campbell and Seymour, 2011a). We incorporated these observations into a map of vegetation types at the site, and into a diagram of the major gradients in vegetation. Botanical nomenclature primarily follows the list of vascular flora in Mississippi that is being developed at the Pullen Herbarium in Oxford (McCook and Kartesz, 2010), based initially on Kartesz (1999). For a few taxa, we use significantly different names, which we detail and explain in the accompanying floristic paper (Campbell and Seymour, 2011c).

Figure 3 (next page). **Map of vegetation at site**. Mapping units generally correspond to following vegetation types, as outlined in the text; original field codes are in brackets [ ]. Transitions between grassland and woodland, as mapped here (03, 09, 14) are generally more heterogeneous than grassland or woodland units.

01: mostly (a); some (b) and (c) [W2a]; occurs west of this map of the main study area.
02: mostly (b); some (c) and (h1) [W1b].
03: mostly (h1); some (i) and (b) [S1]; also includes thin pine plantations.
04: mostly (c), plus local poorly drained areas (c2); some (e) and (f) [G2 upper].
05: mostly (c) in disturbed or eroded variants; much transitional (f) and some (e) [G2 wetter].
06: mostly (d); some (e), (f), (h) and (i) [G1].
07: mostly (f); some (d), (e) and (g) [G2].
08: mostly (e); some (f), (d) and (g) [G2 plowed].
09: mostly (h), or mixes of (i) and (d)-(g) [S2]; highly heterogeneous.
10: mostly (i), or mixes of (i), (j) and (d)-(g) [W1a].
11: mostly (g); some (f), (h) [G3].
12: mostly (g) in disturbed variants; some (e) and (f) [G3 plowed].
13: mostly current (2009) soybean fields [potential G3?]
14: mostly (h2); some mixes with (g), (h3), (i) and (j) [S3].
15: mostly (m); some (j), (i), (h) and (n) [W2b].
16: mostly (n1); some (m) and (h3) [W3a].
17: mostly (n2); some (n1), (m) and (h) [W3b]; defined from only one patch so far.

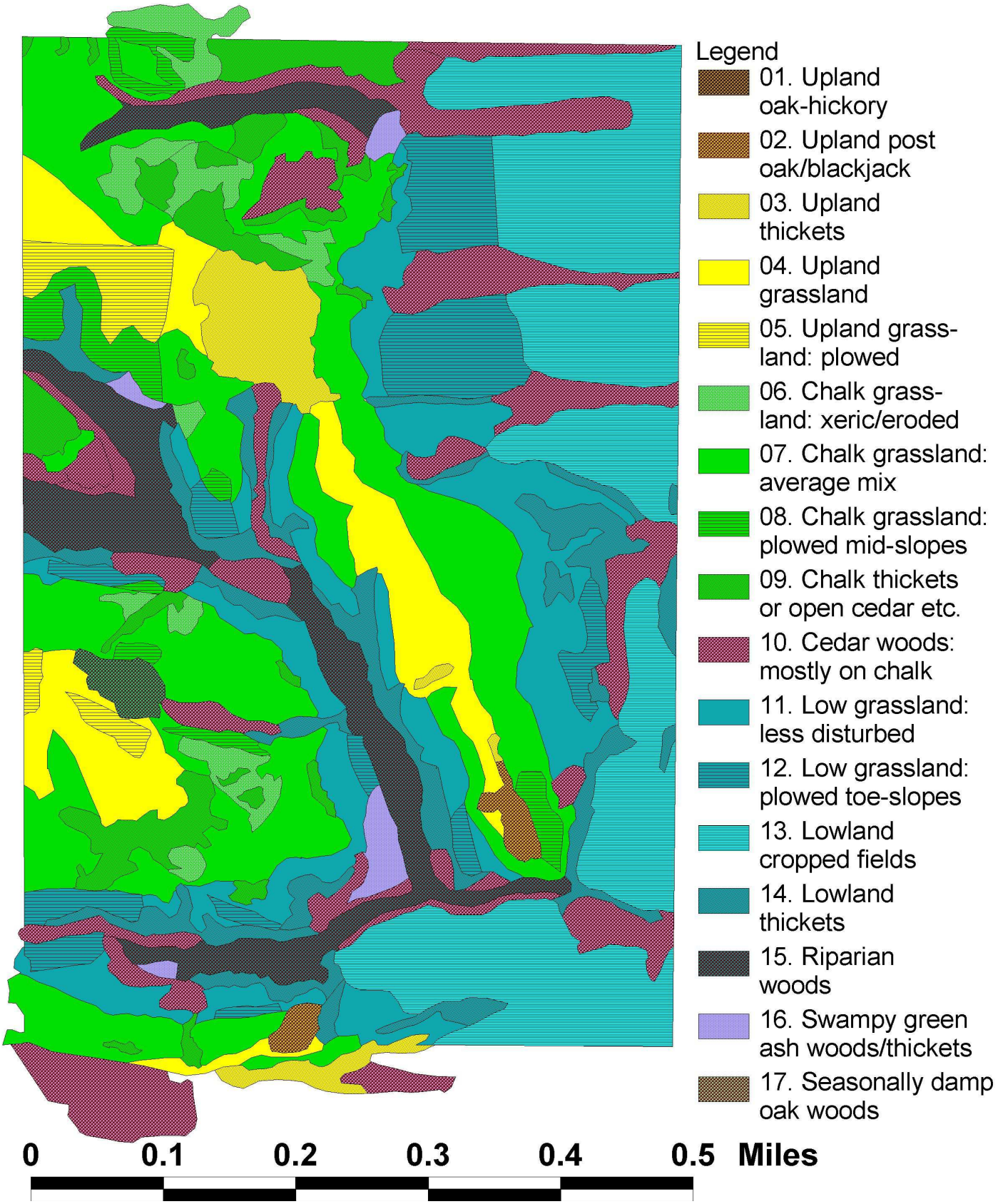

Figure 3 (for caption see previous page).

