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Baseline surveys for ants (Hymenoptera: Formicidae) of the western Everglades, Collier County, Florida

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Abstract
Baseline surveys for ants were conducted in hydrologically disturbed and undisturbed preserves in the western Everglades in Collier County, Florida, by using baited vials and sweep nets. The 50 sampling sites were selected based on 1) major plant communities and 2) whether or not the site was located in an area that is expected to be affected by the hydrologic restoration of Picayune Strand State Forest. Forty-eight species were collected, of which 33 were native and 15 were exotic. The surveys revealed that approximately half of the species identified were associated with specific plant communities. As these surveys were site specific and can be repeated at a later date, shifts in the distribution and frequency of the ant species can be used to assess successional changes in the plant communities resulting from the hydrologic restoration of the Picayune Strand State Forest and adjacent preserves.

Key Words: hydrologic restoration; exotic species; plant communities

Materials and Methods
The sampling sites corresponded to major plant communities identified by Burch et al. (1998) and Barry & Woodmansee (2006) (Table 1). The majority of the sampling sites were located in SG (n = 27). The hydrology of CS and TT was also altered by the roads and canals in SG. In 1996, the South Florida Water Management District developed a hydrologic restoration plan for SG and, in 2006, began removing roads and filling canals. The objective of these surveys was to obtain baseline data on existing assemblages of ant species within SG, CS, and TT prior to hydrologic restoration. The hydrology in FP and FS more closely mirrors historic conditions. The ant surveys conducted in those preserves were performed to obtain baseline data on ant assemblages in areas with more natural hydrology. As the collection method used is repeatable, the same sites could be sampled again after restoration is completed. Changes in the distribution and frequency of ant species present in the preserves could be used to assess ecosystem changes resulting from the hydrologic restoration.

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remaining 23 sites were located in FS (n = 9), CS (n = 6), FP (n = 6), and TT (n = 2). The longitude and latitude of each site was recorded with a Magellan Explorer 500 GPS. The locations were then archived at the Conservancy of Southwest Florida. For the purposes of this study, the conservation areas with altered hydrology, SG, CS, and TT, were defined as being “hydrologically impacted” (HI). The adjacent less impacted conservation areas, FS and FP, were characterized as being “hydrologically unaltered” (HU).

Ants were collected using sweep nets and baited vials. Sweep netting was conducted in Aug 2005, 2006, 2009, and 2010. An aerial insect net with a 30 cm diameter was used to collect the specimens. For sampling consistency, all the sweep netting was done by the same individual. Starting from a predetermined center point at each sampling site, sweeps were conducted along 5 transects in the north, south, east, west, and southeast directions. Along each 20 m transect, the net was swept through an arc of 180° 20 times. The data were pooled for each sampling event. All the sampling sites were >30 m from roads to avoid sampling consistency, all the sweep netting was done by the same individual. Starting from a predetermined center point at each sampling site, sweeps were conducted along 5 transects in the north, south, east, west, and southeast directions. Along each 20 m transect, the net was swept through an arc of 180° 20 times. The data were pooled for each sampling event. All the sampling sites were >30 m from roads to avoid sampling terrestrial species living on road shoulders. Ants were field sorted, preserved in 70% ethanol, and returned to the laboratory for identification. Conservancy biologists conducted the initial taxonomic identification. Conservancy biologists conducted the initial taxonomic identification. These were later verified by Mark Deyrup at Archbold Biological Station’s Entomology Laboratory.

Ant species were sampled using baited vials during Jan to Feb of 2006 and 2007 and during May to Jun of 2006, 2007, 2009, and 2010. At each site, the sampling array consisted of nine 45 mL plastic snap-cap vials. One vial was placed at an established center-point and 2 vials (1 at 20 m and 1 at 40 m) were set along transects located in the north, south, east, and west cardinal directions. According to the methods of Kaspari et al. (2000), the vials were baited with pieces of pecan sandy cookies, and deployed for approximately 2 h before retrieval. Ants in the vials were preserved with 70% isopropyl alcohol for later sorting and taxonomic identification and verification. The long hydroperiods at the saltwater marshes precluded terrestrial sampling at these sites.

