A COMPARISON OF NATIVE VERSUS OLD-FIELD VEGETATION IN UPLAND PINELANDS MANAGED WITH FREQUENT FIRE, SOUTH GEORGIA, USA

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ABSTRACT

Fire-maintained, herb-dominated upland pinelands of the southeastern U.S. Coastal Plain may be broadly divided into those that have arisen through secondary succession following abandonment of agriculture (old-field pinelands) and those that have never been plowed (native pinelands). The ability to distinguish these habitat types is important for setting conservation priorities by identifying natural areas for conservation and appropriate management and for assessing the ecological value and restoration potential for old-field pine forests managed with frequent fire. However, differences in species composition have rarely been quantified. The goals of this study were to characterize the species composition of native and old-field pineland ground cover, test the ability to distinguish communities of previously unknown disturbance history, and suggest indicator species for native versus old-field pinelands. Plant composition was surveyed in areas known to be native ground cover, those known to be old fields, and those with an uncertain disturbance history. Twelve permanent plots were established in each cover type and sampled in spring (April–May) and fall (October–November) in 2004 and 2005. Of the 232 species identified in the plots, 56 species were present only in native ground-cover plots, of which 17 species occurred in a sufficient number of plots to have a statistically significant binomial probability of occurring in native ground cover and might be considered indicator species. In addition, 15 species were confined to old fields, of which 5 had a statistically significant binomial probability. Additionally, plant census transects from a previous survey were comparatively analyzed, yielding a total of 432 species, of which 111 were present only in native ground-cover transects and 3 occurred in a sufficient number of transects to have statistically significant binomial association with native areas. Also, 111 species were confined to old fields but none in a sufficient number of transects for a significant association with old fields. In both the plot and transect data sets, most old-field species represented a subset of those found in native areas, suggesting differential ability of certain native species to disperse to and become established in abandoned agricultural land. These results will assist in identifying natural areas for conservation as well as assessing the ecological value and restoration potential of old-field pine forests managed with frequent fire.

keywords: indicator species, longleaf pine, native ground cover, old fields, *Pinus palustris,* prescribed fire, secondary succession, South Georgia, upland pinelands.

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INTRODUCTION

A detailed knowledge of a region's natural communities is crucial for conservation and restoration efforts as well for the management of currently protected areas. This baseline knowledge allows for a determination of the degree to which a degraded system has changed and potentially concurrent loss of biodiversity and possible changes in ecosystem processes (Noss 2000). The ability to identify undisturbed natural communities may be obfuscated by a past history of anthropogenic disturbance or alteration of natural disturbance regimes. In the southeastern U.S. Coastal Plain, intensive agriculture is chief among anthropogenic activities that have contributed to a 97% conversion of native pineland habitat (Frost 1993). Thus, conservation efforts require the means to distinguish and characterize native versus post-agricultural communities in order to set conservation priorities for acquisition and protection and to assess the ecological value and restoration potential of each.

Following the large-scale abandonment of agricultural fields on the Coastal Plain in the late 19th and early 20th centuries (Paisley 1968, Brueckheimer 1979), fallow fields that were periodically burned returned to pinelands with an herb-dominated understory (Moser et al. 2002). Thus, fire-maintained, herb-dominated upland pinelands of the southeastern U.S. Coastal Plain may be broadly divided into those that have arisen through secondary succession following abandonment of agriculture (old-field pinelands) and those that have never been plowed (native pinelands). With proactive management (i.e., prescribed burning and selective timber thinning), these old-field pinelands provide habitat to gopher tortoises (*Gopherus polyphemus*), Bachman's sparrows (*Aimophila aestivalis*), fox squirrels (*Sciurus niger*), and reintroduced red-cockaded woodpeckers (*Picoides borealis*) (Masters et al. 2003). Even so, old-field successional habitats are thought to constitute a major shift in floristic characteristics from their original composition (Means and Grow 1985, Myers 1990). In the eastern portion of the southeastern U.S. Coastal Plain, upland old-field

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pinelands once dominated by longleaf pine (*Pinus palustris*) and wiregrass (*Aristida stricta*) are now typically dominated by loblolly pine (*Pinus taeda*) and shortleaf pine (*P. echinata*) (Moser et al. 2002) and have lost wiregrass as a component of their herbaceous ground cover (Crafton and Wells 1934, McQuilken 1940, Oosting 1942, Grelen 1962, Clewell 1986, Hedman et al. 2000). It is generally observed that old-field vegetation has a smaller number of native species and that these species are relatively common (Clewell 1986, Hedman et al. 2000, Kirkman et al. 2004). This prevalence is attributed to their ability to disperse to and colonize disturbed soil (Kirkman et al. 2004). Thus, old-field pinelands may be placed at a lower priority for conservation and protection.

Although species composition of native longleaf pine habitats has often been described (e.g., Bridges and Orzell 1989, Hardin and White 1989, Drew et al. 1998, Kush and Meldahl 2000, Varner et al. 2003, Carter et al. 2004), comparatively few published studies have compared vegetation composition between old-field and relatively undisturbed upland pine habitats (Hedman et al. 2000, Kirkman et al. 2004). These studies have shown significant differences in species composition between old-field sites and ''reference sites'' representing the native community type, as well as lower species richness in old-field sites because of dispersal limitations on certain native species (Kirkman et al. 2004). Native pineland communities are also sensitive to vehicular traffic, soil compaction, and surface scarification associated with planted pine site preparation, logging, and military training (Hedman et al. 2000, Dale et al. 2002, Smith et al. 2002). However, soil disturbance associated with intensive agriculture appears to have the greatest impact on species composition in fire-maintained pinelands relative to these other disturbance types (Hedman et al. 2000).

The sensitivity of many species to anthropogenic disturbance makes them useful indicators of habitat integrity (Noss 1990, Kimberling et al. 2001, McLachlan and Bazely 2001, Moffatt and McLachlan 2004). Indicator species should be sensitive to the environmental stress of interest, and thus may indicate the biological integrity of an ecosystem (Dale and Beyeler 2001) and abundant and tractable components of the system (Welsh and Ollivier 1998). Indicator species for relatively undisturbed native pinelands maintained with frequent fire in the Coastal Plain have been proposed in other studies (Rodgers and Provencher 1999, Dale et al. 2002, Smith et al. 2002, Kirkman et al. 2004). However, additional studies are needed both to confirm the reliability of certain widely distributed species as indicators throughout the region as well as to identify local indicator species among physiographic features within the region (e.g., Dougherty Plain, Tifton Uplands).

The goals of this study were to characterize and contrast the species composition between native and old-field upland clayhill pinelands in Southwest Georgia, to test the utility of these data in interpreting the community integrity of sites with unknown disturbance history, and to identify possible indicator species that can aid in distinguishing these community types. The results should assist in identifying natural areas for conservation and appropriate management and for assessing the ecological value and restoration potential for old-field pine forests managed with frequent fire.

METHODS

Study Area

The study was conducted within the Red Hills region of southern Georgia and northern Florida on Pebble Hill Plantation (PHP) (30°35′N, 84°20′W), which covered approximately 1,222 ha in Grady and Thomas counties, Georgia. The Red Hills region was characterized by gently sloping, well-drained sandy or loamy soils underlain by clayey or sandy sub-horizons (Calhoun 1979). Plots were more or less evenly distributed among the following soil types: Bonneau loamy sand, Dothan loamy sand, Lucy loamy sand, Tifton loamy sand, Faceville sandy loam, and Nankin–Cowarts sandy loam. Mean annual temperature was 19.6°C (11°–27.4°C monthly means) and mean annual precipitation was 1,373.4 mm (Southeast Regional Climate Center 2004). The growing season for this region was from early March to November (Calhoun 1979; T.E. Ostertag and K.M. Robertson, unpublished data). PHP had been managed for northern bobwhite (*Colinus virginianus*) and timber during the past century, primarily with the use of frequent prescribed fire (1- to 2-y fire interval) and both even- and uneven-aged management systems.

The forested upland habitats at PHP were a mixture of old fields, pine plantations, and native pinelands (never plowed) (Robertson and Ostertag 2003). The native areas had a canopy dominated by longleaf pine, often mixed with shortleaf pine, and an understory supporting a high diversity of other woody plants, forbs, and grasses, especially wiregrass. The old-field pineland habitats had a canopy dominated by some mixture of shortleaf and loblolly pines and an understory of woody species typical of disturbed areas in the region, such as water oak (*Quercus nigra*) and sweetgum (*Liquidambar styraciflua*), and herbs composed of some subset of native species as well as agricultural weeds. Timber management had been similarly applied to the specifically selected native and old-field pineland sites, such that stand densities and structure were similar between the two habitat types (average of 9.6 ± 6.3 SD m^2/ha in native stands based on 54 random plots, 10.9 m^2 ± 6.3 m^2 basal area/ha in old-field stands based on 59 random plots [K.M. Robertson, unpublished data]).