Figure 4. **View of Pulliam Prairie, 23 Aug 2009**. This is facing north along the gentle, long low slope on the east-central side of the site. Vegetation is mostly type (f). Grasses are mostly *Sorghastrum nutans*, *Panicum virgatum*, *Schizachyrium scoparium* and (at lower levels) *Andropogon gerardii*. In flower are *Liatris aspera* and *Silphium terebinthinaceum*.

RESULTS

The following notes outline composition in each vegetation type at the Pulliam Prairie. This general classification matches the regional outline presented already, based on review of the literature, with the same lettered codes from "a" to "n" (Campbell and Seymour, 2011a). Fig. 3 presents a map of vegetation over the site. The mapping units correspond to the vegetation types outlined below, as much as possible, but several mapping units include transitions and mixtures, as explained in the key. There is, of course, much intergradation between types. The lists of characteristic species provided below are best estimates, offered here for continual revision with further field work on the whole flora. For linkage with our accompanying floristic paper, the ecological codes given to characteristic species in that paper are added in brackets after each vegetation title below [with "C&S 2011c"]. Fig. 4 presents the scheme of ecological relationships among our interpreted vegetation types.

Uplands with Acid Soils Overlying Calcareous Sediments: *including damp flats*

(a) Oak woods on ridges and knolls [see species A1/A2 and B1/B2 in C&S 2011c]. There are virtually no areas of such woods at the Pulliam Prairie itself, but they are scattered near the paved road a few hundred meters to the west. In older woods, post oak (*Quercus stellata*) is common, with most canopy trees 2–4 dm, plus a few 5–6 dm or more. Other trees include southern red oak (*Q. falcata*), blackjack oak (*Q. marilandica*), hickories (*Carya glabra*, *C. ovata* and *C. tomentosa*) and winged elm (*Ulmus alata*). A distinctive shrub is *Vaccinium arboreum*. On the ground, there are patches of *Vitis rotundifolia*, scattered graminoids (e.g., *Dichanthelium dichotomum*, *Eleocharis* cf. *tenuis*) and legumes (e.g., *Desmodium laevigatum*, *Lespedeza intermedia*).

(b) Open oak woodlands and thickets [see species A3 and B3 in C&S 2011c]. On uplands within the Pulliam Prairie, there are a few patches of thin woods dominated by post oak or blackjack oak, plus scattered winged elm. These woods have been burned, browsed or otherwise disturbed for at least several decades, and probably much longer. In one area at the head of an ephemeral stream, there are several larger water oaks (*Q. nigra*) in a transition from post oak to riparian woods (see j below). Hickories are curiously absent. Loblolly pine (*Pinus taeda*) has been planted on similar soils near some of these woods, but it is probably not native to the site. In more open areas or at woodland edges, there also some distinctive shrubby species, but mostly in small numbers: *Vaccinium arboreum* (on more acid soils), *Rhus copallina* (locally abundant in transitions to grassland), *Toxicodendron pubescens*, *Ceanothus americanus*, *Crataegus engelmannii*, *Hypericum hypericoides*, *Rosa carolina* and *Rubus* spp. (with *R. trivialis* locally common). The alien Japanese honeysuckle (*Lonicera japonica*) is frequent in some areas. On the ground, frequent graminoids include *Carex* spp. (*leavenworthii*, *muhlenbergii*, cf. *umbellata*), *Danthonia spicata*, *Dichanthelium* spp. (*dichotomum*, *linearifolium*, cf. *meridionale*, *sphaerocarpon*), *Panicum anceps* var. *rhizomatum*, and *Scleria* spp. (especially *triglomerata*). Locally abundant herbs include *Helianthus* spp. (especially *hirsutus* and *pauciflorus*) and *Verbesina helianthoides*. Other characteristic species include *Desmodium* spp. (*glabellum*, *laevigatum*, *marilandicum*), *Lespedeza* spp. (*intermedia*, *procumbens*, *violacea*), *Phlox* spp. (*carolina*, *pilosa*), *Ruellia* cf. *ciliosa*, *Salvia lyrata*, *Stylosanthes biflora*, *Symphyotrichum patens*, *Tephrosia virginiana* and *Tragia urticifolia*.

