Ant (Hymenoptera: Formicidae) Communities of the Southern Cumberland Plateau

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ABSTRACT The Cumberland Plateau supports diverse plant communities that vary greatly across cove and plateau habitats. Unfortunately, little is known about how terrestrial invertebrate communities vary across cove and plateau habitats and how disturbance affects these communities. To address this deficiency, we used the Ant Leaf Litter protocol to survey ant diversity on the southern Cumberland Plateau in Tennessee. We surveyed forested habitats on top of the plateau surface and on the cove slopes, as well as sites that were logged within the past 6 yr. After surveying 14 sites we found 1) 10,130 ants representing 55 species from 21 genera and six subfamilies, including five new records for Tennessee; 2) significant differences in ant communities by habitat type; 3) that south-facing cove slope ant communities more closely resembled the ant community of plateau surface native forest sites than the ant community of north-facing cove slopes; 4) that recently logged sites hosted a distinct ant community (including hybrid imported fire ants) not found in undisturbed habitats; and 5) by resampling three sites surveyed 5 yr earlier, that the ant leaf litter protocol can be used to track ant community change over time. Ants thus proved to be an excellent system for examining invertebrate diversity across habitats on the Cumberland Plateau.

KEY WORDS ants, Ant Leaf Litter protocol, Tennessee, Cumberland Plateau, forest conversion

The Cumberland Plateau covers 55,000 square kilometers, extending from eastern Kentucky through Tennessee and into northeastern Alabama (McGrath et al. 2004). It supports one of the most diverse woody plant communities in the eastern United States (Ricketts et al. 1999) and is composed primarily of two adjacent but distinct habitats: the plateau surface and its steep-sided slopes. These habitats differ greatly in soil composition and tree community composition. In southern Tennessee, the plateau surface ranges in elevation from 600 to 550 m above sea level. The sandstone-derived soils of the plateau surface host forests composed primarily of mixed oak (*Quercus prinus* L., *Q. coccinea* Münchhausen, *Q. alba* L., *Q. velutina* Lamarck) and hickory [*Carya glabra* (Miller), *C. alba* (L.)] species, with smaller numbers of red maple (*Acer rubrum* L.) and sourwood [*Oxydendrum arboreum* (L.)]. The slopes leading down from the edges of the plateau are referred to as coves, with elevations from 550 to 300 m above sea level. Cove soils are a clay mixture derived from shale and limestone substrates, with forests composed of a mixture of black walnut (*Juglans nigra* L.), shagbark hickory [*Carya ovata* (Miller)], basswood (*Tilia americana* L.), black gum (*Nyssa sylvatica* Marshall), yellow buckeye (*Aeschylus flava* Solander), sycamore (*Platanus occidentalis* L.), tulip poplar (*Liriodendron tulipifera* L.), and sugar maple (*Acer saccharum* Marshall) (Ramseur and Kelly 1981, Hinkle et al. 1993, Reid et al. 2008).

Forest communities on the Cumberland Plateau also vary in their composition and diversity as a function of disturbance. Disturbance may be natural (tornado, fire, landslide), or anthropogenic (road or housing development, logging). During recent decades the southern Cumberland Plateau has been affected by logging and forest conversion. Between 1981 and 2000 across a seven-county area of the southern Cumberland Plateau in Tennessee, 14% of native forest cover was lost, 74% of which resulted from conversion of native hardwood forests to pine plantations (McGrath et al. 2004). Although native forest conversion on the southern Cumberland Plateau has been shown to affect stream macroinvertebrates and breeding bird populations (McGrath et al. 2004, Haskell et al. 2006), little is known about the variance of terrestrial invertebrate communities across cove and plateau habitats and how disturbance affects these communities.

Ant communities are diverse, abundant, and ecologically important components of terrestrial ecosystems around the world, performing a variety of important ecological functions such as soil aeration, seed distribution, and carbon cycling. They are also central to many terrestrial food webs as both predators and prey (Hölldobler and Wilson 1990). Many ant species use resources within a predictable area, and occupy permanent nesting sites with restricted foraging ranges, making them useful tools for assessing habitat

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Table 1. Sampling site transect numbers, elevation, location, and description