Site Selection and Sampling Methods

Plant communities were compared among the following cover types: native ground cover, old fields, and areas of unknown soil disturbance history. Native ground cover was identified by the presence of wiregrass, based on the general observation that wiregrass does not readily return to extensive areas of heavily disturbed soil or prolonged fire suppression (Hebb

1957, 1971; Woods 1959; Grelen 1962; Harris et al. 1974; Schultz and Wilhite 1974; White et al. 1975; Myers 1990). Old-field sites were identified as cultivated in a 1928 (earliest known) aerial photograph. Based on the age of current pines and other historical records, we estimated these sites had been abandoned from cultivation circa 1950. Areas of unknown management history (may or may not be native ground cover) were forest at the time of the 1928 aerial photograph (current age of trees approximately 150 y old) but lacked wiregrass at the time of this study.

For each of the three cover types, 12 permanent sampling plots were established, with 3 plots in each of 4 separate burn units. Burn units ranged in area from 2.6 to 18.5 ha. Burn units and plot locations within burn units were randomly chosen using ArcView 3.2 Animal Movement extension (Environmental Systems Research Institute 1999). Potential plot locations were limited to ridge tops and the upper halves of slopes to restrict them to upland pine habitats. Each plot was 100 m^2 (10 m $\times$ 10 m), with nested subplots of 10 m^2 and 1 m^2 in one corner. Thus, the 36 total plots covered 3,600 m^2. Species were censused starting with the 1-m^2 subplot, then proceeding to the 10-m^2 and the 100-m^2 plots. Species of all herbaceous vascular plants and woody shrubs and trees $<$1 m high were censused within the plots. Percent cover within the 100-m^2 plot was estimated for each species using a modified Daubenmire cover class method (Peet et al. 1998). Maximum cover for each species was 100%, but cumulative cover for all species could exceed 100%. The plots were censused four times between fall 2003 and spring 2005 (once in each of the following: October–November 2003, October–November 2004, April–May 2004, and April–May 2005) to incorporate seasonal and annual variation in the presence and visibility of plant species. Plants were identified to species and otherwise were not included in the analysis. Unidentified plants were generally seedlings or those badly damaged by herbivory or senescence. Unidentified specimens accounted for 8% of all samples collected.

Species composition in the study plots was compared to species lists compiled between July 1995 and November 2002 from transects running throughout PHP (A. Gholson and C. Martin, PHP, unpublished data). Transects used in the analysis were limited to those entirely contained within native (n = 9) and old-field (n = 8) cover types. There were no transects contained entirely within the unknown-disturbance-history cover type. These censuses incorporated plants that could be easily observed by the surveyors to either side of each transect (total width of 4 m). Transects varied in length from 160 to 719 m due to size of the burn unit. The total area censused for all transects was approximately 22,000 m^2. Transects were not bound by topographic or hydrological constraints as were the study plots, such that lower hillslope and wetland pinelands were included. All plants, including trees and shrubs regardless of size, were recorded. Taxonomy and nomenclature for both the plot censuses and transects follows Wunderlin and Hansen (2003).

Data Analysis

A detrended canonical correspondence analysis (DCCA) in CANOCO 4.5 (ter Braak and Smilauer 2002) was used to test the null hypothesis of no predictable difference in species composition and cover among native, old-field, or unknown study plots. The median cover values for 100-m^2 plots estimated for species were used as the response variables in the analysis, and plots served as units of replication. Monte Carlo permutations (499 iterations) on the first canonical axis were used to produce an F-statistic testing for differences among sampling plots (Leps and Smilauer 2003). A detrended correspondence analysis (DCA) in CANOCO 4.5 was used to create an ordination diagram in CANODRAW 4.5 (ter Braak and Smilauer 2002) to visually assess floristic similarity among sampling plots (Leps and Smilauer 2003). Similarly, DCCA and DCA were used to test for differences in species composition between native and old-field transects based on presence–absence of species.

Binomial analyses were used to identify the most likely indicator species for native and old-field ground cover using both the plot and transect data. Plots (excluding those of unknown disturbance history) containing a given species were assigned a binomial variable based on whether they were native or old field. Binomial tables were used to determine if there was a statistically nonrandom (two-sided α = 0.05) association of a species with a particular ground-cover type (Sokal and Rohlf 1995). Each occurrence of a species in a plot or transect was considered to have a 0.5 probability of occurring in either native or old-field cover by chance; for example, occurrence of a species in 5 native plots and none in old-field plots would be assigned the probability of 0.031 (nonrandom). Indicators were defined as plants characteristic of and confined predominately to a particular habitat based on the binomial analysis. This assessment was made separately for plots and transects.

Plant species affiliated with one cover type were placed in one of three categories: 1) restricted to one cover type and in a sufficient number of plots or transects (5 or more) to have a statistically significant affinity ($P \leq 0.031$); 2) found predominately in one cover type with a statistically significant affinity; 3) found only in one cover type in 3 or 4 plots or transects (P = 0.125 or 0.063, respectively). Category 3 was designed to identify plants with a trend toward a definitive association with one ground-cover type versus the other, which might be revealed with additional sampling. Species for which plot and transect data contradicted one another were not listed as potential indicators.

RESULTS

A total of 232 plant species in 53 families were identified in the study plots, of which six were nonnative species (Appendix A). Five families, Poaceae, Fabaceae, Asteraceae, Fagaceae, and Ericaceae, encompassed 58% of the species, and 31 families were represented by a single species. The number of species

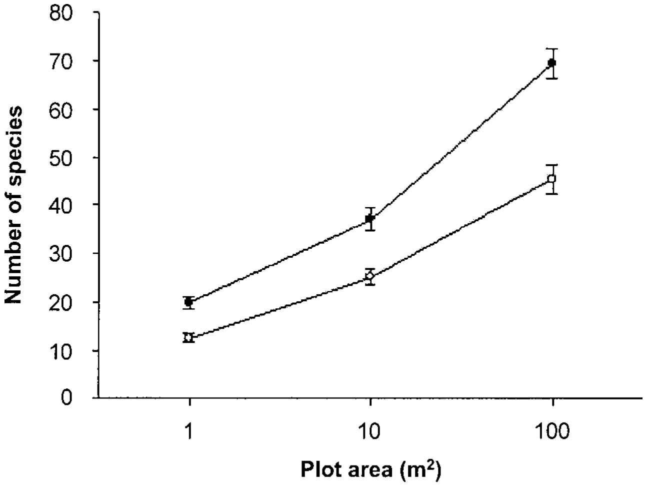

Fig. 1. Species area curve for vegetation plot data collected spring 2003–fall 2005 on Pebble Hill Plantation, Grady and Thomas counties, Georgia. Mean number of species and standard error among 12 plots are given for each scale censused within 100-m² plots. Closed circles indicate native ground cover and open circles indicate old fields.

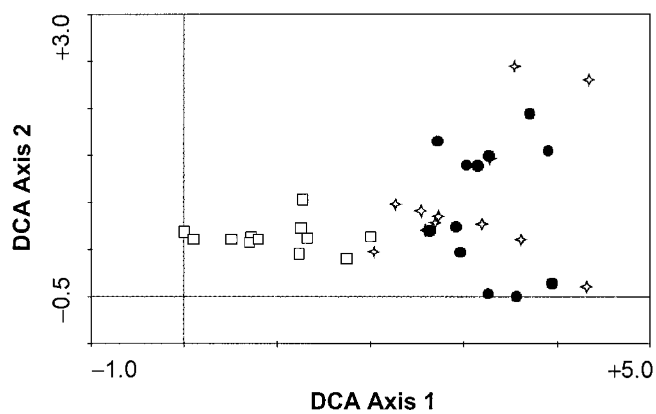

Fig. 2. Ordination diagram of vegetation plot data using detrended correspondence analysis (DCA). Data were collected between spring 2003 and fall 2005 on Pebble Hill Plantation, Grady and Thomas counties, Georgia. Squares indicate native ground-cover plots, circles indicate old-field plots, and stars indicate plots of unknown soil disturbance history. Proximity of symbols reflects their similarity in species composition and cover.

restricted to one cover type was 56 for native, 15 for old-field, and 16 for unknown-disturbance-history cover plots. Native and old-field plots shared in common 103 species (Appendix A). Average species richness among the 100-m² plots was 69.5 ± 15.9 (± SD) for native plots, 45.4 ± 10.8 in old-field plots, and 46.4 ± 10.8 in unknown-disturbance-history plots. Average species richness was approximately 50% higher in native compared to old-field cover at each of the three spatial scales surveyed (Figure 1).