(c1) Relatively well-drained grassland on ridges [see species A4/A5 and B4/B5 in C&S 2011c]. Most of the ridges with more acid clayey substrate above the chalk have been farmed, especially on deeper soils. However, the older fields have a diverse mix of native species, and there are some less disturbed areas, especially on old roadsides, in swales and other transitions down to the chalk grassland (see d, e and f below). Locally abundant grasses include broomsedges (especially *Andropogon virginicus*), switch grass (*Panicum virgatum*), Indian grass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*). Other gram-

inoids are characteristic, including *Aristida* spp. (*longespica, oligantha*), *Carex* spp. (especially *bushii* and *hirsutella*), *Gymnopogon ambiguus*, *Muhlenbergia capillaris* and *Scleria* spp. (including *ciliata*). Locally frequent herbs include *Agalinis* spp. (especially *purpurea* or *fasciculata*), *Ambrosia psilostachya*, *Brickelia eupatorioides*, *Buchnera americana*, *Cirsium discolor*, *Desmodium* spp. (*canescens, glabellum, sessilifolium*), *Eryngium yuccifolium*, *Eupatorium* spp. (*hyssopifolium, pubescens, serotinum*), *Helenium nudiflorum*, *Helianthus* spp. (especially *mollis* and *pauciflorus*), *Liatris* spp. (*spicata, squarrosa, squarrulosa*), *Linum medium*, *Solidago* spp. (including *nitida*), and *Symphoricarpus* spp. (*ericoides, dumosus, patens*).

(c2) More poorly-drained grassland on ridges; somewhat xerohydric [see species A4/B4 as well as H/HX in C&S 2011c]. On broader flats, there are seasonally wet conditions in some areas, but generally less than an acre in extent. There are a few small ephemeral ponds that appear to be at least partly artificial. Composition is highly varied, depending on hydrology and disturbance history. Several graminoids appear to be characteristic: *Andropogon tenuispatheus*, *Cyperus* spp. (*echinatus, pseudovegetus*), *Dichanthelium scoparium*, *Eleocharis* spp. (*compressa, erythropoda*), *Juncus* spp. (*acuminatus, biflorus, effusus, scirpoides*), *Saccharum* spp. (*contortus, giganteus*), and *Tridens strictus*. Also, *Tripsacum dactyloides* has filled a small brushy pond. There are few characteristic broad-leaved herbs, but the rather weedy *Eupatorium serotinum* is relatively frequent. Uncommon species of interest include *Mecardonia acuminata* and *Spiranthes vernalis*. One of the ephemeral ponds has abundant *Potamogeton diversifolius*, and is lined by *Trachelospemum difforme*.

Uplands with Calcareous Soils: mostly on slopes. Note that the grassland types (d), (e), (f) and (g) outlined below are usually intermixed at small scales. In areas larger than 0.1–1 acres [0.04–0.4 ha], it is often impossible to assign a predominant type.

(d) Upland grassland on shallow, partly bare soils; mostly xeric-tending or xerohydric [see species C4/C5 as well as X/XH in C&S 2011c]. A more detailed analysis of microsites would separate further variants here related to degrees of soil formation versus erosion. In general, the most common graminoids include three-awns (especially *Aristida longespica*), dropseeds (*Sporobolus vaginiflorus*, *S. clandestinus*, *S. compositus* var. *drummondii*), little bluestem (*Schizachyrium scoparium*), glade panic (*Panicum flexile*), switch grass (*P. virgatum*), sedges (*Carex crawei*, *C. meadii*) and glade irisette (*Sisyrinchium albidum*). Locally frequent herbs include *Agalinis* spp. (*gattingeri, oligophylla*), *Asclepias* spp. (especially *viridiflora*), *Coreopsis lanceolata*, *Dalea* spp. (*candicans, purpurea*), *Erigeron strigosus* (with some *var. calcicola*), *Eurybia hemispherica*, *Houstonia* spp. (*lanceolata, nigricans*), *Hypericum sphaerocarpon*, *Liatris* spp. (especially *squarrosa* var. *glabrata*), *Linum sulcatum*, *Lobelia spicata* var. *leptostachya*, *Ruellia* cf. *humilis*, *Spiranthes magnicamporum* (especially in disturbed, puddled areas), *Solidago* spp. (especially *nemoralis*) and *Symphyotricum* spp. (especially *laevis* var. *purpuratus* and *patens* var. nov.). Alien species are usually rare or absent.

(e) More disturbed variants, often transitional from shallow to deeper soils [see, especially, species C5 in C&S 2011c]. Composition appears related to disturbance history and gradients in soil. There is much intermixing among species characteristic of drier and damper types (from c to g), especially where the ground is plowed, gullied, compacted or stripped of organic matter. More weedy grasses tend to predominate, including several annuals in *Aristida*, *Eragostis* and *Panicum*. Typical perennial grasses include broomsedges (*Andropogon virginicus* and its allies) and locally *Muhlenbergia capillaris*. Typical herbs include *Ambrosia* spp. (especially the perennial *psilostachya*), *Asclepias* spp. (*tuberosa, viridis*), *Croton* spp. (especially *monanthogynus*), *Erigeron strigosus*, *Neptunia lutea*, *Plantago virginica* and *Symphyotrichum* spp. (especially *dumosum* var. *subulifolium*). Several aliens are usually present: white sweet clover (*Melilotus alba*) is locally frequent;

large plots of sericea lespedeza (*L. cuneata*) have been established in some areas; and patches of Johnson grass (*Sorgum halepense*) occur on deeper soils.

