Journal of the Arkansas Academy of Science

Volume 62 Article 10

2008

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Ants of Arkansas Post National Memorial: How and Where Collected

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Abstract

A knowledge of the fauna of natural areas is necessary for their sustainable management. Thus, intensive ant sampling over multiple years was conducted at Arkansas Post National Memorial in southeastern Arkansas. Our collecting techniques included: pitfalls; leaf litter sifting with Berlese extraction; breaking into twigs, branches, and coarse woody debris located on the ground; baiting tree trunks with peanut butter; and general hand collecting. Ants were collected from diverse habitats, including: open mowed-grass, mowed-grass under hardwood trees, unmowed tall-grass and weeds, and numerous forest types. A total of 43 species in 25 genera and 6 subfamilies were identified. The number of species discovered varied by sampling technique: leaf litter extraction collected 28, wood breaking 29, tree baiting 9, hand collecting 25, and pitfalls 35. Two-way hierarchical cluster analysis of ant species against sampled habitats showed that 5 species were almost ubiquitous, while 9 species were present in many of the forested habitats, and 29 other species were much less common. The analysis also showed that successionally "older" forested habitats usually had richer ant communities than successionally "younger" ones, although there were several important exceptions. Additionally, mowed areas without trees supported the fewest ant species, while mowed areas with overhead trees supported more species.

Introduction

Biological inventories are a central element of natural science. They provide the essential information needed for meaningful resource management or conservation biology. Inventories that use structured sampling (i.e. randomizations and repetitions) permit statistical characterization of different spatiotemporal units, like habitats or seasons. Structured sampling uses a variety of methods that emphasize finding many species, but is also quantitative in terms of capture per unit area or time. For structured sampling, relative abundances of focal taxa over space and time are usually more important than absolute numbers of individual species.

The ant literature is filled with articles on the ants of specific locations, for example the Ants of Arkansas (Warren and Rouse 1969). Typically, the methods for a study are provided in detail to help understand the species amassed, or perhaps what might have been missed. As a way of improving on the collecting process, the book, *Ants: Standard Methods for Measuring and Monitoring Biodiversity* (Agosti et al. 2000), was produced. In Chapter 9, Bestelmeyer et al. (2000) detail many of the best collecting procedures developed over the years, their logic, pros and cons, and usefulness of the data collected.

Social insects like ants create a unique sampling problem in that the numbers of individuals collected is often a function of multiple factors: how close sampling is conducted relative to the location of a colony; whether an entire colony may be collected; when the substrate is sampled; how effective a species might be at recruiting workers to baits; or how effective a species might be at defending baits from competitors. Another complication to sampling is that ants occupy many different niches in the landscape. Some species are arboreal and thus are encountered only when they fall off the trees and shrubs patrolled. Many ant species forage and nest in the ground while others can be found only in leaf litter. In addition to spatial separation, ants are also temporally separated, some being diurnal, crepuscular, and/or nocturnal (Hölldobler and Wilson 1990).

Quality of the habitat is likely the most important factor in determining the ant species present (Hölldobler and Wilson 1990). In addition, the advance of forest succession is usually associated with improved ant community richness (Carvalho and Vasconcelos 1999, Maeto and Sato 2004, Osorio-Perez et al. 2007, Silva et al. 2007) because of increasing accumulations and diversity of course woody debris (Grove 2002, Ulyshen 2004, Vanderwel 2006), and the increasing complexity of the soil and litter (Kaspari 1996, Oliver et al. 2000), and vegetation structure (Oliver et al. 2000). Consequently, we expected successionally "older" forested sites to support more ant species than successionally "younger" ones.

The aim of this study was to describe the advantages and disadvantages of the collecting methods and to ascertain the species habitat relationships of the ant community at the Arkansas Post National Memorial (APNM). Understanding habitat preferences should help the National Park Service be aware of how their management of APNM affects native ants.