Transect	Elevation	Location	Description
1	579 m	35° 13′16″ N, 85° 58′42″ W	Recently logged plateau, logged in 2001
2	581 m	35° 12′49″ N, 85° 57′52″ W	Plateau native forest, mixed hardwood and pine stand
3	561 m	35° 12′26″ N, 85° 57′23″ W	Plateau native forest, oak and hickory stand
4	475 m	35° 12′6″ N, 85° 57′20″ W	South facing cove slope, mixed hardwood stand
5	500 m	35° 12′12″ N, 85° 56′25″ W	South facing cove slope, mixed hardwood stand
6	412 m	35° 12′48″ N, 85° 54′24″ W	North facing cove slope, mixed hardwood stand, beside stream
7	580 m	35° 13′10″ N, 85° 54′0.5″ W	Plateau native forest, hardwood and pine stand, sandstone outcrop
8	573 m	35° 12′47″ N, 85° 57′14″ W	Plateau native forest, oak and hickory stand
9	400 m	35° 13′14″ N, 85° 57′34″ W	North facing cove slope, mixed hardwood stand
10	559 m	35° 12′40″ N, 85° 55′55″ W	Plateau native forest, oak and hickory stand, beside stream
11	581 m	35° 12′56″ N, 85° 56″9″ W	White Pine plantation on plateau, 'P1' in Martelli et al. (2004)
12	588 m	35° 13′11″ N, 85 55″53″ W	Plateau native forest, oak and hickory stand, 'H1' in Martelli et al. (2004)
13	564 m	35° 10′15″ N, 85° 55′48″ W	Recently logged plateau, logged in 2002, 'P2' in Martelli et al. (2004)
14	564 m	35° 10′23″ N, 85° 55′46″ W	Recently logged plateau, logged in 2004

level biodiversity (Alonso and Agosti 2000). The introduction of invasive species, resource-extractive land use, and commercial or residential development can have dramatic effects on the diversity of ant populations, which can be sampled to determine the degree of habitat disturbance (Kaspari and Majer 2000). Inventorying the ant fauna of an area can identify rare or endangered species, species with important ecological roles, and invasive species only found in certain habitats (Alonso and Agosti 2000), providing a biodiversity benchmark against which to track habitat change or evaluate the success of conservation efforts in the future (Kaspari and Majer 2000).

Dennis (1938) surveyed ants across the state of Tennessee, and identified 58 currently recognized species. Cole (1940) conducted the largest survey of ants in Tennessee, studying the ant communities of the Great Smoky Mountains National Park. Across diverse habitats spanning nearly 1,500 m of elevation, Cole identified 71 currently recognized species. Recent ant surveys in Tennessee have emphasized the influence of elevation on ant diversity (Lessard et al. 2007), of forest cover type and disturbance on ant communities (Gibbs et al. 2003), and compared methodologies for sampling ants (Martelli et al. 2004). Currently, 127 ant species are known from Tennessee (MacGown 2011).

Although the ant fauna of the region is fairly well known, we have little idea about how these species are spread across the diverse habitats of the Cumberland Plateau. Studying ant communities has promise for revealing how invertebrate communities differ between habitats and how these communities change in response to disturbance. In this study, we used the Ant Leaf Litter (ALL) protocol (Agosti et al. 2000) to survey ant communities on the southern Cumberland Plateau, sampling native plateau surface and cove forests, a mature pine plantation, and three recently logged sites. Included in our study were three sites studied 5 yr earlier by a different group of researchers (Martelli et al. 2004). Two of those sites remained largely the same as 5 yr previously, with one site logged in the interim. Consequently, this allowed an examination of ant community change over time and in response to disturbance. Our goal was to determine whether distinct ant communities could be identified in various habitats, as well as to determine the effect of disturbance (specifically, logging) on native ant communities. Understanding how ant communities, as a representative group of terrestrial invertebrates, vary across the diverse habitats of the Cumberland Plateau contributes to our ecological understanding of this biodiverse region.

Methods

Site Selection. The University of the South in Sewanee, TN is one of the largest landholders on the southern Cumberland Plateau, with a campus of around 13,000 acres. Fourteen sites on the campus were chosen using GIS data compiled by the Landscape Analysis Laboratory at the University of the South. Site selection criteria took into account differences in woody plant diversity, mean woody plant basal area, aspect and orientation of slope, relative moisture concentration, elevation, soil composition, and dominant canopy tree species. Mixed oak/hickory forests, pine plantations, sandstone outcropping with mixed native pines, postlogging tracts, and hardwood cove forests were selected to cover the range of habitats found on the southern Cumberland Plateau (Table 1).

