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Species composition of forested natural communities near freshwater hydrological features in an urbanizing watershed of west central Florida

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Biological Sciences

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Abstract Natural communities near freshwater hydrological features provide important ecosystem functions and services. As human populations increase, forested landscapes become increasingly fragmented and deforested, which may result in a loss of the functions and services they provide. To investigate the current state of forested natural communities in the rapidly urbanizing Tampa Bay Watershed, this study examined a systematic random sample of fixed radius 0.04 hectare (0.10 acre) plots that were located within 15.2 meters of a hydrologic feature. These 85 plots were further stratified based on site legacy, and were categorized into three groups: remnant (43 plots), emergent (23 plots), and altered (19 plots). A hierarchical agglomerative cluster analysis identified plots that were most similar to one another within each group. These clusters were then compared to Florida Natural Area Inventory (FNAI) descriptions of natural community types. A high degree of clusters in the remnant and emergent groups resembled natural community types, but variations in species composition and dominance also occurred. However, zero clusters in the altered group resembled natural community types, suggesting anthropogenic changes to the landscape have impacted natural plant community assemblages. Findings from this study fill a gap in our current understanding of how natural communities in the Tampa Bay Watershed differ from those in a non-urban context.

Keywords Freshwater, natural communities, urbanizing watershed, west central Florida

Introduction

As human populations increase, forested landscapes become increasingly fragmented and deforested (Alberti 2005). Forest fragmentation and removal alters natural processes such as hydrology (Haag and Lee 2010) and fire regimes (Duncan and Schmalzer 2004). For instance, the quantity and quality of freshwater have been reduced because of anthropogenic changes to the

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landscape that have resulted in modifications to hydrologic regimes, an increase in nutrients and pollutants into freshwater resources, and the over use of freshwater resources (FDEP 2003, FDEP 2005). These changes can also cause shifts in species composition and structure of remaining forest fragments (Zipperer 2002a), which may modify how they function and thus the services they provide (Alberti 2008, Grimm et al. 2008, Vitousek et al. 2008).

Forest communities near freshwater hydrological features play an integral role in the quantity and quality of freshwater resources by intercepting, absorbing, and storing precipitation; recharging groundwater supplies; and filtering pollution and excess nutrients. In addition, these communities help regulate storm water flows and thus reduce flooding, regulate water temperatures, and provide critical habitat for fish and wildlife (Sprague et al. 2006, Haag and Lee 2010).

The state of Florida is rapidly urbanizing, with 30% of the region's population increase occurring over the last 20 years (U.S. Census Bureau 2012). Zwick and Carr (2006) estimated that central Florida is expected to experience more growth than any other region of the state by 2060. As of 2010, the U.S. Census Bureau (2012) estimated that Hillsborough County, FL was the 4th most populous county in the state and the most populous county in the Tampa Bay Watershed.

A limited number of studies have investigated forested communities near freshwater hydrological features within an urban context in the Southeastern U.S. (Burton et al. 2005, Lowenstein and Lowenstein 2005, Burton and Samuelson 2008). While some studies have investigated natural communities in Florida (e.g. Gunderson 1977, Wharton et al. 1982, Vince et al. 1989, Light et al. 2002, Darst and Light 2008), they generally focused on one community type and their studies took place within known natural areas. In addition, many classification systems are used to identify forested natural communities in Florida (FDOT 1999, Kawula 2009, FNAI 2010). Though all are primarily descriptive in nature, they are useful in classifying natural community types within the Florida landscape. Of all resources, Florida Natural Areas Inventory (FNAI) provides the most comprehensive and detailed descriptions of natural community types in the state.

In this study, we quantified, identified, and examined multiple forested natural community types located within the urban and urbanizing context of the Tampa Bay Watershed, and compared them to FNAI's (2010) descriptions of natural community types. Findings from this study not only fill a gap in our current understanding of how these communities differ from those in a non-urban context in Florida, but also add to the existing body of literature presently available on freshwater forested natural communities in Florida and the Tampa Bay Watershed.