Methods

Study Site

APNM is an historical park managed by the National Park Service, and is located 20 km northeast of Dumas, Arkansas County, Arkansas. It is a peninsula bounded on its southeastern tip by an inlet from the Arkansas River (Fig. 1). APNM has a total land area of about 114 ha. Within APNM there are 5 general land cover types; although most cover consists of oak forests mixed with other hardwoods and some conifers. From the general cover types at APNM, 10 stand pairs were selected for ant sampling to provide contrasting successionally "younger" and "older" stands of vegetation that included a separating ecotone (the boundary between two stands or vegetation types). The first stand of the pair is presumed to be "successionally younger" than the second. This successional classification is based on a realization that for the tree species represented in this study, oaks are typically considered late successional species, and conifers, sweetgum (*Liquidambar styraciflua*), and black locust (*Robinia pseudoacacia*) more early successional species (see discussions of successional patterns in Oosting 1956, Bowling and Kellison 1983, and Oliver and Larson 1996, and tree ecological characteristics in Burns and Honkala 1990). For use in the results, abbreviations of the stand types are shown as follows with each stand of a pair being linked using a suffix number:

1. Oak prescribed burned 12 year ago (Oakburn1) vs. unburned oak (Oakubur1)
2. Young sweetgum (YSwtgum2) vs. oak (Oak-2)
3. Old sweetgum (OSwtgum3) vs. oak (Oak-3)
4. Cedar (Cedar-4) vs. oak (Oak-4)
5. Tall grass (Tgrass-5) vs. black locust (Locust-5)
6. Pine (Pine-6) vs. oak (Oak-6)
7. Mowed without trees (Mowed-7) vs. mixed sweetgum (Swtgum-7)
8. Mowed without trees (Mowed-8) vs. tall grass (Tgrass-8)
9. Mowed with trees (Mowed-9) vs. mixed oak (MOak-9)
10. Mowed with trees (Mowed-10) vs. oak (Oak-10)

The stands were characterized by their overstory tree vegetation. All forested sites have a midstory of winged elm (*Ulmus alata*). Oak stands are mostly water oak (*Quercus nigra*), willow oak (*Q. phellos*), and cherrybark oak (*Q. pagoda*). Mixed oak stands additionally have winged elm and sweetgum. Sweetgum and mixed sweetgum stands are dominated by sweetgum, but also include some oaks. There were 3 small unique stands: eastern red cedar (*Juniperus virginiana*), loblolly pine (*Pinus taeda*), and black locust. The lone tall grass stand is dominated by Bahia grass (*Paspalum notatum*), blackberry (*Rubus sp.*), and goldenrod (*Solidago spp.*). All mowed areas are dominated by bermuda grass (*Cynodon dactylon*), and the mowed areas with trees have scattered post oak (*Q. stellata*) and pecan (*Carya illinoinensis*). Details of the overstory, midstory, and understory vegetation on these sites can be obtained from General (2007).

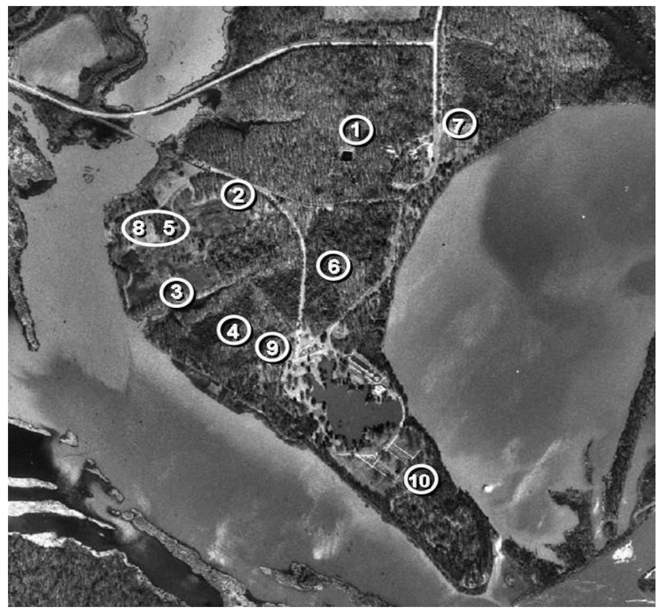

Figure 1. Location of numbered collecting sites at Arkansas Post National Memorial.