The transect data yielded a total of 432 plant species in 92 families, of which 36 were nonnative species (Appendix A). Five families, Asteraceae, Fabaceae, Poaceae, Cyperaceae, and Fagaceae, contained 49% of the species, and 42 families were represented by a single species. There were 111 species confined to native ground-cover transects and 111 species confined to old-field transects, and 210 species were in both native and old-field transects. Of species confined to native transects, 69% occurred in only 1 of 9 transects, 15% occurred in 2 transects, and 16% occurred in >2. Of species confined to old fields, 66% occurred in 1 of 8 transects, 29% occurred in 2, and 5% occurred in >2.

Native and old-field plots were distinctly different in their species composition, as indicated by the Monte Carlo test (F = 3.827, P = 0.002) and DCA scatter plot (Figure 2). Unknown-disturbance-history plots were largely clustered with old-field plots, although a few appeared to be in a transition zone between old-field and native plots (Figure 2). Similarly, species composition differed significantly between native ground-cover and old-field transects (F = 1.311, P = 0.008) and appeared to be distinctly different in the scatter plot (Figure 3).

Native sites were characterized by greater dominance of grasses, especially wiregrass and slender bluestem (*Schizachyrium tenerum*), and a lower dominance of forbs and woody species compared to old-field sites (Table 1). Native plots had an average absolute cover of 29.6% grasses, 7.0% forbs, and 38.4% woody shrubs and vines. In comparison, old-field sites had an absolute cover of 0.6% grasses, 15.7% forbs, and 63.2% woody shrubs and vines (Table 1). Of the forbs in old-field plots, several species (hyssopleaf thoroughwort [*Eupatorium hyssopifolium*], dogfennel [*E. capillifolium*], lesser snakeroot [*Ageratina aromatica*], and wrinkleleaf goldenrod [*Solidago rugosa*]) are structurally similar to woody shrubs and account for approximately two-thirds of forb cover (Table 1).

Potential indicator species were identified for each cover type by using binomial analyses in both the plot and transect data (Table 2). Twelve species were restrict-

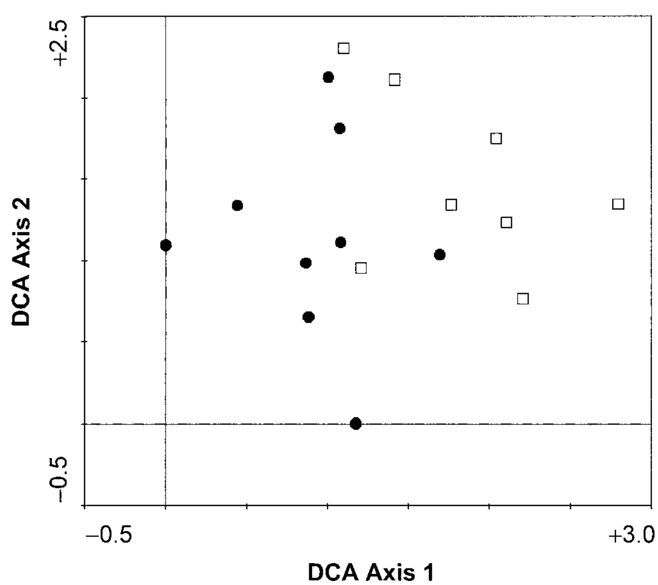

Fig. 3. Ordination diagram of vegetation transect data using detrended correspondence analysis (DCA). Data were collected between spring 2003 and fall 2005 on Pebble Hill Plantation, Grady and Thomas counties, Georgia. Squares indicate native ground-cover transects and circles indicate old-field transects. Proximity of symbols reflects their similarity based on species presence–absence.

Table 1. The 30 most dominant plant species, based on percent absolute cover, for native and old-field plots, in descending order of average cover among study plots, Pebble Hill Plantation, Grady and Thomas counties, Georgia, from spring 2003 to fall 2005.

Native ground-cover sites			Old-field sites		
Species	Growth form[a]	% cover	Species	Growth form[a]	% cover
Aristida stricta	G	24.3	*Liquidambar styraciflua*	W	14.8
Ilex glabra	W	7.3	*Callicarpa americana*	W	10.5
Pinus palustris	W	6.2	*Pinus taeda*	W	7.8
Schizachyrium tenerum	G	4.0	*Eupatorium hyssopifolium*	F	4.6
Quercus elliottii	W	3.8	*Rubus cuneifolius*	W	3.9
Quercus incana	W	3.8	*Pinus echinata*	W	3.6
Quercus laurifolia	W	2.9	*Pityopsis aspera*	F	3.5
Quercus marilandica	W	2.4	*Myrica cerifera*	W	2.8
Quercus falcata	W	2.0	*Rhus copallinum*	W	2.7
Pteridium aquilinum	F	1.9	*Quercus falcata*	W	2.6
Vaccinium corymbosum	W	1.7	*Quercus nigra*	W	2.4
Quercus stellata	W	1.2	*Prunus serotina*	W	2.1
Viola palmata	F	1.1	*Ageratina aromatica*	F	2.0
Vaccinium darrowii	W	1.0	*Eupatorium capillifolium*	F	1.8
Rhus copallinum	W	0.9	*Quercus stellata*	W	1.5
Myrica cerifera	W	0.8	*Vitis rotundifolia*	V	1.5
Pinus echinata	W	0.8	*Erythrina herbacea*	F	1.3
Pityopsis aspera	F	0.8	*Carya alba*	W	1.2
Vaccinium myrsinites	W	0.7	*Smilax glauca*	V	1.1
Mimosa quadrivalvis	F	0.7	*Quercus virginiana*	W	1.0
Rhynchosia reniformis	F	0.6	*Diospyros virginiana*	W	1.0
Sorghastrum nutans	G	0.6	*Lespedeza virginica*	F	0.9
Dyschoriste oblongifolia	F	0.6	*Quercus laurifolia*	W	0.7
Gelsemium sempervirens	V	0.6	*Rubus argutus*	W	0.6
Rubus cuneifolius	W	0.6	*Chamaecrista nictitans*	F	0.6
Seymeria pectinata	F	0.5	*Saccharum alopecuroides*	G	0.6
Symphyotrichum concolor	F	0.4	*Solidago rugosa*	F	0.5
Carya alba	W	0.4	*Hypericum hypericoides*	F	0.5
Cornus florida	W	0.4	*Ampelopsis arborea*	V	0.4
Vaccinium arboreum	W	0.4	*Parthenocissus quinquefolia*	V	0.4

[a] Growth form: F, forb; G, grass; V, woody vine; W, woody shrub or tree.

ed to native ground-cover plots with a sufficiently high frequency to be statistically associated with this cover type (category 1), 4 species were statistically associated but were not restricted to native plots (category 2), and 11 species were found only in native cover in 3 or 4 plots (category 3) (Table 2). Old fields had 3 species in category 1, 2 species in category 2, and 0 species in category 3 (Table 2). Native ground-cover transects had 5 indicator species in category 1, 0 species in category 2, and 12 species in category 3. Old-field transects had 0 species in categories 1 or 2 and 8 species in category 3 (Table 2). Considering plots and transects together, a total of 17 species were identified as having statistically significant associations with native ground cover and 5 species had significant associations with old fields (Table 2). An additional 16 species occurring only in native ground cover and 8 species occurring only in old fields had affinities to those cover types, with random probabilities of <0.125.

DISCUSSION

Results from both the study plots and transect data showed distinctive compositional differences between native and old-field sites. In the study plots, this difference was mostly attributable to the larger number of species occurring on native sites and differences in relative cover of species. Old fields were primarily composed of a subset of native species, with only a few exceptions. Additionally, nonnative species were found in greater numbers in old-field plots and transects than in native ground-cover plots and transects. These results are consistent with other studies comparing old-field and native sites (Means and Grow 1985, Myers 1990, Hedman et al. 2000, Kirkman et al. 2004). Limitations on dispersal and ability for native species to colonize disturbed sites are likely the strongest determinants of species differences between the community types (Kirkman et al. 2004). It should be noted that in our and in the previously cited studies, native pinelands were located on the same properties as the old fields studied, apparently providing a source for colonizing propagules. The proximity of native sites may be a key factor in direction of succession of abandoned old fields (Kirkman et al. 2004).