Materials and Methods

The 78,220 hectare (ha) study area was located near the west coast of Florida in Hillsborough and Pasco counties, and included the City of Tampa proper and the sub-basin watersheds adjacent to the city (Figure 1). The study area sits between two major basins, the Tampa Bay Basin and Tampa Bay Tributaries Basin, both of which make up the Tampa Bay Watershed. Average annual temperature within the study area was 23°C and average annual precipitation was 118 centimeters (cm) (FCC 2014).

A systematic random sampling design, represented by a hexagonal grid, was projected over the 78,220 ha study area, and was used to create the Tampa Bay Watershed Urban Ecological Assessment (Andreu et al. 2008). Each hexagon consisted of 177 ha, and a randomly generated fixed radius 0.04 ha (0.10 acre [ac]) plot was located within each hexagon. A subset of plots that occurred within 15.2 meter (m) (50 feet [ft]) of freshwater hydrological features, including rivers, streams, lakes, canals, and ponds, regardless of whether they were natural or anthropogenic in origin, were selected for this study, and resulted in a total of 85 plots that met this criteria (Figure 1).

Plot data were collected from February 2007 through July 2008 and consisted of 2 strata: tree and shrub. The tree stratum included all woody stems ≥2.5 cm (1 inch [in]) in diameter at breast height (DBH; 1.37 m), and the shrub stratum consisted of woody plants that were at least 0.3 m (1 ft) tall with a DBH <2.5 cm. The methodology for data collection followed guidelines suggested by Nowak et al. (2003) for an urban ecological analysis. Data collected for trees included species, crown width, and DBH. For shrubs, percent cover by species was estimated ocularly. In addition, the percent of actively maintained (mowed) grass was also estimated ocularly. Trees and shrubs were identified to genus, with most trees and shrubs identified to specific epithet; nomenclature followed Godfrey (1988). Native species were defined as those with a native range that included Florida, and non-native species were defined as those with a native range that did not include Florida. Range determination was made with the use of Godfrey (1988) and the USDA Natural Resource Conservation Service online plants database (2010). In cases where vegetation could not be identified beyond genera, genera with species that were solely native to Florida were considered native and genera with species solely introduced to Florida were considered non-native. Genera with both native and non-native species in Florida were not given a nativity status. Native species known to colonize disturbed sites (Godfrey 1988) but not considered common to natural community types in Florida (FNAI 2010) were considered 'weedy natives.' Invasive species were identified using the most up-to-date list provided by the Florida Exotic Pest Plant Council (FLEPPC) (2013), and the University of Florida's Center for Aquatic and Invasive Plants online database (2014). Category I invasives are species that have altered native plant communities, changed community structure and function, or have hybridized with native species, and are therefore deemed to cause ecological damage (FLEPPC 2013).

Sample plots were stratified into three groups: remnant, emergent, and altered. Plots without actively mechanically maintained grass were considered "forested," and plots with actively mechanically maintained grass were considered "altered." The forested plots were further stratified by legacy - remnant and emergent (Zipperer 2002b). Remnant plots occurred in forest patches that had canopy closure on 1948 and 2007 aerial photographs, and emergent plots lacked canopy closure in 1948 but had closure on 2007 aerial photographs. In other words, remnant plots were assumed to have remained in a forested condition from 1948 through 2007, whereas emergent plots became forested by 2007. Out of 85 plots, 43 were remnant, 23 were emergent, and 19 were altered.

A hierarchical agglomerative cluster analysis was conducted for each group in order to identify plots that were most similar within them (Kachigan 1991, McCune and Grace 2002). A data matrix of importance values (IV) (IV = [(relative basal area + relative crown cover + relative density)/3]*100) for each tree species within each plot was used for cluster analyses. A combination of the Sørensen distance measure and flexible β group linkage method of −.25 was used for each cluster run to avoid distortion in outputs (McCune and Grace 2002); thus plots that were more similar to one another clustered closer together (Gotelli and Ellison 2004). Results from each cluster analysis were viewed using a dendrogram tree scaled by Wishart's (1969) objective function. Community clusters were determined based on the distance at which the dendrogram tree was pruned. Optimal pruning distance was guided by two factors. Firstly, long limbs in a dendrogram tree lead to an umbrella of more homogeneous plots and denoted community types more likely to