Sampling transects were designed to extend from one stand type, through an ecotone, and into the adjoining stand type. The ecotones were typically sharply defined, such as the boundary between a mowed area and a forested stand or between pine and oak stands, but an ecotone may be indistinct in the case of the transition between burned and unburned stands. Figure 1 presents a map of APNM with the locations of the 10 study sites for the stand pairs listed above.

Sampling Methods

The ant community was sampled over 2 years and it was sampled differently each year. Pitfall traps were used in 2005 and plot sampling in 2006. Details of the sampling methods are described in General and Thompson (2007). In short, pitfalls sampled the community once in June, July, August, and September.

Pitfalls were plastic vials partially filled with propylene glycol and inserted into a drilled hole so the lip of the vial was level with the ground, and were retrieved after 72 hours. Plot sampling was conducted in each stand of a pair in subplots where ants were collected using leaf-litter extraction, wood breaking, tree-trunk baiting, and visual searching. The species list generated by this sampling is a composite assemblage from these techniques.

Ant Identification

Specimens were identified to species using the most appropriate keys (Bolton 1994, 2000; Bolton et al. 2007; Buren 1968; Creighton 1950; DuBois 1986; Johnson 1988; MacGown 2006; MacKay 1993, 2000; Trager 1984, 1991; Wilson 2003). Problematic specimens and many species determinations were checked and verified by Stefan Cover of the Museum of Comparative Zoology (MCZ) at Harvard University. The Arkansas ant list of Warren and Rouse (1969) has been updated based on the ants collected in this study (General and Thompson 2007). Voucher specimens were deposited with the Arthropod Museum of the University of Arkansas at Fayetteville and the MCZ at Harvard University.

Data Analysis

Ants live in colonies of varying sizes and their distributions are spatially and behaviorally clumped (Longino 2000). Thus, it was necessary to convert our ant abundance data into presence/absence data. Within each stand, species from the 2005 pitfall collections were pooled with those from the 2006 plot collections to generate the presence/absence data set.

We removed only 1 species from the species-stand data set; a single specimen of *Aphaenogaster fulva* collected from the site 10 ecotone was eliminated because the ecotone did not represent a single stand type. Although rare species can cause noise when included in some analyses (McCune and Grace 2002), our objective was to graphically show where all species were collected and to concurrently show possible habitat and species groupings; thus we did not remove any additional rare species. Accordingly, we analyzed 43 species within 20 stands. Before running the analysis, we relativized the raw presence/absence data using the "Information Function of Ubiquity" procedure in PCORD 5.0 (McCune and Mefford 1999, p. 60). This procedure gives less weight to very common and very rare species, and gives more weight to species occurring in half the samples, those that provide the maximum information content according to information theory (Pierce 1980). Additionally, in an attempt to provide a better graphical presentation for species groups, we tried multiple linking methods and distance measures for the 2-way cluster analysis procedure used in PCORD. We ended up using the flexible-beta linking method (beta = -0.25), and the Jaccard distance measure, as recommended by Gotelli and Ellison (2004) for incidence data**.** The resulting dendrogram provides a 2-dimensional picture of the combined relationships of stands among ant species and ant species within stands. Stands were depicted in the dendrogram in rows and species in columns. Within a dendrogram, cluster "breaks" were on a sliding scale with a value of 100 being most similar and 0 being very dissimilar. Natural groups have longer stems in the dendrogram, and very divergent groups were typically linked where the information remaining scale shows zero.

Results

More than 50,000 individual ants were collected in this study, representing a total of 43 species in 25 genera and 6 subfamilies. Table 1 shows the species found at APNM and the sampling methods that collected them. The number of species discovered varied by sampling technique: pitfalls collected 35, wood breaking 29, leaf litter extraction 28, hand collecting 25, and tree baiting 9. Six species were collected only by pitfalls, 3 species were collected only by leaf litter extraction, and 1 species each was collected only by wood breaking and by hand collecting. Tree baiting collected no unique species. This shows that although pitfall trapping was effective in collecting 35 species, it missed 8 species. In contrast, the plot sampling, which in combination resulted in a total of 38 species, missed 5 species.