On the plateau surface we sampled six native forest stands (transects 2, 3, 7, 8, 10, and 12), one mature white pine (*Pinus strobus* L.) plantation (transect 11), and three recently logged sites (transects 1, 13, and 14). On the cove slopes we sampled four forested sites, two of which were north facing (transects 6 and 9), and two of which were south facing (transects 4 and 5) (Table 1). Three of the sites were previously sampled in 2002 by Martelli et al. (2004). Two of those sites (transects 11 and 12) remained largely the same, but one site (transect 13), formerly a mixed loblolly pine (*Pinus taeda* L.) and shortleaf pine (*Pinus echinata* Mill.) planting, was logged in the interim.

All sites were sampled between 15 May and 18 August 2007. The year 2007 had a notably dry summer. Total precipitation for May–August was the lowest in the past 60 yr, and was slightly more than half of the 60-yr average for those months (based on data for

Monteagle, TN from the Southeastern Regional Climate Center, http://www.sercc.com/).

Sampling Methodology. Ant specimens were collected using the ALL protocol as described by Agosti et al. (2000). At each site, a linear 200-m transect was traced on the landscape using predefined vectors linked to GPS coordinates. Pitfall traps, constructed of plastic cups with a mouth diameter of 5 cm, were buried level with the surface of the forest floor at 10-m intervals along the 200-m transect, for 20 traps in total per transect. These then were filled 3/4 of the way with 95% ethanol and 2–3 ml of glycerol. After 48 h, the contents of these traps were retrieved, processed and preserved in 95% ethanol. At the same time, a 4-ft-square area of the forest floor leaf litter was collected down to the mineral soil every 10 m along the transect and sifted for 1.5 min per sample. The siftate from each sample was processed in the lab by using mini-Winkler sacks (Bestelmeyer et al. 2000), which were suspended for 48 h. The ants extracted from these leaf litter samples also were stored in 95% ethanol. At the three sites previously sampled by Martelli et al. (2004), we replicated their methodology and used three parallel 50-m transects spaced 25 m apart for 18 pitfall traps and 18 leaf litter samples per site, in total.

Ant Identification. Specimens were identified to species using standard ant taxonomic resources (Creighton 1950, Fisher and Cover 2007 and references therein, LaPolla et al. 2010, MacGown 2011). Umphrey (1996) provided a systematic methodology for differentiating species in the *Aphaenogaster fulva* Roger-*rudis-texana* group; however, because of numerous individuals collected both on the plateau and in the cove with indeterminate morphological characteristics, *A. rudis* and *A. carolinensis* Wheeler (formerly a subspecies of *texana*) were grouped for purposes of analysis as *Aphaenogaster carolinensis.* All voucher specimen identifications were confirmed by James C. Trager (Shaw Nature Reserve, Gray Summit, MO).

Ant Community Comparisons

Comparison Between Habitats and to Previous Studies. We compared our species list to those from other recent ant surveys done in the region. Some taxa reported in other studies were identified only to the genus level; these unidentified species were not included in these comparisons.

Detrended Correspondence Analysis. To compare ant communities between sites, we used the Multivariate Statistical Package (MVSP; version 3.1, Kovach 2007) to generate detrended correspondence analysis (DCA) scatterplots where each transect was represented by a single point, and then looked for groupings of points as an indication of similar ant communities. Ann Fraser (Kalamazoo College, Kalamazoo, MI) provided us with the data from the Martelli et al. (2004) study. We constructed DCA scatterplots incorporating their data from 2002 as well as our data from a resampling of their sites in 2007 to examine changes in ant community composition over time.

Species Richness and Species Evenness. After combining transects that had similar ant communities we generated rarefaction curves of species richness as a function of sampling effort and ant density in EcoSim (version 7.72, Gotelli and Entsminger 2009). Average species richness and 95% confidence intervals for each ant community were calculated over one thousand iterations. We compared species evenness between ant communities using the probability of interspecific encounter (PIE) index (Hurlbert 1971). The PIE value is the probability that any two individuals from a sample represent different species; higher PIE values indicate greater species evenness. PIE values were computed over 1,000 iterations for each ant community.

Results

Collective Results. In total, 10,130 ant specimens were collected from 544 leaf litter samples and pitfall traps with 1,494 individuals recovered from pitfall traps and 8,636 individuals recovered from leaf litter samples. The average species richness was 16.2 species per transect. In all, 55 species were identified from 21 genera and six subfamilies (Table 2). Five species, *Crematogaster vermiculata* Emery, *Crematogaster pinicola* Deyrup and Cover, *Formica pergandei* Buren, *Hypoponera inexorata* (Wheeler), and *Ponera exotica* Smith appear to be new records for the state of Tennessee (MacGown 2011).