(f) Upland grassland on average soils; typical subxeric slopes [species C4 in C&S 2011c, see also Fig. 4]. Dominant graminoids are little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*) and switch grass (*Panicum virgatum*). Sedges are often present, but most typical of transitions to swales and low thickets (see d, g and h). Frequent herbs include *Asclepias* spp. (*tuberosa, viridis*), *Agalinis* spp. (especially *oligophylla*), *Allium canadense* var. *mobilense*, *Arnoglossum plantagineum*, *Blephilia ciliata*, *Buchnera americana*, *Dalea* spp. (especially *purpurea*), *Desmanthus illinoensis*, *Eryngium yuccifolium*, *Eupatorium altissimum*, *Eurybia hemispherica*, *Liatris* spp. (especially *aspera*), *Physostegia angustifolia*, *Polytaenia nuttalii*, *Prenanthes aspera*, *Ratibida pinnata*, *Silphium* spp. (*laciniatum, terebinthinaceum*), *Solidago* spp. (especially *nitida* and *rigida*), *Symphyotrichum* spp. (especially *dumosum*), and *Valerianella radiata*. Additional legumes are locally frequent, especially at upper levels: *Chamaecrista fasciculata*, *Galactia regularis*, *Desmodium* spp. (especially *ciliare*), *Lespedeza* spp. (especially *virginica*). Invasive aliens are mostly excluded, except in formerly plowed or planted areas.

(g1) Variants on deeper or damper soils; relatively mesic to slightly hydric [see species D4 in C&S 2011c]. In areas with relatively little agricultural disturbance, remnants of taller grassland are usually dominated by big bluestem (*Andropogon gerardii*); other common prairie grasses are also frequent (switch grass, Indian grass, little bluestem) plus, especially in low brushy transitions (see h2), wild rye (*Elymus glabriflorus*). In more disturbed areas, especially on damper soils, the broomsedge *Andropogon tenuispatheus* is often dominant; also, *Saccharum giganteum* and *Paspalum floridanum* var. *glabrum* are locally common. Frequent herbs include *Agalinis* spp. (especially *auriculata* and *purpurea*), *Allium canadense*, *Apocynum cannabinum*, *Asclepias tuberosa*, *Desmanthus illinoensis*, *Desmodium* spp. (especially *paniculatum* and *sessilifolium*), *Dracopsis amplexicaulis*, *Gaura longiflora*, *Helenium flexuosum*, *Helianthus resinosus*, *Liatris* spp. (especially *aspera* and *spicata*), *Monarda fistulosa*, *Ratibida pinnata*, *Physostegia angustifolia*, *Silphium* spp. (especially *terebinthinaceum*), *Solidago* spp. (*altissima, gigantea, rigida*), *Symphyotrichum* spp. (especially *novae-angliae*) and *Valerianella radiata*. Aliens occur in some areas, especially where there has been agricultural disturbance. In old fields, Johnson grass (*Sorghum halepense*) is locally dominant and fescue (*Festuca arundinacea*) is also frequent.

(g2) Variants on the wettest soils; somewhat hydric or hydroxeric [see species D4 as well as H/HX in C&S 2011c]. This vegetation of swales or slope bases is rather heterogeneous; it generally matches the "seepy inclusions" of NatureServe (2010, under CEGL 4664). These sites tend to be in rather small patches or narrow zones, and are often fragmented or disturbed by farming of various kinds. It is likely that gamma grass (*Tripsacum dactyloides*) was formerly common, but there are only scattered patches now. Other tall native grasses include scattered *Saccharum giganteum* and *Paspalum* spp. Instead, shorter graminoids are locally common, including *Scirpus pendulus*, *Carex* spp. (especially *granularis*), *Cyperus* spp. (especially *echinatus*), and *Juncus* spp. (especially *biflorus* and *torreyi*). *Lythrum alatum* var. *lanceolatum* is often dominant in mid-summer. Other characteristic herbs may include *Agalinis* spp. (*heterophylla, purpurea*), *Eupatorium* spp. (*coelestinum, fistulosum, serotinum*), *Ptilimnium nuttalii*, *Solidago* spp. (*altissima, gigantea*) and *Symphyotrichum praealtum*. Aliens are infrequent; none are abundant.

(h) Upland thickets, edges and associated transitions from grassland to woodland. These are varied types of transition, including isolated shrubby patches within the grassland, broader shrubby zones at upper or lower levels, narrower edges along woodland borders, and relatively thin woods that have been burned or otherwise disturbed. The most abundant shrubby species on more calcareous soils is usually roughleaf dogwood

(*Cornus drummondii*). Also common are chickasaw plum (*Prunus angustifolia*), which is locally dominant, especially at upper levels; redbud (*Cercis canadensis*), especially at lower levels; and supplejack (*Berchemia scandens*), which often takes hold in viney tangles, especially at lower levels. Other locally frequent woody species include osage-orange (*Maclura pomifera*), honey-locust (*Gleditsia triacanthos*), sugarberry (*Celtis laevigata*), ashes (*Fraxinus americana* and, on wetter sites, *F. pennsylvanica*), sumacs (*Rhus glabra* at lower levels, *R. copallina* at upper levels), blackberries (especially *Rubus trivialis* at upper levels). Bully-buckthorn (*Bumelia lycioides*) and hawthorns (*Crataegus crus-galli* and, at upper levels, *C. engelmanii*) are infrequent, but may have been much more common in the pre-Columbian landscape (Campbell and Seymour, 2011a). Red-cedar (*Juniperus virginiana*) is generally absent from recently burned, mowed or plowed areas, but tends to increase where such disturbance has waned. In ground vegetation, as well as climbing high, vines are locally frequent: green-briars (especially *Smilax bona-box* on drier sites), grape vines (several species), peppervine (*Ampelopsis arborea* on damper sites), poison-ivy (*Toxicodendron radicans* var. *pubens*) and trumpet-creeper (*Campsis radicans*). The Japanese honeysuckle (*Lonicera japonica*) is also locally abundant, being virtually the only alien woody species in this type.