The 2-way hierarchical cluster analysis (Fig. 2) organized the ant species into a dendrogram with ant species in columns and stands in rows. The species were oriented with the ubiquitous species on the right and moving left toward the less common species. Based on the ants present, 3 groups of stands were identified (A, B and C in Fig. 2). Group A represented the 2 mowed stands without overhead trees. Group B represented the forested stands with greater species richness. These included the oak stands that were assumed to be successionally "older", and where the forest floor was dominated by leaf litter from the overstory. Group C represented stands with lower ant species richness and included diverse habitats like the "open" sites of mowed grass with trees, the 2 tall grass and weeds sites, plus 5 forested stands. The "open"

Table 1. Ant species collected at Arkansas Post National Memorial by sampling method.

	Subfamily Dolichoderinae	Pitfall	Wood	Litter	Trees	Hand
1	*Forelius pruinosus*	X				
2	*Tapinoma sessile*	X				
	Subfamily Formicinae					
1	*Brachymyrmex depilis*	X		X		
2	*Camponotus americanus*	X				X
3	*Camponotus castaneus*	X	X			
4	*Camponotus discolor*	X	X			X
5	*Camponotus pennsylvanicus*	X	X	X		X
6	*Camponotus pylartes*		X		X	X
7	*Camponotus snellingi*		X			X
8	*Formica pallidefulva*	X	X			X
9	*Lasius alienus*	X	X	X		X
10	*Paratrechina terricola*	X	X	X	X	
11	*Prenolepis imparis*	X	X			X
	Subfamily Myrmicinae					
1	*Aphaenogaster fulva*	X				
2	*Aphaenogaster lamellidens*	X	X	X	X	X
3	*Aphaenogaster texana*	X	X	X		X
4	*Crematogaster ashmeadi*	X	X	X	X	X
5	*Crematogaster atkinsoni*	X				
6	*Crematogaster laeviuscula*		X	X	X	X
7	*Crematogaster lineolata*	X	X	X	X	X
8	*Crematogaster minutissima*	X		X		
9	*Crematogaster missuriensis*			X		
10	*Monomorium minimum*	X	X	X	X	X
11	*Myrmecina americana*	X	X	X		X
12	*Myrmica punctiventris*	X	X	X		X
13	*Pheidole bicarinata*	X	X	X		X
14	*Pheidole dentata*	X	X	X	X	X
15	*Pheidole dentigula*			X		
16	*Pheidole pilifera*	X				
17	*Pheidole tysoni*	X	X	X		
18	*Protomognathus americanus*		X			
19	*Pyramica clypeata*	X	X	X		X
20	*Pyramica ornata*		X	X		
21	*Solenopsis invicta*	X	X			X
22	*Solenopsis molesta*	X	X	X		X
23	*Strumigenys louisianae*	X		X		X
24	*Temnothorax curvispinosus*	X	X	X	X	X
25	*Temnothorax pergandei*	X	X	X		X
26	*Temnothorax schaumii*	X				
	Subfamily Ponerinae					
1	*Hypoponera opacior*	X	X	X		
2	*Ponera pennsylvanica*	X	X	X		
	Subfamily Proceratiinae					
1	*Discothyrea testacea*			X		
2	*Proceratium pergandei*	X		X		
	Subfamily Pseudomyrmecinae					
1	*Pseudomyrmex pallidus*					X
	TOTAL SPECIES	35	29	28	9	25