The plots of unknown soil disturbance history were generally similar to old-field plots in their species composition and dominance, with the exception of some plots that appeared to be in a transition zone between the two. The latter plots may have been subject to various degrees of disturbances other than intensive agriculture, such as those associated with logging or mechanical methods of shrub control. Given the history of selective timber management on our particular study sites, these areas may have been affected to some degree by past vehicular traffic and surface disturbance. The other plots we interpret as being old fields that were abandoned before the earliest available

Table 2. Potential indicator species of native ground cover and old fields from Pebble Hill Plantation, Grady and Thomas counties, Georgia, 2003–2005, and their identification as suggested indicator species in other studies in the southeastern U.S. Coastal Plain. Nomenclature follows Wunderlin and Hansen (2003).

Species	Category[a] Plots	Category[a] Transects	Other studies[b]
Native ground-cover indicators			
Angelica dentata	3	1	F
Aristida stricta	–[c]	1	B, D, E
Asimina angustifolia	2		
Aureolaria pedicularia	3		
Carphephorus odoratissimus	1	3	
Chrysopsis mariana		1	D, E
Dalea carnea	3		
Dyschoriste oblongifolia	1		B, E
Euphorbia curtisii		3	A
Euphorbia discoidalis	1		A
Gaylussacia dumosa	1	3	
Gaylussacia frondosa	3	1	
Gymnopogon brevifolius	3		
Helianthus angustifolius	3		
Hypericum hypericoides		3	
Ilex glabra	1		
Lobelia amoena		3	
Mimosa quadrivalvis	2		E
Monotropa uniflora	3		
Muhlenbergia capillaris	3	3	E
Panicum virgatum		3	E
Pityopsis graminifolia	1		
Pleopeltis polypodioides		3	
Pteridium aquilinum	1		B, C, E
Quercus elliottii	1		
Quercus incana	1	3	
Quercus laevis	1	3	
Sebastiania fruticosa		3	
Saccharum coarctatum	3		
Salvia azurea	1	1	
Seymeria pectinata		3	
Strophostyles umbellata	2		C, E, F
Stylisma patens	3		
Symphyotrichum adnatum	1		B, E
Symphyotrichum concolor	2		C, E
Tephrosia virginiana	3		A, B, C, E, F
Old-field indicators			
Croton glandulosus		3	
Erythrina herbacea	2		
Eupatorium capillifolium	2		
Gamochaeta pensylvanica		3	
Lespedeza procumbens		3	
Liatris tenuifolia		3	
Quercus virginiana	1		
Ruellia caroliniensis		3	A, B, D
Sebastiania fruticosa		3	
Seymeria pectinata		3	
Solidago rugosa	1		
Trichostema dichotomum	1		
Yucca filamentosa		3	

[a] Category: 1, plants restricted to one cover type with a statistical affinity; 2, plants predominately in one cover type with a statistical affinity; 3, plants restricted to one cover type without statistical affinity.

[b] Other studies: A, Rodgers and Provencher 1999; B, Hedman et al. 2000; C, Dale et al. 2002; D, Smith et al. 2002; E, Kirkman et al. 2004; F, Carter et al. 2004.

[c] *Aristida stricta* was used as an indicator of whether or not sites had been disturbed and hence was not included in the analysis.

aerial photograph, based on their close similarity in species composition and structure to confirmed old-field plots. This assessment provides an example of the way in which baseline data characterizing the composition and dominance of native and old-field sites may be used in interpreting the disturbance history of pineland ground cover through multivariate analysis.

In contrast to the study plots, transects had an equal number of species limited to either native or old-field sites. This difference is attributable to the incorporation of a much larger area and thus a greater accumulation of rare species in transects relative to the plots, reflected by the fact that the great majority of species in the transect data occurred in only one or two transects. These species may be either naturally rare species or species associated with isolated disturbances; in either case, they are likely to be missed by transects in the other cover type.

In addition to compositional differences between native and old-field sites, there were significant differences in structure and species dominance. In particular, native sites were characterized by high grass cover and relatively lower forb and woody species cover, whereas old fields had only trace cover by grass and were dominated by large-statured forbs and woody plants. Clearly the likelihood of dispersal and establishment of plants from native areas to abandoned fields is dependent, at least in part, on whether they are grass, forb, or woody species. The association of higher forb and woody species dominance with degree of soil disturbance in southern pinelands has been noted in other studies (Hedman et al. 2000, Dale et al. 2002, Smith et al. 2002). This observation has implications for the management techniques that may be required to restore certain old-field pinelands to a more natural vegetation structure, including more frequent burning (White et al. 1991, Waldrop et al. 1992, Provencher et al. 2001*c,* Glitzenstein et al. 2003) and use of selective herbicides (Brockway et al. 1998, Litt et al. 2001, Provencher et al. 2001*a,b,* Jones and Chamberlain 2004, Miller and Miller 2004).

In addition to distinguishing native versus old-field pinelands, our study reveals the potential for old-field pine forests to harbor a significant proportion of native pineland species when managed with frequent fire and selective timber thinning. Such forests are more appropriately described as partially to mostly restored native pinelands rather than purely anthropogenic habitats, as demonstrated by their potential to support a diversity of rare animal species adapted to native pinelands (Masters et al. 2003, Provencher et al. 2003). These qualities attest to the benefits of frequent fire and appropriate timber management for restoring and maintaining high-quality wildlife habitat in post-agriculture pine forests.

We propose 17 species as indicators of native ground cover lacking intensive soil disturbance, based on their statistical affinity to that cover type, and 16 species to be potential indicators based on their nearly significant associations with native sites. Of these, 14 species have been identified as indicators of native ground cover lacking an intensive soil disturbance history in Coastal Plain pinelands in other studies (Rodgers and Provencher 1999, Hedman et al. 2000, Dale et al. 2002, Smith et al. 2002, Kirkman et al. 2004; Table 2). In addition to wiregrass, used to identify native plots in this study and thus excluded from analysis, coastalplain angelica (*Angelica dentata*), Maryland goldenaster (*Chrysopsis mariana*), oblongleaf snakeherb (*Dyschoriste oblongifolia*), Curtis' spurge (*Euphorbia curtisii*), summer spurge (*Euphorbia discoidalis*), sensitive brier (*Mimosa quadrivalvis*), hairawn muhly (*Muhlenbergia capillaris*), switchgrass (*Panicum virgatum*), brackenfern (*Pteridium aquilinum*), pink fuzzybean (*Strophostyles umbellata*), eastern silver aster (*Symphyotrichum concolor*), and goat's rue (*Tephrosia virginiana*) appear to have geographically broad utility as indicators of pineland sites which have experienced minimal ground-cover disturbance. Other species, live oak (*Quercus virginiana*), Carolina wild petunia (*Ruellia caroliniensis*), wrinkleleaf goldenrod, and forked bluecurls (*Trichostema dichotomum*), appear to be reliable indicators of soil disturbance.

These studies of upland pine forests also point out the variation in floristic composition among pinelands. In individual studies, most of the species identified as potential indicators have not been found in sufficiently large numbers in other studies to merit distinction (Hedman et al. 2000, Dale et al. 2002, Smith et al. 2002, Kirkman et al. 2004). This may be related to inherent site and soil differences (i.e., sandy vs. clayey soils). However, given that it is recommended to use the full suite of plant species available in interpreting natural habitat integrity (Zonneveld 1983, Kremen 1992, Carignan and Villard 2002), all suggested species, when appearing in significant numbers, should be considered as indicative of native community presence. Such interpretations are critical and time sensitive, given the ongoing conversion of native pinelands to other land uses in the southeastern U.S. Coastal Plain.

In summary, southern pineland native ground cover contains a significant number of species that do not readily become reestablished during several years or even decades following extensive soil disturbance. The extreme sensitivity of many native species to intensive soil disturbance underscores the need to identify remaining undisturbed areas for conservation, as facilitated by the use of indicator species suggested by this and other studies. Nevertheless, our data demonstrate the potentially high species richness of native plants in old fields managed with frequent fire and selective timber management. Understanding the differences and similarities between these community types, including species composition and community structure, is important for prioritizing future conservation, restoration, and management of the species they support.

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Appendix A. Plant species list for plots and transects, with number of occurrences for three ground-cover types, Pebble Hill Plantation, Grady and Thomas counties, Georgia, 2003–2005. Nomenclature follows Wunderlin and Hansen (2003). Asterisks denote nonnative species.