Herbaceous composition is highly varied and differs greatly between upper levels and lower levels, as follows.

(h1) Transitions at upper levels [see species B2 and B3 in C&S 2011c]. Graminoids are locally abundant, including *Carex* spp. (*leavenworthii*, *texensis*, cf. *umbellata*), *Danthonia spicata*, *Dichanthelium* spp. (especially *acuminatum* and allies), *Panicum anceps* var. *rhizomatum*, *Scleria* spp. (especially *triglomerata*). The more distinctive herbs include *Desmodium* spp. (especially *glabellum*), *Helianthus* spp. (especially *hirsutus*), *Lespedeza* spp. (especially *frutescens*), *Ruellia* cf. *ciliosa*, *Salvia lyrata* and *Verbesina helianthoides*.

(h2) Transitions at lower levels [see species D2 and D3 in C&S 2011c]. Graminoids are locally abundant, including *Carex* spp. (*blanda*, *cherokeensis*, *oxylepis*), *Chasmanthium latifolium*, *Elymus* spp. (*virginicus* in shade, *glabriflorus* in open), *Festuca* spp. (*subverticillata* in shade, *paradoxa* in open), *Sphenopholis* spp. (*intermedia* in shade, *obtusata* in open). The more distinctive perennial herbs include *Dasystoma macrophylla*, *Desmodium* spp. (especially *paniculatum*), *Erigeron philadelphicus*, *Helianthus resinosus*, *Rudbeckia* sp. nov., *Ruellia strepens*, *Packera* spp. (*obovata*, *glabella*), *Verbesina virginica*, *Vernonia gigantea* and *Viola* cf. *missouriensis*. There are also a few winter annuals in the shade, including *Chaerophyllum tainturei*, *Galium aparine* and *Myosotis macrosperma*.

(h3) Wet thickets. Young thickets dominated by green ash are noted below under swampy woods (section n). With more analysis, it might be reasonable to provide separate descriptions.

(i) Red cedar woods, on drier uplands (i1) and on damper soils (i2). Apart from the dominance of red-cedar itself, there may be little general difference in associated species between these young woods and the thickets or transitions outlined in preceding paragraphs. But the ground cover below canopy of red cedar is sparse, except for abundant mosses (especially *Thuidium delicatum* (Hedw.) B.S.G.). Spleenwort (*Asplenium platyneuron*) is one of the few vascular species typical of this habitat at the Pulliam Prairie. A curious feature is the frequent persistence of the alien, sericea lespedeza (*L. cuneata*), into more open stands of red cedar, where it has perhaps invaded old fields sown with sericea some decades ago. The vegetation varies from uplands to lowlands. Some relatively infrequent species appear characteristic of more open stands on drier ground (i1): *Agalinis gattingeri*, *Crotolaria sagittalis*, *Dichanthelium laxiflorum*, *Potentilla simplex*, *Spiranthes ovalis*, *Symphyotrichum laeve* var. *laeve*. Lower woods (i2) are dense and extensive along some gullies, down into adjacent lowlands, and associated species are similar to the lower thickets outlined above (h2).

(j) Submesic mixed hardwoods. Woods of submesic streamheads, toe-slopes or terraces (j3) are treated here provisionally under "Lowlands" below (type m) but in a broader regional analysis it might be reasonable to segregate some of these woods from true lowlands. More mesic woods below bluffs (j1), locally with *Acer floridanum* (j2), were outlined for the region by Campbell and Seymour (2011a) but do not occur at the Pulliam Prairie.

***Lowlands with Alluvial Soils*.** As noted by Campbell and Seymour (2011a), distinction of lowland from uplands in the Black Belt is somewhat arbitrary.

(k) Lowland grassland. This is not clearly recognized at the Pulliam Prairie, but the wettest grassland variant outlined above (type h2) may have graded into true lowland prairie during pre-Columbian times. Gamagrass (*Tripsacum dactyloides*) is present locally in that variant, and used to be extensive on the adjacent lowlands before conversion to agriculture, when it was known as "chicken corn" by early settlers (S.D. Pulliam, pers. comm.). The species remains locally abundant along roadsides on lowlands within a few miles of the site.

(l) Lowland canebrakes and associated thickets. Cane (*Arundinaria gigantea*) was not found at the Pulliam Prairie, but it occurs on lowlands within a mile or two. Some areas of current soybean fields directly below the site might well have supported cane in the original vegetation.