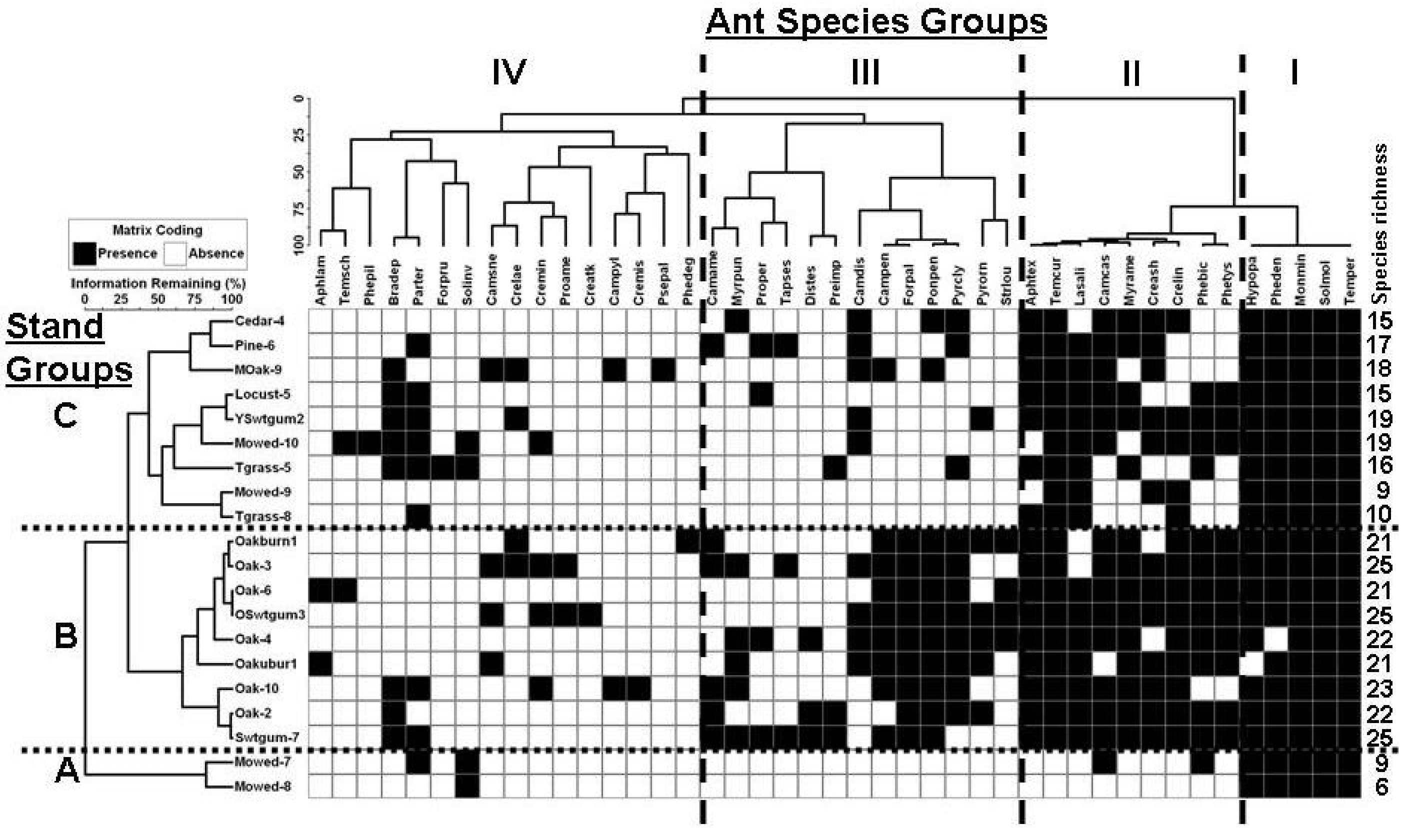

Figure 2. Dendrogram providing a 2-dimensional picture of the combined relationships among stands (rows) and ant species (columns) at Arkansas Post National Memorial. See methods for stand descriptions. Three stand groups were identified: Group A representing mowed sites without trees, Group B successionally "older" stands, and Group C successionally "younger" stands. Four ant species groups were also identified: Group I included the 5 most ubiquitous ants; Group II, 9 common ants that occur in most stands in Groups B and C, but were mostly absent from Group A; Group III, 13 less common ants, that were more species rich in Group B than Group C, and were absent from Group A; and Group IV, 16 ants that were hard to characterize to habitat, and included all 6 rare species (found in only one stand type). Cluster "breaks" within the dendrogram were on a sliding scale with a value of 100 being most similar and 0 being very dissimilar. Natural groups had longer stems in the dendrogram, and very divergent groups were typically linked where the information remaining scale shows zero.