		Plots[a]			Transects[a]	
Species	Family	N	O	U	N	O
Acalypha gracilens	Euphorbiaceae	3	2	0	4	5
Acer rubrum	Sapindaceae	2	1	3	3	4
Aesculus pavia	Sapindaceae	0	0	0	0	1
Agalinis divaricata	Orobanchaceae	2	0	0	0	0
Agalinis fasciculata	Orobanchaceae	0	0	0	1	1
Agalinis filifolia	Orobanchaceae	1	0	0	0	0
Agalinis tenuifolia	Orobanchaceae	0	0	0	1	0
Ageratina aromatica	Asteraceae	5	3	8	5	8
Ageratina jucunda	Asteraceae	0	0	0	1	3
Agrimonia microcarpa	Rosaceae	0	0	0	1	0
*Albizia julibrissin**	Fabaceae	0	0	0	0	1
Aletris aurea	Nartheciaceae	0	0	0	1	0
Aletris obovata	Nartheciaceae	1	0	0	0	0
Ambrosia artemisiifolia	Asteraceae	0	4	0	4	7
Ampelopsis arborea	Vitaceae	0	3	2	0	1
Amphicarpaea bracteata	Fabaceae	1	0	0	0	0
Andropogon gerardii	Poaceae	2	0	0	0	0
Andropogon gyrans	Poaceae	1	1	0	2	1
Andropogon longiberbis	Poaceae	2	0	0	0	0
Andropogon ternarius	Poaceae	3	0	1	1	1
Andropogon virginicus	Poaceae	2	4	5	2	3
Angelica dentata	Apiaceae	4	0	0	5	0
Anthaenantia villosa	Poaceae	0	0	0	1	0
Apios americana	Fabaceae	0	0	0	0	1
Apocynum cannabinum	Apocynaceae	0	0	0	0	1
Aralia spinosa	Araliaceae	0	0	0	1	3
Arisaema triphyllum	Araceae	0	0	0	0	2
Aristida purpurascens	Poaceae	3	4	2	1	0
Aristida stricta	Poaceae	12	0	3	7	3
Aristolochia serpentaria	Aristolochiaceae	2	0	0	0	0
Arundinaria gigantea	Poaceae	0	0	0	0	2
Asclepias amplexicaulis	Apocynaceae	0	0	0	0	1
Asclepias cinerea	Apocynaceae	1	0	0	0	0
Asclepias tuberosa	Apocynaceae	1	0	1	0	0
Asclepias variegata	Apocynaceae	0	0	0	0	1
Asclepias verticillata	Apocynaceae	0	0	0	2	0
Asimina angustifolia	Annonaceae	8	1	3	6	7
Asimina parviflora	Annonaceae	0	0	0	1	0
Asplenium platyneuron	Aspleniaceae	0	0	0	1	4
Athyrium filix-femina	Dryopteridaceae	0	0	0	0	2
Aureolaria flava	Orobanchaceae	0	0	0	1	2
Aureolaria pedicularia	Orobanchaceae	4	0	0	2	0
Aureolaria virginica	Orobanchaceae	0	0	0	1	0
Baccharis halimifolia	Asteraceae	0	0	0	2	1
Baptisia lecontei	Fabaceae	0	0	0	2	0
Bidens bipinnata	Asteraceae	0	0	0	0	1
Bignonia capreolata	Bignoniaceae	0	0	1	1	4
Boehmeria cylindrica	Urticaceae	0	0	0	0	1
Brickellia eupatorioides	Asteraceae	0	0	0	1	0
Buchnera americana	Orobanchaceae	0	0	0	1	1
Callicarpa americana	Lamiaceae	7	10	12	6	9
Campsis radicans	Bignoniaceae	0	0	0	2	7
Carex abscondita	Cyperaceae	0	0	0	0	1
Carex comosa	Cyperaceae	0	0	0	0	1
Carex retroflexa	Cyperaceae	0	0	0	0	1
Carex verrucosa	Cyperaceae	0	0	0	1	0
Carphephorus corymbosus	Asteraceae	0	0	0	1	0
Carphephorus odoratissimus	Asteraceae	6	0	0	4	0
Carpinus caroliniana	Betulaceae	0	0	0	0	1
Carya alba	Juglandaceae	5	5	7	8	6
Carya glabra	Juglandaceae	3	1	1	2	3
*Carya illinoinensis**	Juglandaceae	0	0	0	0	2
Castanea pumila	Fagaceae	0	0	1	0	1
Ceanothus americanus	Rhamnaceae	2	0	0	2	3

Appendix A. Continued.

		Plots[a]			Transects[a]	
Species	Family	N	O	U	N	O
Ceanothus microphyllus	Rhamnaceae	0	0	0	2	0
Centrosema virginianum	Fabaceae	4	2	1	4	3
Cercis canadensis	Fabaceae	0	0	0	0	2
Chamaecrista fasciculata	Fabaceae	0	0	0	3	3
Chamaecrista nictitans	Fabaceae	9	10	7	4	2
Chamaesyce hirta	Euphorbiaceae	0	0	0	0	1
Chasmanthium laxum	Poaceae	0	2	4	4	5
Chionanthus virginicus	Oleaceae	0	0	0	1	1
Chrysopsis mariana	Asteraceae	7	2	2	7	0
Cirsium horridulum	Asteraceae	0	0	0	1	0
Clethra alnifolia	Clethraceae	0	0	0	1	0
Clitoria mariana	Fabaceae	6	2	4	3	3
Cnidoscolus stimulosus	Euphorbiaceae	5	3	1	3	6
Commelina erecta	Commelinaceae	0	0	0	1	2
Conoclinium coelestinum	Asteraceae	3	4	0	4	4
Conyza bonariensis	Asteraceae	0	0	0	0	1
Conyza canadensis	Asteraceae	1	1	0	2	2
Cornus florida	Cornaceae	5	2	8	5	7
Crataegus flava	Rosaceae	0	0	0	2	1
Crataegus uniflora	Rosaceae	0	0	1	0	0
Croptilon divaricatum	Asteraceae	0	0	0	1	0
Crotalaria purshii	Fabaceae	0	0	0	2	1
Crotalaria rotundifolia	Fabaceae	3	2	1	2	3
*Crotalaria spectabilis**	Fabaceae	0	2	0	0	2
Croton argyranthemus	Euphorbiaceae	0	0	0	0	1
Croton glandulosus	Euphorbiaceae	0	0	0	0	4
*Cuphea carthagenensis**	Lythraceae	0	0	0	1	2
Cyclospermum leptophyllum	Apiaceae	0	0	0	0	2
*Cynodon dactylon**	Poaceae	0	0	0	1	0
Cyperus croceus	Cyperaceae	0	0	0	1	2
Cyperus filiculmis	Cyperaceae	1	0	0	0	0
Cyperus hystricinus	Cyperaceae	0	0	0	1	0
Cyperus plukenetii	Cyperaceae	1	2	0	2	1
Cyperus retrorsus	Cyperaceae	0	0	0	1	2
Cyrilla racemiflora	Cyrillaceae	0	0	0	1	1
Dalea carnea	Fabaceae	4	0	1	2	0
Dalea pinnata	Fabaceae	0	0	0	2	2
Decumaria barbara	Hydrangeaceae	0	0	0	0	1
Desmodium ciliare	Fabaceae	5	4	3	1	1
Desmodium floridanum	Fabaceae	1	0	1	1	4
Desmodium glabellum	Fabaceae	1	0	0	0	0
Desmodium laevigatum	Fabaceae	0	2	3	3	5
Desmodium lineatum	Fabaceae	1	1	1	4	1
Desmodium marilandicum	Fabaceae	1	0	0	4	3
Desmodium nudiflorum	Fabaceae	0	0	0	1	1
Desmodium obtusum	Fabaceae	0	0	0	1	0
Desmodium paniculatum	Fabaceae	0	3	1	3	5
Desmodium perplexum	Fabaceae	1	0	0	0	0
Desmodium rotundifolium	Fabaceae	0	0	0	2	0
Desmodium strictum	Fabaceae	1	0	1	1	0
Desmodium tenuifolium	Fabaceae	1	0	0	2	0
Desmodium viridiflorum	Fabaceae	1	0	1	4	4
Dichanthelium aciculare	Poaceae	4	3	1	3	1
Dichanthelium acuminatum	Poaceae	1	1	0	2	1
Dichanthelium boscii	Poaceae	0	0	0	2	5
Dichanthelium commutatum	Poaceae	2	1	6	0	2
Dichanthelium dichotomum	Poaceae	0	0	1	0	0
Dichanthelium ensifolium	Poaceae	3	2	2	1	0
Dichanthelium laxiflorum	Poaceae	0	1	0	0	2
Dichanthelium oligosanthes	Poaceae	1	2	1	0	0
Dichanthelium ovale	Poaceae	5	3	0	0	0
Dichanthelium ravenelii	Poaceae	1	1	1	0	0
Dichanthelium sphaerocarpon	Poaceae	1	4	1	0	0
Dichanthelium strigosum	Poaceae	1	1	0	0	0
Dichondra carolinensis	Convolvulaceae	0	0	0	0	2
Digitaria ciliaris	Poaceae	0	0	0	0	1
Digitaria filiformis	Poaceae	2	4	0	0	0
Diodia teres	Rubiaceae	2	2	1	4	4

Appendix A. Continued.