Comparison to Regional Fauna. The ant fauna observed by Martelli et al. (2004) in Sewanee was the most similar to that found in this study. Of the 23 species they identified, only two, *Trachymyrmex septentrionalis* and *Formica integra,* were not found in this study. These species were found in small numbers by Martelli et al. (2004)—three *T. septentrionalis* individuals and one *F. integra* individual. Our survey found 86.5% (32 of 37 species) of the species found in a recent survey in the Great Smoky Mountains National Park (Lessard et al. 2007). We found 65.4% (34 of 52 species) of the species identified on a recent collecting trip that sampled diverse habitats across three counties in southern Tennessee (MacGown 2010). Our species list shared 61.9% (13 of 21 species) of the species found in a study done to the east of the Cumberland Plateau in northern Tennessee (Gibbs et al. 2003). We found 42.9% (21 of 49 species) of the species identified by a survey conducted a dozen miles to the northwest, but off the Cumberland Plateau, at the Arnold Air Force Base near Manchester, TN (Lambdin and Grant 1999).

Habitat Groupings. DCA scatterplots of the sites sampled in this study indicated the presence of three distinct ant communities that were correlated with particular habitats (Fig. 1). Transects in north-facing coves grouped together ("north-facing cove"), as did transects in recently logged locations on the plateau surface ("recently logged") (Fig. 1). Transects on the surface of the plateau in native forests grouped with transects located in south-facing coves. This grouping was designated "plateau native forest + south-facing

Table 2. Ant subfamilies and species and the number collected in various habitats

Subfamily and species	Abundance	Plateau habitats										Cove habitats			
		Native forest						Logged			Pine	South		North	
		2	3	7	8	10	12	1	13	14	11	4	5	6	9
Amblyoponinae															
Amblyopone pallipes (Haldeman)	13		7		2		1				2	1			
Dolichoderinae															
T. sessile	1,961	2						534	1,344	81					
Formicinae															
Brachymyrmex depilis Emery	247		5				4		2				2	2	232
Camponotus americanus Mayr	18	6	1		3		5		1	1			1		
Camponotus castaneus (Latreille)	4		1		1		1								1
C. chromaiodes	101	20	1	2	9		16	2	31	5	1	4	5		5
Camponotus nearcticus Emery	2	1			1										
Camponotus pennsylvanicus (DeGeer)	5	2			1	1				1					
Camponotus subbarbatus Emery	3		1				1								1
Formica dolosa Buren	2	1								1					
Formica neogagates Emery	6	4					2								
Formica pallidefulva Latreille	40	16	4	4	2		7			5			2		
F. pergandei	100	100													
Formica rubicunda Emery	5						4				1				
Formica subsericea Say	33	13	2	1			12						3		2
Lasius alienus (Foerster)	223				1						23			6	193
N. faisonensis	2,487	2	119		282	131	99	812	186	45	19	497	73	49	173
Prenolepis imparis (Say)	82	12	4	1		1						48	2	2	12
Myrmicinae															
Aphaenogaster carolinensis	1,642	52	172	35	116	415	77	27	28	58	92	167	128	130	145
Aphaenogaster fulva Roger	40			1	6	17	4	1	8					2	1
Aphaenogaster picea (Wheeler)	450											5		181	264
Aphaenogaster tennesseensis (Mayr)	5						5								
Crematogaster cerasi (Fitch)	296	1	30	80	3		105	22	1	49			5		
Crematogaster lineolata (Say)	4						4								
C. pilosa	26								26						
C. pinicola	3												3		
C. vermiculata	7	1	1				5								
M. minimum	135							46	34	55					
M. americana	345		16	3	7	9	12	13	1	6	147	34	23		74
Myrmica latifrons Starcke	15			4			11								
Myrmica pinetorum Wheeler	6						6								
Myrmica punctiventris Roger	30		1	3	12	2						1	8		3
Myrmica spatulata Smith	6			1			5								
Pheidole bicarinata Mayr	4							4							
P. tysoni	16							15		1					
Pyramica clypeata (Roger)	3		3												
Pyramica dietrichi (Smith)	61				4	55		2							
Pyramica ohioensis (Kennedy and Schramm)	9							1				1			7
Pyramica ornata (Mayr)	28		8		1	17		2							
Pyramica reflexa (Wesson and Wesson)	5														5
Pyramica rostrata (Emery)	38					5						6			27
Solenopsis molesta (Say)	163		22				40	77	24						
Solenopsis invicta x *richteri*	502							125	292	85					
Stenamma brevicorne (Mayr)	1														1
Stenamma diecki Emery	2		1												1
Stenamma schmittii Wheeler	3														3
T. curvispinosus	266		11	8	1	1		20	23	72	1	26	29	21	53
T. longispinosus	5													1	4
Temnothorax pergandei (Emery)	115	2		3		1	17		2	90					
Ponerinae															
H. inexorata	2								2						
H. opacior	15							6	9						
P. exotica	1							1							
P. pennsylvanica	546		26		16	29	12	4	10	5	148	94	10	11	181
Proceratiinae															
Proceratium crassicorne (Emery)	1					1									
Proceratium silaceum Roger	2		1		1										