sites had an herbaceous layer dominated by grasses. The 5 forested sites in Group C actually occurred in 2 subgroups with different forest floors. The locust and young sweetgum stand (YSwtgum2) stand clustered with the "open" sites; the locust stand's ground cover was dominated by Cherokee sedge (*Carex cherokeensis*) and the young sweetgum stand was dominated by blackberry. Ground cover in the 2 conifer stands (cedar and pine) and the mixed oak stand (MOak-9) was dominated by leaf litter from their overstory

The successionally "older" forested habitats that included major oak components had richer ant communities (21 or more species, except MOak-9 with 18) than the successionally "younger" conifer, locust, and young sweetgum stands. However, there were 2 major exceptions in the old sweetgum (OSwtgum3) and mixed sweetgum (Sweetgum-7) stands, both with 25 species each. Although in our scheme sweetgum was considered successionally "younger", it obviously can support a rich diversity of ant species.

The cluster analysis of ant species within stands identified 4 groups (I – IV, Fig. 2). Group I included the 5 most ubiquitous ants. Group II included 9 common ants that occurred in most stands in stand Groups B and C, but were mostly absent from stand Group A. Group III included 13 less common ants that were more species rich in stand Group B than Group C, and were absent from stand Group A. And finally, Group IV included 16 ants that were hard to characterize to habitat, and included all 6 rare species (found in only one stand type). Of note in the species clustering was the linking of *Brachymyrmex depilis* (coded Bradep) with *Paratrechina terricola* (Parter) in species group IV (Fig. 2) with the less common species. Regardless of the clustering methods or relativizations used, these species were typically paired. Although we have no specific biological information to support this connection, both species have been known to occur in "open" habitats (AntWeb 2008). *Solenopsis invicta* (Solinv), an invasive species also known to prefer open habitats, occurred in many of the mowed and tallgrass sites.

Discussion

How Collected

As a stand alone technique, pitfall trapping collected the most species. Its advantages are that it traps nocturnal ants and is relatively easy to deploy if a trap line has already been set up marking trap locations. Its major drawback is that it takes a considerable amount of time to sort through the trap vials and find and remove ants, especially if the vials have been disturbed by vertebrates while deployed and include lots of soil and debris.

Of the plot techniques, wood breaking worked best. Many colonies were found, which produced many workers and often a queen. This is especially helpful if a species was hard to identify. However, extracting the ants from the wood often took lots of time because each branch or twig had to be dissected. Often a Berlese extractor was used for large nests in rotten wood. Litter sifting worked just as well. It went fairly quickly in the field, but slowed down in the laboratory when a backlog of material awaited the availability of Berlese extractors. Litter from a 1-m^2 quadrant might fill 5 Berlese extractors; so having several dozen Berlese extractors available should help facilitate extraction. Bestelmeyer et al. (2000) recommend a litter extractor called a mini-Winkler sack, but this alternative also takes time to construct. Either way, plenty of space is needed to house litter extractors. Hand collecting was almost as useful as litter extraction in finding new species. It is the method of choice for experienced collectors because they know where to look for rare species, and it involves moving around to productive niches to be effective. Also, for collectors experienced with field identification, there are lots of exhilarating moments when a rare species is discovered. However, if the weather is not suitable for ant activity when at the location, the ants may not be out. With this technique, detailed notes on when and where the ants were collected are required for hand collection results to be meaningful. So collectors must spend considerable time "detailing" specimen labels. Certainly, extra effort and superior techniques usually generate more comprehensive ant inventories (King and Porter 2005).

Where Collected

Based on clustering, it does not appear that the ants "perceived" the stands as we viewed them. Our overstory descriptive characteristic of plant species composition and its corresponding relative successional age did not work all that well. Although the presence of trees appears important to the ants, the characteristics of the ground vegetation also seems to be important to them. We have also sampled soil surface characteristics and other habitat characteristics, but this data has yet to be analyzed relative to ant species presence.

Much has been published about relationships between ants and the environmental features of their habitat (more recent studies include Lassau and Hochuli 2004, Parr et al. 2004, Boulton et al. 2005, Ratchford et al. 2005). As would be expected, relating cause and effect relationships is problematic if the environmental variables measured in a study are not those actually affecting the ant community, but may be correlated with variables that are. When taken as a group, the results of ant-environment studies are often puzzling. Regularly, the use of ant abundance measures confuses these relationships, and in other studies the relationship between vegetation and soil related parameters are not well developed. That is, the soil and site conditions influence the vegetation, and over time, the vegetation in turn influences the nature of the litter, duff, and soils. So, which is more important and what is to be measured? This study was not designed to resolve these issues, but simply to characterize the ants in the sampled habitats.