(m) Riparian hardwoods; generally submesic [see species D1/D2 and E1/E2 in C&S 2011c]. These woods occur at the Pulliam Prairie in narrow strips and small patches within riparian zones, excluding the more poorly drained (hydric) areas outlined below (type n). They have varied soils, hydrology and disturbance history, and only a provisional generalization is provided here. Larger trees are mostly 2–4 dm in diameter. The most common trees include sugarberry (*Celtis laevigata*), osage-orange (*Maclura pomifera*), chinquapin oak (*Quercus muhlenbergii*), and elms (especially *Ulmus americana*). Also scattered in some areas are ashes (*Fraxinus americana*, *F. pennsylvanica*), honey locust (*Gleditsia triacanthos*), black walnut (*Juglans nigra*), and pecans (*Carya myristicaeformis*, *C. illinoenensis*). Distinctive shrubby species are relatively infrequent: *Amorpha croceolanata*, *Asimina triloba*, *Ilex decidua*, *Symphoricarpos orbiculatus*, and *Viburnum rufidulum*. Elderberry (*Sambucus canadensis*) is remarkably absent here, and it appears uncommon to rare elsewhere in the northern Black Belt (USDA, 2010b). However, there are several frequent distinctive vines: *Ampelopsis* spp. (especially *cordata*), *Berchemia scandens*, *Campsis radicans*, *Toxidodendron radicans* var. *pubens*, *Smilax* spp. (especially *hispida*), and *Vitis* spp. (especially *cinerea* and *vulpina*). The alien privet (*Ligustrum sinense*) and Japanese honeysuckle (*Lonicera japonica*) are local problems. The low thickets and other transitions described above (types h2, h3, i2) intergrade with the more mature woods outlined here, and many of the characteristic herbs are shared. Some grasses are locally abundant, especially wild-rye (*Elymus virginicus*) and wild-oats (*Chasmanthium latifolium*). Other graminoids include *Carex* spp. (*blanda*, *cherokeensis*, *oxylepis*), *Festuca subverticillata*, *Leersia virginica*, *Muhlenbergia* spp. (*sylvatica*, cf. *frondosa*), and *Poa autumnalis*. Locally frequent herbs in deeper shade include *Cryptotaenia canadensis*, *Galium* spp. (*aparine*, *circaezans*), *Packera obovata*, *Sanicula odorata*, and *Viola* cf. *missouriensis*.

(n) Swampy woods with green ash (n1) or oaks (n2); subhydric to hydric [for n1, see species E1/E2 as well as H in C&S 2011c]. The study area does not extend into the adjacent bottomlands of Sakatonchee Creek, but it does include small patches of swampy woods, rarely more than an acre in extent, on more poorly drained bottoms along ephemeral streams. There is much intermixing with the more widespread submesic riparian woods (type m) and thickets (types h2 and h3). Most woods are young but some larger trees are 3–5 dm in diameter. The most common tree is green ash (*Fraxinus pennsylvanica*); other common trees include sugarberry (*Celtis laevigata*) and elm (*Ulmus americana*). Sweetgum (*Liquidambar styraciflua*)

is infrequent. There are also small groups of oak trees (*Quercus phellos, Q. nigra*) or pecans (*Carya illinoinensis*) associated with seasonally drier soils, and a segregate characterized by *Q. nigra* might be recognized along ephemeral streamheads (n2). Locally frequent graminoids include *Carex* spp. (*aureolensis*, cf. *normalis*, cf. *socialis*), *Cinna arundinacea*, *Elymus virginicus*, and *Glyceria striata*. Characteristic herbs include *Trepocarpus aethusae*, usually in more open thickets.

DISCUSSION

Vegetation of Pulliam Prairie: pattern, process and prospects for restoration. This initial overview has emphasized the general gradient from lowlands to uplands, which is relatively stable, and a more complex gradient from deeper shade to more open grassland (Fig. 4). The latter gradient must involve several dynamic processes and will deserve more detailed analysis. To some extent the