Frequency of occurrence for individual species and species richness were tabulated by plant community code and whether the sampling site was classified as HI or HU. Frequency of occurrence by species (x) was defined as $x = n_i / n \times 100$, where $n_i$ is the number of times an individual species occurred in a given habitat and a given hydrological classification and $n$ is the number of times sampled within a given habitat and hydrological classification. All data collected from sweeps and baited vials were combined separately.

Results

Forty-eight species of ants representing 22 genera were collected from combined sampling sites (Table 2). Nineteen species nest in trees, herbaceous plant stems, or other above-ground vegetation, hereafter called plant-nesting species. Twenty-five were ground-nesting species. This includes species that nest underground as well as those that nest on or in material on the ground. Four more species were identified as being capable of nesting either on the ground or in plants.

Three plant-nesting and 2 ground-nesting species were found in all or all but 1 of the plant communities surveyed (Table 2). Pseudomyrmex ejectus F. Smith, a native arboreal species, was present in all plant communities surveyed within the conservation areas. This ubiquitous native species is widely distributed throughout Florida. Crepatogaster atkinsoni Wheeler, a native plant-nesting ant, was found in all plant communities with the exception of hardwood hammocks. Pseudomyrmex gracilis (Santschi), the elongate twig ant, was found in all plant communities with the exception of saltwater marshes. This is an exotic plant-nesting species that inhabits a wide range of vegetative associations from mangroves to hammocks. Camponotus floridanus (Buckley), the Florida carpenter ant, was found in all surveyed plant communities with the exception of saltwater marshes. Solenopsis invicta Buren, the red imported fire ant, an aggressive invasive exotic species, was found in all plant communities with the exception of saltwater marshes.

Species richness at HI sites was highest in hydric pine flatwoods, followed by cypress and graminoid (grasses & sedges) plant communities, whereas saltwater marshes had the lowest richness (Table 2). Thirteen out of 32 species collected at the HI sites are considered to be plant-nesting. Species richness at HI sites was highest within mesic pine flatwoods, followed by cypress, cypress with graminoid, and graminoid-only plant communities, whereas freshwater marshes had the lowest richness. Nineteen out of 47 species collected at HI sites were considered to be plant-nesting. The greater number of species recorded in the SG may be a function of the man-made hydrological disturbance that occurred there as opposed to more natural conditions in HI sites, summarized below. Additionally, 4 species, 1 of which was collected in HI sites and 3 of which were collected in both HI and HU sites, were considered to be both plant- and ground-nesting.

Frequency of occurrence is tabulated in Table 2. Solenopsis invicta was the most frequently collected species at approximately 40% of the individual HU sites. Interestingly, S. invicta was absent at FP1-Cg, FS4-C, and FS9-Ms and was found once at HU site FS6-Cg. At these sites, either the native species Pheidole dentata Mayr or C. atkinsoni was collected with the highest frequency or another exotic species, Pheidole moerens Wheeler, dominated. The native species P. dentata and Pheidole floridana Emery accounted for the highest occurrence at the HU sites FP1-Cg, FP6-Ph, FS3-Ph, and FS8-Ph. Solenopsis invicta occurred in higher frequencies (>50%) within graminoid and hydric pine flatwood communities and at lower frequencies (<25%) in cypress habitats in the HU sites.

Frequency in HI sites are given in Table 2. Solenopsis invicta had the highest frequency of occurrence within approximately 51% of the HI sites but was not collected at HI sites TT1-Ms, CS6-C, and SG26-C. It was documented once at sites TT2-Ms, SG4-Pm, and SG12-C. At these sites C. atkinsoni, P. dentata, Dorymyrmex burenii (Trager), and Forelius pruinosus (Roger) were collected with the highest frequency.
Table 1. Vegetative community descriptions along with sampling locations categorized by hydrologically unaltered vs. hydrologically impacted. CS – Collier Seminole State Park, FP – Florida Panther National Wildlife Refuge, FS – Fakahatchee Strand Preserve State Park, SG – Picayune Strand State Forest (Southern Golden Gate Estates), and TT – Ten Thousand Islands National Wildlife Refuge. NA – not applicable.