All sites were sampled using the Ant Leaf Litter protocol (Agosti et al. 2000). As per the ALL protocol, the number of ants is the total collected from 20 pitfall traps and 20 leaf litter samples along a 200-m transect at that site, as described in the Methods. Transect numbers correspond to those in Table 1.

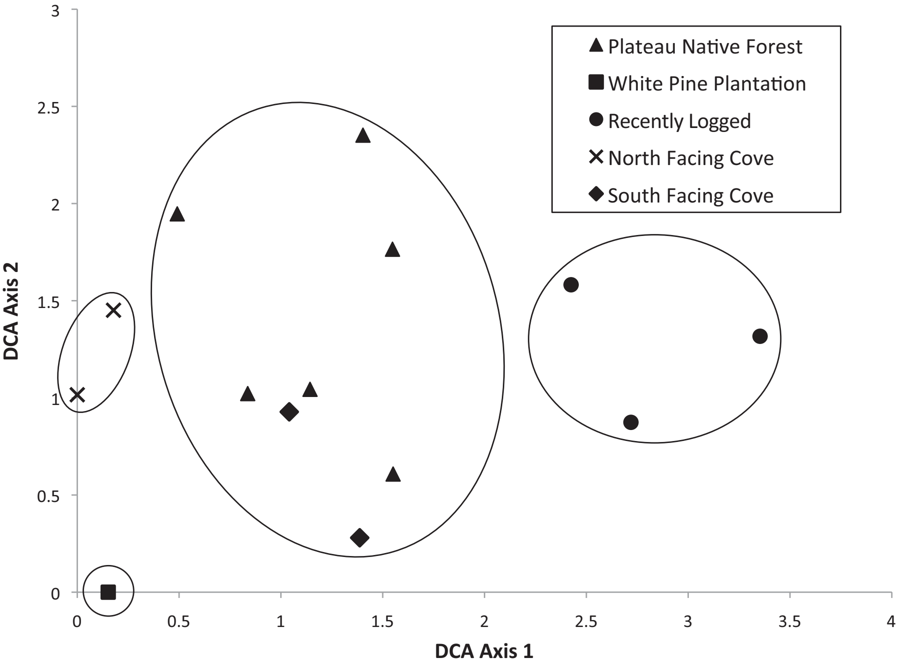

Fig. 1. Detrended correspondence analysis of ant communities calculated at the scale of transects. Each point represents the position in ordination space of the ant community sampled at that transect. The two axes show the relative position of each study site in the two dimensional space defined by the species found at each transect. Transects with similar ant species cluster together on the graph. The first axis (DCA Axis 1) is the one along which most of the variation in the ordination space is arranged (eigenvalue = 0.69) and the second axis (DCA Axis 2) is the second most important axis in ordination space (eigenvalue = 0.25). The four ant communities identified in this analysis are enclosed in ovals: 'Plateau Native Forest + South Facing Cove', 'North-facing cove', 'Recently Logged', and 'White Pine Plantation'.

cove". For further analyses, the results from all transects within these grouping were combined. The ant community in the white pine plantation did not group with other sites (Fig. 1).

Species Richness, Abundance, and Species Evenness. Species richness for the ant communities identified by DCA varied considerably, with the "plateau native forest + south-facing cove" community being the most species rich at 43 species. The "recently logged" community had 27 species, and the "north-facing cove" community was had 22 species. The white pine plantation was least species-rich, with only nine species (Table 2). We compared species richness, although controlling for sampling effort and ant density using rarefaction curves (Fig. 2). These indicated that the "plateau native forest + south-facing cove" habitat was the most species-rich. North-facing coves and recently logged habitats had intermediate, and equivalent, levels of species richness. The mature white pine plantation was the least species-rich (Fig. 2).

Abundance per transect varied significantly by habitat, with more ants collected in recently logged habitats (1,433 per transect) than in "plateau native forest + south facing cove" habitats (451 per transect) ($t = 2.26$; df = 9; $P = 0.007$). A mean of 897 ants were collected in two transects in north-facing coves, and 434 individuals were collected in the white pine plantation.