Of note, all the forested stands have had minimal management over the years and consequently probably have adequate supplies of the coarse woody debris, litter, and structural features preferred (Oliver et al. 2000) by many of the forest inhabiting ant species collected. Of the forested sites, the cedar and black locust stands had very different forest floor characteristics; the cedar stand had lots of bare ground, and the black locust stand had dense sedge cover. Both these stands had the lowest species richness among forested sites, 15 species each. Additionally, APNM is a small peninsula, and the forested areas comprise about 85% of the total land area, hence, the matrix effects of the mowed areas and roads within the park are probably not limiting the movement of ants among these mostly adjoining forested sites.

The fewest ant species occurred in the 2 mowed areas without overhead trees (Group A) (Fig. 2), the tall grass stand (Tgrass-8), and one of the mowed sites with a few overhead oaks (Mowed-9). However, the Mowed-10 stand had 19 species collected (Fig. 2). This mowed area had numerous overstory pecan trees, plus 1 black walnut (*Juglans nigra*). Pecans are known for maintaining diverse populations of foliage feeding and sap-sucking insects (Texas A&M 2008) that might help sustain via honeydew (Blüthgen et al. 2000) the diverse ant species found on the ground below. Interestingly, the lone open tall-grass stand (one stand sampled twice and identified as Tgrass-5 and Tgrass-8) clustered differently based on where the ants were sampled. This unique stand yielded 10 species when sampled closer to the mowed grass, but 16 species when sampled adjacent to the black locust and other trees along an old fence line on the edge. Evidently the nearness of trees was important to some ants.

Most interesting was the low abundance of *S. invicta* within APNM. *Solenopsis invicta* is a sun-loving ant, but we have found it in many forests showing some disturbance, like canopy gaps from dead or fallen trees. We suspect the absence of *S. invicta* was likely due to the ubiquitous presence of *Monomorium minimum* (Monmin) and *S. molesta* (Solmol) that prey upon young *S. invicta* colonies (Rao and Vinson 2004, Vinson and Rao 2004).

Site 3 (Oak-3 and Old Sweetgum3) was a special location because it had the highest overall species richness of 25 (Fig. 2). Three new state records (General and Thompson 2007) of species were recorded there: *C. atkinsoni* (Creatk) and *Strumigenys louisianae* (Strlou) (in the "younger" Old Sweetgum3), and *Protomognathus americanus* (Proame) (in both Old Sweetgum3 and "older" Oak-3). In addition, 15 new county records of species were recorded from site 3. Both stands had 12 new county records each. Likewise, the mixed sweetgum stand (Sweetgum-7) had 25 species, but it had fewer new state records, only *Discothyrea testacea* (Distes) and *Proceratium pergandei* (Proper), and 11 new county species records.

Conclusions

APNM is habitat to some interesting and important ant species. It is intuitive to think that the different stand types identified at APNM may be offering a variety of habitats to ants. In fact, this study showed that the ants responded to few differences among the forested stands. Unique stands, such as the pine, cedar, and black locust, did not harbor any unique ants. Instead of managing the different forested stands individually, it may be better to manage them as a single complex forest, thus simplifying management.

Mowed areas are important for park visitors by providing space for recreation. The mowed areas without trees are relatively depauperate of ant species, except for the 5 ubiquitous species, the red imported fire ant, and a few other natives. The mowed area with pecan trees, however, harbored forest ants, highlighting the importance of having some large overstory trees in mowed areas.

Acknowledgments

We thank the University of Arkansas-Monticello, the Arkansas Forest Resources Center, and the National Park Service for funding. We also thank Lloyd Davis, Chris Watt, John Stephens, Ted Kluender, and Andres Bacon for helping with the field and laboratory work, and Stefan Cover for verifying ant identifications.

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