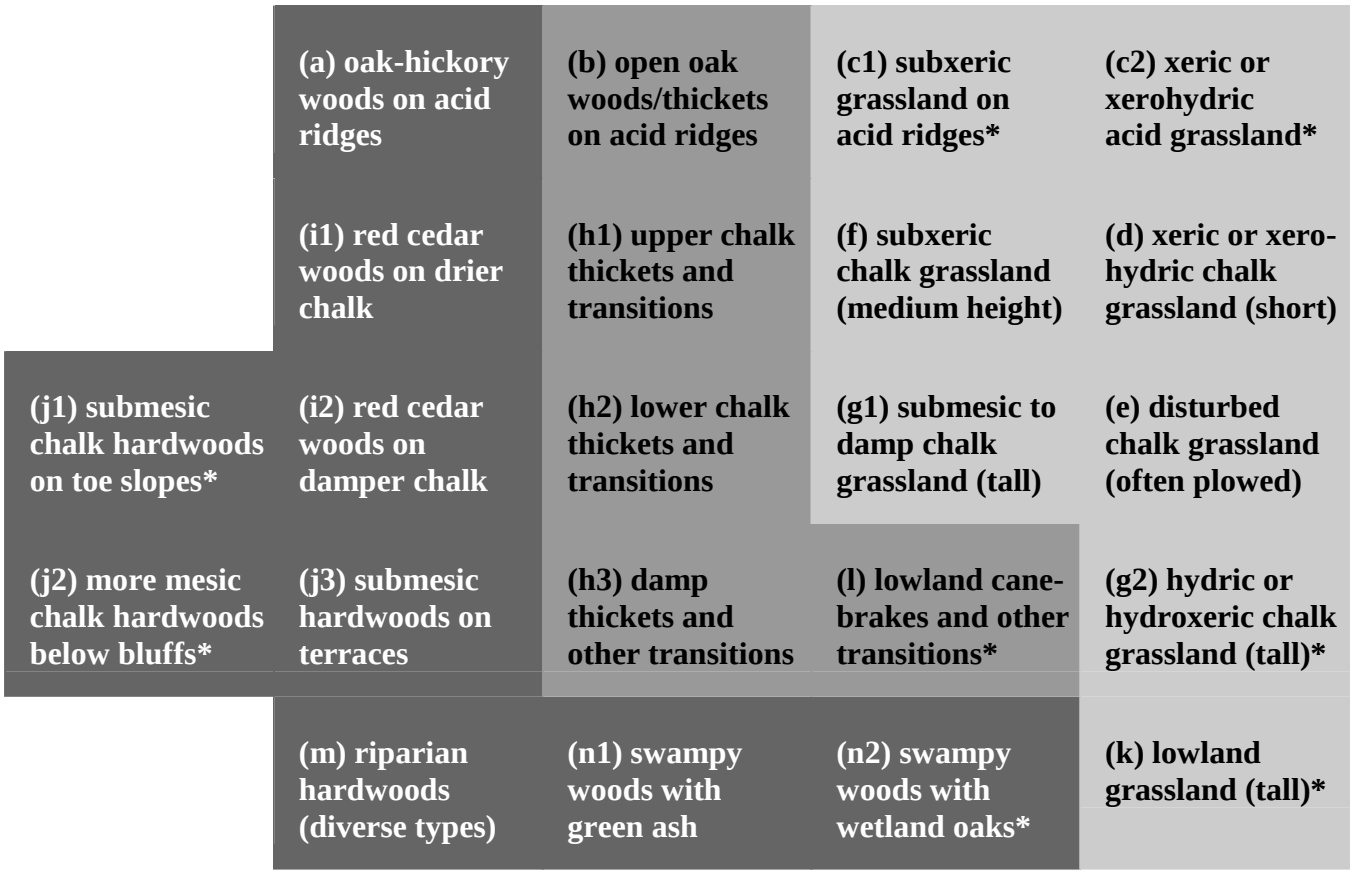

Figure 4. Diagram showing concept of major gradients among native vegetation types outlined at the Pulliam Prairie or nearby. Drier or more acid upland types are above; damper lowland types are below. More mature or mesic woodland is to left; more open, stressed or disturbed grassland is to right. Letter codes in parentheses refer to the sequence of notes on vegetation types in text. Asterisks (*) indicate absent or less well-defined types at the Pulliam Prairie, but these are documented elsewhere in the Black Belt region. Deeper wetlands are excluded.

most calcareous soils on slopes between flatter. ridges and bottomlands may be inhospitable to woody plants and favorable for grassland. In addition to the shallow rooting depth of some calcareous soils, much is classed as vertisol, characterized by seasonal swelling and shrinking along with associated extremes of wetness and dryness. Even without fires, some degree of opening may exist on chalk in this region's woodland.

Various disturbance regimes have been overlayed on the Black Belt's edaphic patterns during recent centuries and millenia, probably lacking clear, consistent correlations with soil types (Campbell and Seymour, 2011a). Before settlement, it is likely that larger herbivores congregated around streamheads, seeps and exposures of bedrock, in order to drink, lick, play and bask. Fires, due to lightning or people, may have spread out from ignitions in more flammable vegetation on the chalk, especially where dense short grass was mixed with red cedars. With increased human ignitions during the past few thousand years, it is possible that fires often spread up from the lowlands with gamagrass, cane and corn-fields. Also, there may have been regular ignitions along nearby upland trails through blackjack oak, post oak and shortleaf pine. After settlement, burning was replaced by cropping on flatter ground, especially lowlands. Livestock eventually increased on less productive soils, especially after much marginal cropped land was abandoned ca. 1930–1950.

Although we have begun to document the flora and vegetation at this site, a deeper ecological analysis should pay more attention to historical details of land uses here. We have only initial general impressions from inspecting the site and from talking to a few people familiar with the locality. Some of the flatter parts appear to have been used for row crops about 50–100 years ago. There are a few strips of slightly raised or shelved ground that suggest limited terracing for plowed plots. But cattle and hogs may have become the main focus of farming here during ca. 1930–1960. That scenario would be consistent with regional trends (Gibson, 1941).

During the past 20 years or so, the site has been used mostly for hunting, especially deer. The landowners have conducted regular burning over much of the site, often down into riparian zones. They have also plowed some plots for temporary wildlife-food crops, and rye-grass (*Lolium perenne*) has been sown in one upland field within the past few years. It is remarkable that native species often recover dominance in these plowed plots within a few years, except where there is dense sericea lespedeza (*L. cuneata*) or Johnson grass (*Sorghum hapenense*).