Species evenness varied across the ant communities. The north-facing cove ant community had the greatest species evenness (PIE = 0.86). The "plateau native forest + south facing cove" ant community had an intermediate level of species evenness (PIE = 0.76). The recently logged and the white pine plantation had equivalent, and low, species evenness (PIE = 0.72 for both).

Community Composition. Several species were found in all habitats whereas other species were unique to particular habitats. The most broadly distributed species, in descending order of occurrence, were *Aphaenogaster carolinensis* (found in 14 out of 14 transects, 1,642 individuals), *Nylanderia faisonensis* (Forel) (13 of 14 transects, 2,487 individuals), *Ponera pennsylvanica* Buckley (12 of 14 transects, 546 individuals), *Myrmecina americana* Emery (12 of 14 transects, 345 individuals), *Temnothorax curvispinosus* (Mayr) (12 of 14 transects, 266 individuals), and *Camponotus chromaiodes* Bolton (12 of 14 transects, 101 individuals) (Table 2). Twenty-four uncommon species occurring only in one habitat also were detected, and 13 species were only detected at one transect (Table 2).

Three species were found only in a single habitat type, and in all transects in that habitat: *Temnothorax longispinosus* (Roger) (north-facing cove), *Monomorium minimum* (Buckley) (recently logged), and *Solenopsis richteri* x *invicta* (recently logged) (Table 2).

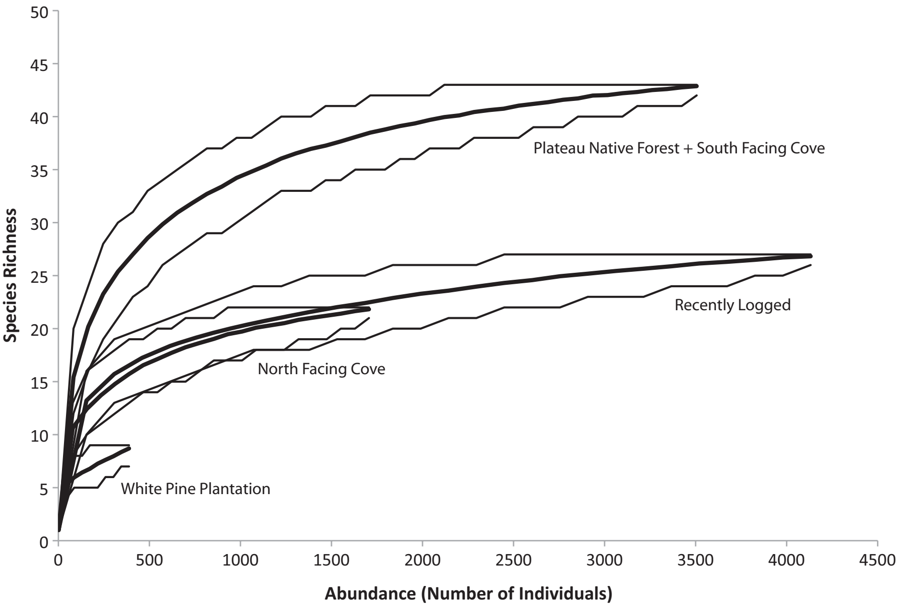

Fig. 2. Species richness in four different habitats. These habitats support distinct ant communities according to the DCA analysis. Rarefaction curves show how species richness changes as a function of number of individuals sampled (thick lines, with 95% confidence intervals) and controls for differences in sampling effort and ant density between habitats.

Tapinoma sessile (Say) was nearly limited to the recently logged habitats, with 1,962 individuals found in the three recently logged transects, and only two individuals found in all the other eleven sites combined (Table 2). Six other species were found only in recently logged sites, though none at all three, and all at low densities (Table 2).

Community Change Over Time. Our resampling (at transects 11, 12, and 13) of three sites studied by Martelli et al. (2004) allowed us to compare their 2002 data to our results from 2007. Changes in ant community composition were reflected in the change in location of the transects in ordination space on the DCA scatterplot (Fig. 3). The ant communities at transects 11 and 12 did not change greatly. In contrast, the ant community at transect 13, a loblolly pine and shortleaf pine plantation that was logged after it was sampled by Martelli et al. (2004) in 2002, changed significantly. This transect moved from the center of the "plateau native forest + south facing cove" grouping to its current location in ordination space in the "recently logged" group (Fig. 3). This shift in ordination space reflects an underlying shift in ant community composition. Six of the sixteen species present in 2002 were lost, and eight species were gained by 2007, including four species found only at recently logged sites—*Monomorium minimum, Solenopsis richteri* x *invicta, Hypoponera inexorata,* and *Hypoponera opacior* (Forel). The abundance of individuals of species that were present both pre- and postlogging changed as well; for example, the number of *Tapinoma sessile* individuals collected increased from six to 1,344.