| Vegetative community       | Major community type                                                                 | Hydrologically unaltered | Hydrologically impacted |
|----------------------------|--------------------------------------------------------------------------------------|--------------------------|-------------------------|
| Cypress slough (C)         | Forested community dominated by *Taxodium distichum*. Occasional hardwoods (*Acer rubrum,* *Fraxinus caroliniana,* *Annona glabra*) form <30% of the canopy. Sparse groundcover often emergent in standing water. Epiphytic bromeliads and orchids present. Understory commonly has ferns. | FP4, FS4                 | CS2, CS6, SG10, SG12, SG15, SG19, SG24, SG26 |
| Cypress with graminoid (Cg)| Moderately dense forest to open scrubby “dwarf cypress”                             | FP1, FS1, FS6            | SG1, SG14, SG17, SG20, SG23 |
| Wet prairie (G)            | Open prairie landscape dominated by graminoids and occasional herbs. Occasional *Pinus elliottii* and *Taxodium distichum* form <30% of the canopy. | FP2, FP5, FS2, FS5, FS7   | CS3, CS5, SG3, SG7, SG11, SG13, SG22, SG25, SG27 |
| Hydric hammocks (Hh)       | Forested community dominated by hardwoods (*Acer rubrum,* *Sabal palmetto,* *Quercus laurifolia*). *Taxodium distichum* occurs, but uncommon. Sparse to moderate understory containing small hardwoods (*Rapanea punctata,* *Ilex cassine*). Epiphytes common. Groundcover variable. Ferns dominant. | NA                       | SG16                                    |
| Mesic hammocks (Hm)        | Forested communities dominated by *Quercus virginiana* and *Sabal palmetto*. Moderate to dense understory containing small hardwoods (*Myrsine floridana,* *Psychotria nervosa,* *Randia acauleata,* *Serenoa repens*). Sparse groundcover. Epiphytes and ferns common. | NA                       | SG2, SG18                                |
| Freshwater marshes (Mf)    | Community with prolonged freshwater hydroperiod. Emergent graminoids or herbs commonly associated with wetlands, dominate (often obligate wetland species). | NA                       | SGS-Mf                                  |
| Saltwater marshes (Ms)     | Tidal communities with prolonged hydroperiods. Dominated by graminoids (*Spartina bakeri* and *Eleocharis cellulosa*). Mangroves occur but are not common. | FS9                      | TT1, TT2                                |
| Hydric pine flatwoods (Ph) | Woodland community, open canopy dominated by *Pinus elliottii* and *Taxodium distichum*. Understory is open, with dense groundcover dominated by graminoids. | FP3, FP6, FS3, FS8       | CS1, SG21                               |
| Mesic pine flatwoods (Pm)  | Woodland community, open canopy dominated by *Pinus elliottii*. Understory dominated by *Serenoa repens* and sparse groundcover. Woodland community, open canopy dominated by *Pinus elliottii*. Understory dominated by *Serenoa repens* and sparse groundcover. | NA                       | CS4, SG4, SG6, SG8, SG9                 |
Table 2. Frequency of occurrence for ant species collected in the western Everglades, categorized by habitat and hydrologic condition (HI = hydrologically impacted, or HU = hydrologically unaltered). * = exotic species; () = number of sites; [] = nesting preference; S.R. = species richness.