Those two alien plants now present serious problems. Johnson grass was widely promoted in the Black Belt for hay and forage ca. 1870–1900, when it became one of the most abundant grasses in the region (Harper, 1913). It is likely that sericea lespedeza was sown in some drier fields and eroding parts of the site when the farming was largely abandoned here after the 1960s. The Johnson grass could be effectively reduced to a much lower level in a few years, by using grass-specific herbicides from a wick-applicator, with treatments in June-July when most native grasses are still relatively short. The sericea lespedeza can be eliminated using broadleaf herbicides, but most other forbs would also be removed. Fortunately, this alien is concentrated in some relatively degraded areas that total only about 10–15 acres [4–6 ha]. After treatment, these areas could be reseeded with forb species using sources on the site.

As well as delving into local history of the land, it would be useful to develop a dynamic model of the vegetation that can be linked with experiments in restoration. Deeper study of the Pulliam Prairie, with integration of similar efforts across the region, could lead to predictive models that can guide management, especially for restoring degraded areas. About a third of the site can be considered significantly degraded, due to insufficient disturbance and resultant invasion of red cedar (especially on drier ground), green ash (on wetter ground) and other woody plants, or due to establishment of locally abundant aliens, especially sericea lespedeza and Johnson grass. Monitoring of changes at the site, with or without various management practices, will be invaluable. The Pulliam Prairie could also supply seed to initiate substantial efforts in restoration at other sites. Populations of dominant grasses and composites, in particular, could be easily harvested for seed.

Regional Significance of Pulliam Prairie. This paper and the accompanying floristic survey (Campbell and Seymour, 2011c) provide evidence that the Pulliam Prairie is among the most significant known remnants of native grassland in the Black Belt, at least within Mississippi. But a more comprehensive review of ecological data from the region would be useful for comparing sites. Such review could be developed as part of ecoregional planning that is focused on the Black Belt, or perhaps nested within a broader review of the whole Upper East Gulf Coastal Plain. In addition to incorporating historical information on orginal vegetation across the region, there should be more analysis of the potential for extending and linking sites like Pulliam Prairie with other potentially conserved areas in their neighborhoods.

Ideally, some larger conserved areas should combine lowlands, intervening slopes and upland ridges, with a wide range of geology, topography and soils. Our initial reconnaissance of the land around Pulliam Prairie indicates much potential for a broader long-term plan. Including some old pastures and hayfields with lower quality, it is likely that at least 1000 acres [400 ha] of native grassland remnants can be identified within 10–20+ square miles [25–50+ km^2] along or near the low ridge that extends north from the Pulliam Prairie. This ridge extends into the eastern edge of Tombigbee National Forest, where prescribed burning has already begun in their best remnant. Whether all these areas have sufficient quality and feasibility for restoration remains to be seen.

The comprehensive survey of prairie remnants in Alabama's Black Belt by Schotz and Barbour (2009) deserves to be extended into Mississippi. They identified 15,509 acres [6,276 ha] of prairie, mostly in the 'average subxeric type' outlined above (f). Their most extensive and significant sites—or site complexes—were as follows:

(1) Bragg-Ridgefield, with ca. 1430 acres [580 ha] clustered in ca. 32 square miles [83 km^2];

(2) Tilden-Carlowville, with 690+ acres [281 ha] in ca. 16+ square miles [40 km^2];

(3) Old Bluffport, with ca. 602 acres [244 ha] in ca. 8 square miles [20 km^2];

(4) Elm Bluff, with ca. 284 acres [115 ha] in ca. 3 square miles [8 km^2];

(5) Jones Bluff-House Bluff, with ca. 281 acres [114 ha] in ca. 3 square miles [8 km^2]; and

(6) Pleasant Ridge, with ca. 210 acres [85 ha] in ca. 10 square miles [25 km^2].

Their other identified sites in Alabama had no more than ca. 75–125 acres [30–50 ha], clustered or scattered over ca. 1–10 square miles.

The Pulliam Prairie is comparable to some of those better sites in Alabama, based on its area, ecological range, and species diversity. Moreover, within a mile or two of our site there are several peripheral or prairie-remnants that might be connected. Although degraded in some sections, the Pulliam Prairie extends onto relatively deep, damp soils with taller grassland dominated by big bluestem and associates. Schotz and Barbour (2009) noted big bluestem at only one of their sites (Pleasant Ridge), and did not list gamagrass at any site. While most of the sites in Alabama tend to be on relatively dry ridges and bluffs, remnants of native grassland within the northern arc of the Black Belt in Mississippi tend to cover more gentle topography, often grading into old pastures and cropped fields on toe-slopes and lowlands. There should be more recognition of the former extension by native grassland onto these landtypes (Campbell and Seymour, 2011a).

The USDA Farm Service Agency has in place a $300 million "Conservation Reserve Enhancement Program" to help reverse the loss of the Longleaf Pine Ecosystem, which lies mostly on sandy soils south of the Black Belt (USDA FSA, 2006). The Black Belt Ecosystem has suffered even more than the Longleaf Pine, and it has become virtually extirpated as a type of natural landscape. Yet much can be done, even in the short-term, to improve management for wildlife (such as deer and quail), enhance remnants of native vegetation, reseed native grassland, and restore riparian buffers for water-quality. The Black Belt is a vital component of natural heritage in Mississippi and Alabama, and there would be much ecological, social and historical benefit from a more concerted program to establish a network of conserved areas.

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