Discussion

The southern Cumberland Plateau supports a diverse ant fauna. We identified 55 ant species, more than previous reports by Martelli et al. (2004) from Sewanee, TN, and regional reports from Arnold Air Force Base in Tullahoma, TN (Lambdin and Grant 1999); Oak Ridge, TN (Gibbs et al. 2003); and the Great Smoky Mountains National Park in eastern Tennessee and western North Carolina (Lessard et al. 2007). With the exception of Gibbs et al. (2003), which only used pitfall traps, these studies used both leaf litter and pitfall sampling, as we did. *Formica pergandei, C. pinicola, C. vermiculata, Hypoponera inexorata,* and *Ponera exotica* are, to our knowledge, new records for the state of Tennessee (MacGown 2011). Of the ants reported in this study, *Solenopsis richteri* x *invicta* (a hybrid between *S. richteri* from Argentina and *S. invicta* from Brazil) is the only introduced species.

Influence of Habitat on Ant Communities. We identified four ant communities that reflected differences in habitat: native plateau forests, white pine plantations, north-facing cove slopes, and recently logged sites on the plateau. South-facing cove slopes had ant communities more similar to native plateau forests than to north-facing cove sites (Fig. 1). This could be because of greater sun exposure on south-facing slopes, resulting in lower soil moisture levels similar to the more xeric conditions common on the plateau surface. Schmalzer (1988), working at the Obed River Gorge on the Cumberland Plateau, similarly found that higher elevation, south-facing cove slopes had vegetation that resembled plateau forests,

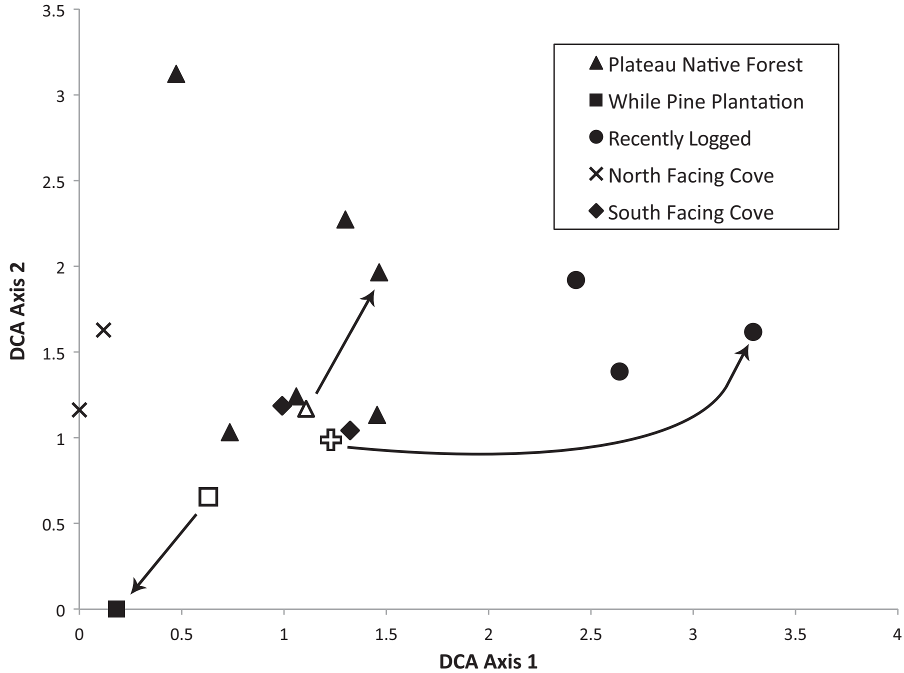

Fig. 3. Tracking ant community change over time using detrended correspondence analysis. This figure includes the fourteen transects from this study as well as data for three of those sites that were sampled 5 yr earlier (Martelli et al. 2004). The 2002 transects are indicated by open symbols, and arrows connect the earlier transect to the corresponding transect from 2007. Two of the sites (one in a white pine plantation and one in plateau native forest) did not significantly change between 2002–2007 and their ant communities are fairly similar. The ant community at the third site (indicated by an open + symbol), which was a mixed shortleaf pine and loblolly pine plantation in 2002, and that was logged less than a year later, shifted radically across ordination space, reflecting major changes in its ant community. The first axis (DCA Axis 1) is the one along which most of the variation in the ordination space is arranged (eigenvalue = 0.68) and the second axis (DCA Axis 2) is the second most important axis in ordination space (eigenvalue = 0.43).

and suggested that moisture played a major role in determining vegetation composition across the Cumberland Plateau.