| Species                              | Cypress | Cypress with graminoid | Wet prairie | Hydric hammock | Mesic hammock | Freshwater marsh | Saltwater marsh | Hydric pine flatwood | Mesic pine flatwood |
|--------------------------------------|---------|------------------------|-------------|----------------|---------------|------------------|-----------------|----------------------|---------------------|
|                                      | HU      | HI                     | HU          | HI             | HI            | HI               | HI              | HI                   | HI                  |
|                                      | (2)     | (8)                    | (3)         | (5)            | (1)           | (2)              | (1)             | (2)                  | (4)                  |
| Aphaenogaster miamiana Wheeler [ground] | 0       | 20.6                   | 0           | 14             | 0             | 3.8              | 10              | 35                   | 0                   |
| Brachymyrmex obscurocerifrons [ground] | 0       | 0                      | 0           | 2              | 0             | 2.3              | 10              | 0                    | 0                   |
| Camponotus decipiens Emery [arboreal] | 0       | 0                      | 0           | 0              | 0             | 0                | 5               | 0                    | 0                   |
| Camponotus floridanus (Buckley) [ground] | 31.6    | 16.2                   | 8.3         | 20             | 2.3           | 14.1             | 20              | 35                   | 20                  |
| Camponotus impressus (Roger) [arboreal] | 0       | 0                      | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Camponotus inaequalis Roger [ground] | 0       | 31.6                   | 16.2        | 8.3            | 20            | 14.1             | 20              | 35                   | 20                  |
| Camponotus planatus* Roger [arboreal] | 5.3     | 0                      | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Cardiocondyla emeryi* Forel [ground] | 0       | 0                      | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Cardiocondyla nuda* (Mayr) [ground]  | 0       | 0                      | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Cardiocondyla obscurior* Wheeler [arboreal] | 0       | 0                      | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Cardiocondyla wrauthii* (Forel) [ground] | 0       | 2.9                    | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Crematogaster ashmeadi Mayr [arboreal] | 5.3     | 26.5                   | 20.8        | 24             | 4.5           | 15.4             | 0               | 20                   | 0                   |
| Crematogaster atkinsoni Wheeler [arboreal] | 15.8    | 20.6                   | 12.5        | 20             | 50            | 26.9             | 0               | 20                   | 50                  |
| Crematogaster pilosa Emery [arboreal] | 0       | 1.5                    | 0           | 2              | 0             | 0                | 0               | 0                    | 0                   |
| Crematogaster pinicola Deyrup & Cover [arboreal] | 0       | 0                      | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Cyphomyrmex minutus* Mayr [ground]   | 0       | 0                      | 0           | 12.5           | 0             | 11.4             | 13              | 0                    | 10                  |
| Dorymyrmex bureni (Trager) [ground]   | 0       | 2.9                    | 0           | 14             | 4.5           | 11.5             | 0               | 5                    | 0                   |
| Formica archboldi M.R. Smith [ground] | 0       | 5.3                    | 1.5         | 4.2            | 24            | 6.8              | 17.9            | 0                    | 0                   |
| Hypoponera opaciceps* (Mayr) [ground] | 0       | 0                      | 0           | 12.5           | 0             | 2.6              | 10              | 0                    | 12.5                |
| Monomorium viride Brown [ground]     | 0       | 10.5                   | 4.2         | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Nylanderia bourbonica* (Forel) [ground] | 0      | 10.3                    | 0           | 10             | 0             | 2.6              | 30              | 0                    | 5                   |
| Nylanderia concinna (Trager) [ground] | 26.3    | 8.8                    | 29.2        | 12             | 11.4           | 13               | 10              | 0                    | 0                   |
| Nylanderia steinheili* (Forel) [ground] | 26.3    | 22.1                   | 0           | 16             | 2.3           | 0                | 30              | 45                   | 0                   |
| Paratrechina longicornis* (Laterelle) both | 0      | 0                      | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Pheidole dentata Mayr [ground]       | 0       | 0                      | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Pheidole floridana Emery [ground]    | 31.6    | 29.4                   | 25          | 12             | 2.3           | 6.4              | 60              | 25                   | 0                   |
| Pheidole moerens* Wheeler (both)     | 68.4    | 50                     | 50          | 42             | 18.2          | 11.5             | 50              | 55                   | 40                  |
| Platythyrea punctata (F. Smith) [both] | 5.3     | 1.5                    | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Pseudomyrmex exiguum (F. Smith) [arboreal] | 26.3    | 23.5                   | 20.8        | 28             | 4.5           | 10.3             | 40              | 15                   | 30                  |
| Pseudomyrmex elongatulus (Mayr) [arboreal] | 0      | 2.9                    | 0           | 0              | 0             | 0                | 0               | 0                    | 0                   |
| Pseudomyrmex gracilis* Santschi [arboreal] | 10.5    | 29.4                   | 25          | 30             | 2.3           | 16.7             | 20              | 30                   | 0                   |
| Pseudomyrmex pallidus (F. Smith) [arboreal] | 10.5    | 8.8                    | 0           | 16             | 4.5           | 16.7             | 0               | 10                   | 0                   |
| Pseudomyrmex seminole Ward [arboreal] | 5.3     | 1.5                    | 4.2         | 12             | 6.8           | 7.7              | 0               | 0                    | 20                  |
| Pseudomyrmex simplex (F. Smith) [arboreal] | 10.5    | 1.5                    | 0           | 4              | 0             | 1.3              | 0               | 0                    | 12.5                |
Table 2. Continued. Frequency of occurrence for ant species collected in the western Everglades, categorized by habitat and hydrologic condition (HI = hydrologically impacted, or HU = hydrologically unaltered). *