		Plots[a]			Transects[a]	
Species	Family	N	O	U	N	O
Diodia virginiana	Rubiaceae	0	0	0	3	1
*Dioscorea bulbifera**	Dioscoreaceae	0	0	1	0	0
Dioscorea floridana	Dioscoreaceae	0	0	0	1	0
Diospyros virginiana	Ebenaceae	8	8	8	6	9
Drosera brevifolia	Droseraceae	0	0	0	1	0
*Duchesnea indica**	Rosaceae	0	0	0	1	0
Dyschoriste oblongifolia	Acanthaceae	11	0	2	5	2
*Elaeagnus pungens**	Elaeagnaceae	0	0	0	0	1
*Elaeagnus umbellata**	Elaeagnaceae	0	0	0	0	1
Elephantopus carolinianus	Asteraceae	0	0	0	0	1
Elephantopus elatus	Asteraceae	9	5	4	6	3
Elephantopus nudatus	Asteraceae	0	0	0	1	1
Elephantopus tomentosus	Asteraceae	0	0	0	1	1
Eragrostis elliottii	Poaceae	0	1	0	0	0
Eragrostis virginica	Poaceae	0	0	0	1	0
Erechtites hieraciifolia	Asteraceae	0	0	0	2	4
Erigeron strigosus	Asteraceae	0	0	0	0	2
Eriocaulon decangulare	Eriocaulaceae	0	0	0	1	0
Eryngium yuccifolium	Apiaceae	1	0	0	4	1
Erythrina herbacea	Fabaceae	1	7	1	3	6
Eupatorium album	Asteraceae	4	0	1	5	3
Eupatorium altissimum	Asteraceae	0	0	0	0	1
Eupatorium capillifolium	Asteraceae	1	7	1	1	1
Eupatorium compostifolium	Asteraceae	2	1	2	6	8
Eupatorium hyssopifolium	Asteraceae	4	8	5	4	7
Eupatorium mohrii	Asteraceae	0	0	0	3	1
Eupatorium perfoliatum	Asteraceae	0	0	0	0	1
Eupatorium rotundifolium	Asteraceae	4	2	1	4	2
Eupatorium semiserratum	Asteraceae	0	0	0	2	0
Euphorbia curtisii	Euphorbiaceae	0	0	0	3	0
Euphorbia discoidalis	Euphorbiaceae	6	0	2	0	0
Euphorbia pubentissima	Euphorbiaceae	0	0	0	4	1
Euthamia caroliniana	Asteraceae	1	0	0	0	1
Fagus grandifolia	Fagaceae	0	0	0	0	2
Fraxinus americana	Oleaceae	0	0	1	1	3
Galactia erecta	Fabaceae	1	0	1	1	0
Galactia regularis	Fabaceae	0	0	1	1	1
Galactia volubilis	Fabaceae	3	1	2	3	6
Galium pilosum	Rubiaceae	11	7	10	8	7
Gamochaeta americana	Asteraceae	0	0	0	1	0
Gamochaeta falcata	Asteraceae	0	0	0	0	1
Gamochaeta pensylvanica	Asteraceae	0	1	0	0	3
Gaura angustifolia	Onagraceae	0	0	0	1	0
Gaura filipes	Onagraceae	2	0	0	0	1
Gaylussacia dumosa	Ericaceae	5	0	0	3	0
Gaylussacia frondosa	Ericaceae	4	0	0	4	0
Gelsemium sempervirens	Gelsemiaceae	4	5	12	8	8
Gentiana villosa	Gentianaceae	0	0	0	0	1
Geranium carolinianum	Geraniaceae	0	0	0	0	1
Gratiola pilosa	Veronicaceae	0	0	0	1	0
Gymnopogon ambiguus	Poaceae	4	5	3	4	5
Gymnopogon brevifolius	Poaceae	3	0	0	0	0
Hamamelis virginiana	Hamamelidaceae	0	0	0	1	1
Helianthemum carolinianum	Cistaceae	1	0	0	0	0
Helianthus angustifolius	Asteraceae	3	0	1	2	0
Helianthus radula	Asteraceae	0	0	0	2	0
Heteropogon melanocarpus	Poaceae	0	0	0	1	0
Hexalectris spicata	Orchidaceae	0	0	0	1	0
Hibiscus aculeatus	Malvaceae	0	0	0	3	2
Hieracium gronovii	Asteraceae	6	3	3	4	3
Houstonia procumbens	Rubiaceae	11	5	5	4	3
Hypericum crux-andreae	Clusiaceae	3	2	1	3	0
Hypericum galioides	Clusiaceae	0	0	0	1	1
Hypericum gentianoides	Clusiaceae	0	0	0	2	1
Hypericum hypericoides	Clusiaceae	2	9	6	5	8
Hypericum microsepalum	Clusiaceae	0	0	0	0	1
Hypericum mutilum	Clusiaceae	0	0	0	0	1
Hypericum setosum	Clusiaceae	0	0	0	1	0
Hypericum suffruticosum	Clusiaceae	0	0	0	1	0

Appendix A. Continued.

		Plots[a]			Transects[a]	
Species	Family	N	O	U	N	O
Hypericum tetrapetalum	Clusiaceae	0	0	0	0	1
*Hyptis mutabilis**	Lamiaceae	0	0	0	0	2
Hypoxis juncea	Hypoxidaceae	1	0	0	0	0
Ilex cassine	Aquifoliaceae	0	0	0	1	0
Ilex coriacea	Aquifoliaceae	0	0	0	2	1
Ilex glabra	Aquifoliaceae	5	0	1	5	2
Ilex opaca	Aquifoliaceae	0	0	0	1	5
Ilex vomitoria	Aquifoliaceae	0	0	0	0	2
Indigofera caroliniana	Fabaceae	0	0	0	0	1
Ipomoea pandurata	Convolvulaceae	0	0	0	0	1
Ipomoea purpurea	Convolvulaceae	0	0	0	1	0
Itea virginica	Iteaceae	0	0	0	2	1
Jacquemontia tamnifolia	Convolvulaceae	0	0	0	0	2
Juncus coriaceus	Juncaceae	0	0	0	0	2
Juncus repens	Juncaceae	0	0	0	1	0
Juniperus virginiana	Cupressaceae	0	0	0	0	1
*Kummerowia striata**	Fabaceae	0	0	0	0	2
Lactuca canadensis	Asteraceae	0	1	0	0	1
Lactuca floridana	Asteraceae	0	1	0	0	0
Lactuca graminifolia	Asteraceae	0	0	0	1	2
Lechea minor	Cistaceae	2	0	0	1	0
Lechea mucronata	Cistaceae	0	0	0	2	4
Lechea pulchella	Cistaceae	1	0	0	0	0
Leersia virginica	Poaceae	0	0	0	0	1
*Lespedeza bicolor**	Fabaceae	0	0	1	0	0
Lespedeza capitata	Fabaceae	0	0	0	1	0
*Lespedeza cuneata**	Fabaceae	0	0	0	1	0
Lespedeza hirta	Fabaceae	4	3	4	0	2
Lespedeza procumbens	Fabaceae	0	0	1	0	3
Lespedeza repens	Fabaceae	1	1	0	1	2
Lespedeza stuevei	Fabaceae	0	0	1	0	0
Lespedeza violacea	Fabaceae	1	4	1	0	0
Lespedeza virginica	Fabaceae	2	2	4	0	1
Leucothoe racemosa	Ericaceae	0	0	0	1	0
Liatris elegans	Asteraceae	2	3	0	4	0
Liatris gracilis	Asteraceae	0	0	0	3	2
Liatris graminifolia	Asteraceae	0	0	1	2	2
Liatris tenuifolia	Asteraceae	2	0	0	3	0
*Ligustrum lucidum**	Oleaceae	0	0	0	0	1
*Ligustrum sinense**	Oleaceae	0	0	0	1	1
Linum floridanum	Linaceae	0	0	0	1	0
Liquidambar styraciflua	Altingiaceae	5	11	11	8	9
Liriodendron tulipifera	Magnoliaceae	0	0	0	1	2
Lobelia amoena	Campanulaceae	0	0	0	4	0
Lobelia puberula	Campanulaceae	1	1	1	1	0
*Lonicera japonica**	Caprifoliaceae	0	0	0	1	2
Lonicera sempervirens	Caprifoliaceae	0	0	0	1	3
Ludwigia hirtella	Onagraceae	0	0	0	1	0
Ludwigia pilosa	Onagraceae	0	0	0	1	0
Ludwigia virgata	Onagraceae	0	0	0	1	0
Lycopodiella alopecuroides	Lycopodiaceae	1	0	0	0	0
*Lygodium japonicum**	Schizaeaceae	0	0	1	4	5
Lyonia lucida	Ericaceae	0	0	0	4	1
Magnolia grandiflora	Magnoliaceae	0	0	0	4	3
Magnolia virginiana	Magnoliaceae	0	0	0	2	3
Malus angustifolia	Rosaceae	0	0	0	4	2
Manfreda virginica	Agavaceae	0	0	0	2	1
Mecardonia acuminata	Veronicaceae	0	0	0	1	0
*Melia azedarach**	Meliaceae	0	0	0	0	1
Mikania scandens	Asteraceae	0	0	0	0	1
Mimosa quadrivalvis	Fabaceae	11	3	2	5	4
Mitchella repens	Rubiaceae	0	0	7	2	3
Monarda punctata	Lamiaceae	0	0	0	1	0
Monotropa uniflora	Ericaceae	3	0	0	2	0
Morus rubra	Moraceae	0	0	0	1	1
Muhlenbergia capillaries	Poaceae	4	0	1	3	0
Myrica caroliniensis	Myricaceae	0	0	0	0	1
Myrica cerifera	Myricaceae	10	8	7	5	7
Nyssa sylvatica	Cornaceae	0	0	0	5	6