Another possible explanation for the similarity between south facing cove ant communities and native plateau forest ant communities is the small elevational difference between the sites on the plateau and those we sampled in south facing coves. The plateau native forest sites varied in elevation between 588 and 559 m, whereas the two south facing cove sites were located at 500 and 475 m of elevation (Table 1). The north-facing cove transects were located at elevations of 412 and 400 m (Table 1). Lessard et al. (2007) demonstrated in the Great Smoky Mountains that elevation plays an important role in determining both species richness and the ant species found, with significant differences detected over as little as 100 m of elevation change. Further sampling of lower elevation sites on south facing cove slopes may reveal greater differences between plateau native forest ant communities and south-facing cove ant communities.

We found that recently logged sites had a distinct ant community (Fig. 1; Table 2). Recently logged sites had greater ant abundance than native plateau forest sites, but they also had lower species richness (Fig. 2) and lower species evenness. The most common species at recently logged sites were *Tapinoma sessile, Nylanderia faisonensis*, and the hybrid imported fire ant *Solenopsis richteri* x *invicta.* In combination, these three species comprised 81.5% (3,504 out of 4,298) of the ants collected at recently logged sites. Of these, *S. richteri* x *invicta* was not found at any nonlogged site, and only two *T. sessile* individuals were found at one nonlogged site. Hybrid imported fire ants have been shown to outcompete native ants at disturbed sites in southern Tennessee (Gibbons and Simberloff 2005), but our location near the northern edge of the range of imported fire ants may limit their overall influence on native ant communities (Calcott et al. 2000). Several other species (*Crematogaster pilosa* Emery, *Hypoponera inexorata, H. opacior, Monomorium minimum,* and *Pheidole tysoni* (Forel) were found only at recently logged sites. It appears that recently logged sites increase gamma diversity of ants on the Cumberland Plateau, but host an ant community that does not greatly penetrate into native forest habitats.

With forest conversion from hardwood to pine common on the Cumberland Plateau (McGrath et al. 2004) it would be interesting to know how ant communities vary across the various native and nonnative communities in which pines are found. Along these lines, Haskell et al. (2006) showed that breeding bird communities change with the age of pine plantations on the Cumberland Plateau. In our limited sampling we found variation across the pine sites that we studied. We surveyed a white pine monoculture (transect 11), and a sandstone outcrop that contained a mixture of oaks and native Virginia pine (*Pinus virginiana* Mill.) (transect 7). In addition, Martelli et al. (2004) sampled a mixed loblolly and shortleaf pine plantation that was later logged (transect 13). Of these three sites, the white pine plantation had the most distinct ant community, whereas the others fell within the native plateau forest grouping (Fig. 3).

Resampling three sites from Martelli et al. (2004), we found that the ant community did not greatly change at the two sites that were largely undisturbed between 2002 and 2007 (Fig. 3). This result suggests that the ALL protocol adequately sampled the ant communities at those sites. In contrast, the ant community at the site that was logged between 2002 and 2007 shifted in a predictable direction on the DCA (Fig. 3). This supports the idea that ant communities are sensitive to change in their immediate environment (Kaspari and Majer 2000), and that the ALL protocol and DCA can be used to track changes in ant communities over time.

Conclusion. The southern Cumberland Plateau supports a diverse ant community. We identified four ant communities found in native plateau forests, white pine plantations, north-facing cove slopes, and recently logged sites on the plateau that were correlated with habitat and level of disturbance. Ant communities on south facing cove slopes were more similar to those of native plateau forests than those of north-facing coves. These ant communities were consistent with habitat-related differences in woody plant diversity. Recently logged sites supported a distinct ant community that is largely limited to those sites. The presence of hybridized red imported fire ants (*Solenopsis invicta* x *richteri*) at the recently logged sites, coupled with their absence from undisturbed forest sites, indicates an inability to establish in native forest habitats on the Cumberland Plateau. As postlogging disturbed sites revert back to a native forest, one would expect the ant community composition to shift toward that found in the undisturbed forests sampled by our study. Tracking changes in ant communities over time has utility in assessing the recovery of disturbed forest ecosystems on the southern Cumberland Plateau.

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