| Species                      | Wet prairie | Cypress with graminoid | Major pine woodland | Hydric pine flatwood | Saltwater marsh | Freshwater marsh | Hydric hammock | Mesic hammock | Cypress | S.R. |
|------------------------------|-------------|------------------------|---------------------|----------------------|-----------------|-----------------|---------------|--------------|----------|------|
| Solenopsis geminata (Fabricius) [ground] | 41.7 | 74 | 67.7 | 30 | 55 | 61.8 | 90 | 0 | 11.5 | 12.5 |
| Solenopsis globularia * Buren [ground] | 21.1 | 26.5 | 3.8 | 0 | 0 | 1.3 | 0 | 0 | 0 | 0 |
| Solenopsis invicta (Say) | 5.3 | 2.9 | 0 | 2 | 4 | 0 | 10 | 0 | 0 | 0 |
| Pheidole moerens (Roger) [both] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aphaenogaster miamiana Mayr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crematogaster atkinsoni | 21.8 | 17 | 28 | 20 | 10 | 4 | 15 | 35 | 15 | 15 |
| Pheidole emeryi [ground] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pheidole dentata | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tapinoma melanocephalum | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tapinoma sessile (Say) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wasmannia auropunctata * Roger [both] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pseudomyrmex spp. | 65 | 25 | 15 | 10 | 20 | 4 | 15 | 35 | 15 | 15 |

Discussion

Distribution of ant species in any given plant community is typically a function of habitat suitability, behavioral traits, and competitive interactions among species (Rosengren 1986; Hölldobler & Wilson 1990). Ants have proven to be good indicator taxa because many species have narrow tolerances and often respond quickly to environmental changes (Kaspari & Majer 2000). Terrestrial macroinvertebrate surveys in Picayune Strand State Forest indicated that approximately half of the ant species sampled was associated with specific plant communities (Addison et al. 2006; Bartoszek et al. 2007, 2011). Of the 48 species of ants documented during this study, certain taxa were clearly more abundant than others; future changes in abundance will help indicate ecological responses to hydrologic change. These abundant species are likely to be better indicators of hydrologic change than those that were collected only occasionally.

The availability of nest sites for individual species is likely to change post-restoration. If hydrologic restoration results in the expected higher water tables and longer hydroperiods, nests of ground-nesting species would likely be inundated. Species tolerant of wet conditions could immigrate into previously over-drained wetlands. If their sources of forage are impacted, plant-nesting species may be affected by higher water tables and longer hydroperiods, nests of ground-nesting species are likely to be better indicators of hydrologic change than those that were collected only occasionally.

Hydrologic restoration of PSSF is expected to result in successional changes in the plant community structure that should be reflected in changes in ant distributions. Ant surveys in PSSF revealed that approximately half of the ant species had affinities to specific plant communities.

The 48 species of ants collected during these surveys are a representative example of the ants occurring in Collier County, Florida. Time and funding prevented us from using additional collection methods. The use of aspiration, pit-fall traps, and soil sampling and utilizing...
different baits in the vials likely would have documented additional species. Two studies within Everglades National Park done by Clouse (1999) and Ferster & Prusak (1994) found 77 species, 28 of which were exotics, compared with this study that identified 48 species, 15 of which were exotics. Eleven species were identified in Collier County that were not identified in these previous studies.

The reasons for differences in species composition of ants found in the HI and HU sites are not clear. Neither are differences in ant species composition between and among the plant communities sampled; the causes of these differences are beyond the scope of this survey. It is likely that a reduction in abundance of terrestrial species such as S. invicta and P. dentata will occur after hydrologic restoration of PSSF if this leads to long-seasonal inundation. Plant-nesting species such as C. atkinsoni, Pseudomyrmex pallidus (F. Smith), Pseudomyrmex seminole Ward, and P. ejectus might increase in abundance in the restored freshwater wetlands if this leads to an increase in the density of perennial vegetation in the form of trees, shrubs, and large bunch grasses. After the expected ecosystem shifts stabilize in the restoration areas, it would be useful to repeat these surveys to assess any changes in the distribution of the ant species at the sampling sites.

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