Appendix A. Continued.

Species	Family	Plots[a] N	Plots[a] O	Plots[a] U	Transects[a] N	Transects[a] O
Oenothera biennis	Onagraceae	0	0	0	1	2
Oplismenus hirtellus	Poaceae	0	0	0	0	1
Osmanthus americanus	Oleaceae	0	0	0	0	2
Osmunda cinnamomea	Osmundaceae	0	0	0	1	3
Osmunda regalis	Osmundaceae	0	0	0	0	1
Ostrya virginiana	Betulaceae	0	0	0	0	1
Oxalis corniculata	Oxalidaceae	0	2	1	1	4
Oxydendrum arboretum	Ericaceae	0	0	0	2	2
Panicum anceps	Poaceae	4	1	7	2	5
Panicum tenerum	Poaceae	1	0	0	0	0
Panicum verrocosum	Poaceae	0	1	0	0	1
Panicum virgatum	Poaceae	0	0	0	4	0
Parthenocissus quinquefolia	Vitaceae	1	6	5	2	8
*Paspalum bifidum**	Poaceae	0	0	1	0	0
*Paspalum dilatatum**	Poaceae	0	0	0	1	0
Paspalum floridanum	Poaceae	0	1	0	1	1
*Paspalum notatum**	Poaceae	0	0	0	3	5
Paspalum plicatulum	Poaceae	0	0	0	0	1
Paspalum praecox	Poaceae	0	1	0	0	0
Paspalum setaceum	Poaceae	2	3	1	2	1
*Paspalum urvillei**	Poaceae	0	0	0	1	1
Passiflora incarnata	Passifloraceae	0	1	0	1	5
Passiflora lutea	Passifloraceae	0	0	0	0	1
Pediomelum canescens	Fabaceae	0	0	0	2	0
Penstemon multiflorus	Veronicaceae	0	0	0	1	0
Persea palustris	Lauraceae	0	0	0	1	1
Phanopyrum gymnocarpon	Poaceae	0	0	0	0	1
Phlox floridana	Polemoniaceae	1	0	0	0	0
Phlox pilosa	Polemoniaceae	0	0	0	1	0
Photinia pyrifolia	Rosaceae	0	1	4	1	0
*Phyllanthus tenellus**	Euphorbiaceae	0	0	0	0	2
*Phyllanthus urinaria**	Euphorbiaceae	0	0	0	1	2
Physalis arenicola	Solonaceae	1	0	0	0	0
Phytolacca americana	Phytolaccaceae	0	0	0	1	2
Pinus echinata	Pinaceae	4	7	10	7	8
Pinus elliottii	Pinaceae	0	0	0	0	2
Pinus glabra	Pinaceae	0	0	0	1	1
Pinus palustris	Pinaceae	10	0	2	8	7
Pinus taeda	Pinaceae	5	4	2	6	9
Piptochaetium avenaceum	Poaceae	0	0	0	1	0
Piriqueta cistoides	Turneraceae	0	0	0	4	6
Pityopsis aspera	Asteraceae	11	7	5	4	2
Pityopsis graminifolia	Asteraceae	5	0	0	3	5
Plantago virginica	Plantaginaceae	0	1	0	0	0
Platanthera ciliaris	Orchidaceae	0	0	0	0	1
Platanthera cristata	Orchidaceae	0	0	0	1	0
Pleopeltis polypodioides	Polypodiaceae	0	0	0	3	0
Pluchea foetida	Asteraceae	0	0	0	1	0
Polygala grandiflora	Polygalaceae	3	0	0	1	4
Polygala incarnata	Polygalaceae	0	0	1	6	6
Polygala nana	Polygalaceae	2	0	3	3	2
Polygala polygama	Polygalaceae	4	2	0	0	2
Polypremum procumbens	Tetrachondraceae	1	4	1	3	4
Polystichum acrostichoides	Dryopteridaceae	0	0	0	0	2
Prenanthes serpentaria	Asteraceae	0	0	0	0	1
Prunus angustifolia	Rosaceae	0	0	0	0	1
Prunus caroliniana	Rosaceae	0	0	0	0	1
Prunus serotina	Rosaceae	8	11	11	8	9
Prunus umbellata	Rosaceae	0	1	0	2	2
Pseudognaphalium obtusifolium	Asteraceae	0	0	0	0	1
Pteridium aquilinum	Dennstaedtiaceae	10	0	4	7	3
Pycnanthemum flexuosum	Lamiaceae	0	0	0	0	1
Pycnanthemum floridanum	Lamiaceae	0	0	0	1	0
Pyrrhopappus carolinianus	Asteraceae	0	0	0	0	1
Quercus alba	Fagaceae	0	2	4	4	3
Quercus elliottii	Fagaceae	5	0	1	3	1
Quercus falcata	Fagaceae	8	7	7	5	6

Appendix A. Continued.

Species	Family	Plots[a] N	Plots[a] O	Plots[a] U	Transects[a] N	Transects[a] O
Quercus incana	Fagaceae	10	1	2	4	0
Quercus laevis	Fagaceae	5	0	0	4	0
Quercus laurifolia	Fagaceae	4	3	8	4	5
Quercus margaretta	Fagaceae	4	3	1	2	1
Quercus marilandica	Fagaceae	1	0	0	0	0
Quercus michauxii	Fagaceae	0	0	0	0	1
Quercus nigra	Fagaceae	3	7	4	4	9
Quercus stellata	Fagaceae	11	7	8	5	3
Quercus velutina	Fagaceae	0	0	0	1	1
Quercus virginiana	Fagaceae	0	6	5	4	6
Rhapidophyllum hystrix	Arecaceae	0	0	0	0	1
Rhexia virginica	Melastomataceae	0	0	0	1	0
Rhododendron canescens	Ericaceae	0	0	0	1	0
Rhus copallinum	Anacardiaceae	12	11	12	7	7
Rhus glabra	Anacardiaceae	0	0	0	1	1
Rhynchosia difformis	Fabaceae	1	0	0	2	1
Rhynchosia reniformis	Fabaceae	11	1	2	4	4
Rhynchosia tomentosa	Fabaceae	1	0	0	3	3
Rhynchospora chalarocephala	Cyperaceae	0	0	0	1	0
Rhynchospora grayi	Cyperaceae	2	0	0	0	1
Rhynchospora harveyi	Cyperaceae	0	0	0	1	0
Rhynchospora intermedia	Cyperaceae	1	0	0	0	0
Rhynchospora miliacea	Cyperaceae	0	0	0	0	2
Rhynchospora plumosa	Cyperaceae	1	0	0	0	0
*Richardia scabra**	Rubiaceae	0	0	0	1	1
Rubus argutus	Rosaceae	7	8	9	1	3
Rubus cuneifolius	Rosaceae	8	11	11	8	9
Rubus flagellaris	Rosaceae	0	0	0	4	4
Rubus trivialis	Rosaceae	1	0	0	1	5
Rudbeckia hirta	Asteraceae	1	0	0	4	1
Ruellia caroliniensis	Acanthaceae	1	0	0	0	3
Ruellia ciliosa	Acanthaceae	1	0	0	0	0
Rumex hastatulus	Polygonaceae	0	0	0	0	1
Sabal minor	Arecaceae	0	0	0	1	2
Sabatia angularis	Gentianaceae	0	0	0	0	2
Sabatia calycina	Gentianaceae	0	0	0	0	1
Saccharum alopecuroides	Poaceae	3	10	4	3	5
Saccharum brevibarbe	Poaceae	0	0	0	1	0
Saccharum coarctatum	Poaceae	3	0	0	0	0
Salix humilis	Salicaceae	0	0	0	2	1
Salvia azurea	Lamiaceae	6	0	1	6	0
Salvia lyrata	Lamiaceae	0	0	0	0	2
Sambucus nigra	Adoxaceae	0	0	0	0	2
Sanicula canadensis	Apiaceae	0	0	0	1	2
Sanicula smallii	Apiaceae	0	0	0	0	1
Sassafras albidum	Lauraceae	4	5	1	6	7
Schizachyrium sanguineum	Poaceae	0	0	0	1	0
Schizachyrium scoparium	Poaceae	9	5	3	0	0
Schizachyrium tenerum	Poaceae	2	0	1	1	0
Scirpus cyperinus	Cyperaceae	0	0	0	1	0
Scleria ciliata	Cyperaceae	4	4	0	0	0
Scleria oligantha	Cyperaceae	0	2	0	0	0
Scleria reticularis	Cyperaceae	0	0	0	1	0
Scleria triglomerata	Cyperaceae	0	0	0	1	3
Scutellaria integrifolia	Lamiaceae	0	0	0	2	3
Scutellaria multiglandulosa	Lamiaceae	0	0	0	1	0
Sebastiania fruticosa	Euphorbiaceae	0	0	0	3	0
*Senna obtusifolia**	Fabaceae	0	0	0	1	2
*Senna occidentalis**	Fabaceae	0	1	0	0	0
Serenoa repens	Arecaceae	0	0	0	1	0
Sericocarpus tortifolius	Asteraceae	10	0	7	7	5
Setaria parviflora	Poaceae	1	0	0	0	0
*Setaria pumila**	Poaceae	0	0	0	0	2
Seymeria cassioides	Orobanchaceae	0	0	0	1	0
Seymeria pectinata	Orobanchaceae	2	0	0	3	0
Sideroxylon lanuginosum	Sapotaceae	0	0	1	0	1
Silphium asteriscus	Asteraceae	0	0	0	4	1
Smilax auriculata	Smilacaceae	3	1	3	7	5
Smilax bona-nox	Smilacaceae	8	5	4	7	5

Appendix A. Continued.

Species	Family	Plots[a] N	Plots[a] O	Plots[a] U	Transects[a] N	Transects[a] O
Smilax glauca	Smilacaceae	4	8	8	8	8
Smilax laurifolia	Smilacaceae	0	2	0	2	0
Smilax pumila	Smilacaceae	0	1	1	3	3
Smilax rotundifolia	Smilacaceae	0	0	0	3	1
Smilax smallii	Smilacaceae	2	5	3	5	7
Smilax tamnoides	Smilacaceae	5	4	7	3	4
Smilax walteri	Smilacaceae	0	0	0	1	0
Solanum carolinense	Solanaceae	0	0	0	1	3
Solidago arguta	Asteraceae	0	0	0	3	3
Solidago auriculata	Asteraceae	0	0	0	0	1
Solidago canadensis	Asteraceae	2	4	3	1	7
Solidago odora	Asteraceae	8	7	7	7	8
Solidago rugosa	Asteraceae	0	5	3	1	4
Solidago stricta	Asteraceae	1	1	1	1	0
Solidago tortifolia	Asteraceae	1	0	0	0	1
Sonchus oleraceus	Asteraceae	0	0	0	0	1
Sorghastrum elliottii	Poaceae	0	0	0	2	1
Sorghastrum nutans	Poaceae	2	1	7	0	0
Sorghastrum secundum	Poaceae	2	7	7	0	0
*Sorghum halepense**	Poaceae	0	0	0	1	1
Spiranthes tuberosa	Orchidaceae	0	0	0	0	2
Sporobolus floridanus	Poaceae	0	0	0	1	0
*Sporobolus indicus**	Poaceae	0	0	0	1	0
Sporobolus junceus	Poaceae	1	0	0	1	0
Stillingia sylvatica	Euphorbiaceae	2	0	0	4	1
Strophostyles umbellata	Fabaceae	9	4	2	1	0
Stylisma humistrata	Convolvulaceae	0	0	0	1	0
Stylisma patens	Convolvulaceae	3	0	0	1	0
Stylosanthes biflora	Fabaceae	7	1	6	5	4
Symphyotrichum adnatum	Asteraceae	9	0	0	4	2
Symphyotrichum concolor	Asteraceae	11	1	3	5	2
Symphyotrichum dumosum	Asteraceae	5	4	8	5	1
Symphyotrichum patens	Asteraceae	0	0	0	1	1
Symphyotrichum sagittifolium	Asteraceae	0	0	0	4	3
Symphyotrichum undulatum	Asteraceae	0	0	0	1	0
Symplocos tinctoria	Symplocaceae	1	1	3	2	2
Taxodium ascendens	Cupressaceae	0	0	0	1	0
Tephrosia hispidula	Fabaceae	1	0	0	0	2
Tephrosia spicata	Fabaceae	2	1	0	2	2
Tephrosia virginiana	Fabaceae	4	0	0	5	2
Tetragonotheca helianthoides	Asteraceae	0	0	0	0	1
Teucrium canadense	Lamiaceae	1	0	0	0	0
Thelypteris kunthii	Thelypteridaceae	0	0	0	0	1
Tillandsia usneoides	Bromeliaceae	0	0	0	5	3
Toxicodendron pubescens	Anacardiaceae	0	0	0	2	1
Toxicodendron radicans	Anacardiaceae	9	6	8	2	5
Toxicodendron vernix	Anacardiaceae	0	0	0	0	1
Tragia smallii	Euphorbiaceae	0	0	0	0	1
Tragia urens	Euphorbiaceae	4	2	1	2	0
Tragia urticifolia	Euphorbiaceae	0	0	0	0	2
Trichostema dichotomum	Lamiaceae	0	6	1	3	3
Trichostema setaceum	Lamiaceae	2	0	0	0	0
Tridens carolinianus	Poaceae	1	0	0	0	0
Tridens flavus	Poaceae	3	7	6	4	2
Utricularia purpurea	Lentibulariaceae	0	0	0	1	0
Vaccinium arboreum	Ericaceae	5	1	6	8	6
Vaccinium corymbosum	Ericaceae	3	0	0	2	1
Vaccinium darrowii	Ericaceae	5	0	4	2	1
Vaccinium myrsinites	Ericaceae	5	1	0	6	2
Vaccinium stamineum	Ericaceae	0	2	6	6	8
Verbesina aristata	Asteraceae	4	0	1	4	4
Verbesina virginica	Asteraceae	0	0	0	1	2
Vernonia angustifolia	Asteraceae	4	1	2	6	6
Viburnum dentatum	Adoxaceae	0	0	0	0	1
Viburnum nudum	Adoxaceae	0	0	0	0	1
Viburnum rufidulum	Adoxaceae	0	0	0	2	3
Viola palmata	Violaceae	1	0	1	2	0
Viola primulifolia	Violaceae	0	0	0	0	2
Viola sororia	Violaceae	0	0	0	0	1

Appendix A. Continued.

Species	Family	Plots[a] N	Plots[a] O	Plots[a] U	Transects[a] N	Transects[a] O
Viola villosa	Violaceae	0	0	0	2	1
Vitis aestivalis	Vitaceae	0	3	1	1	3
Vitis cinerea	Vitaceae	0	0	0	0	1
Vitis rotundifolia	Vitaceae	2	5	9	7	10
Wahlenbergia marginata	Campanulaceae	0	0	0	1	3
Woodwardia areolata	Blechnaceae	0	0	0	0	1
Woodwardia virginica	Blechnaceae	0	0	0	1	1
Xyris caroliniana	Xyridaceae	0	0	0	1	0
Yucca filamentosa	Agavaceae	0	0	0	0	3

[a] Abbreviations: N, native ground cover; O, old-field ground cover; U, unknown soil disturbance history.