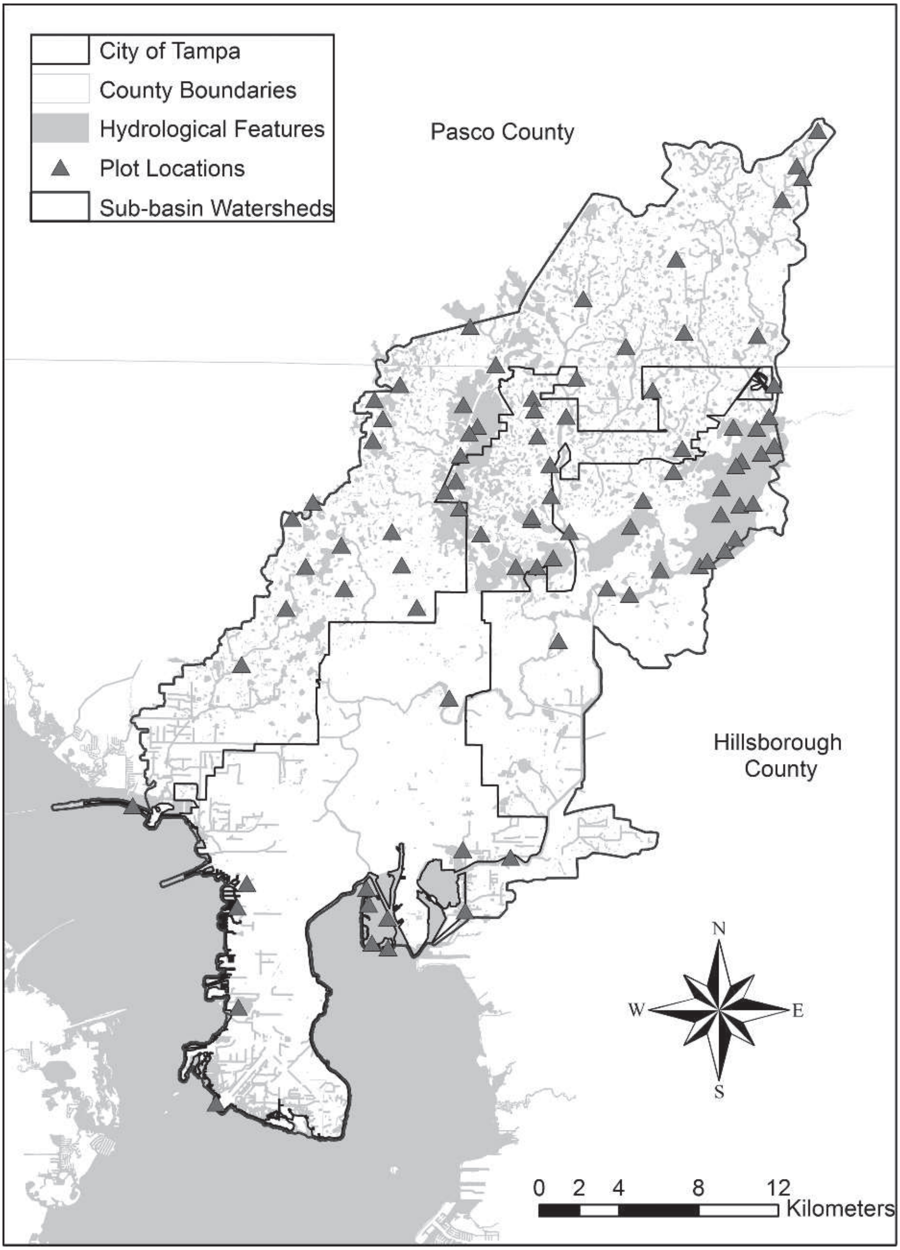

Figure 1. Plot locations near hydrological features in Tampa, FL and the surrounding sub-basin watersheds.

occur in nature, and secondly, clustered plots needed to be biologically meaningful (McCune and Grace 2002).

For each cluster a mean IV was calculated for each species in the tree (IV = [(relative basal area + relative cover + relative density)/3]*100) and shrub (IV = [(relative cover + relative

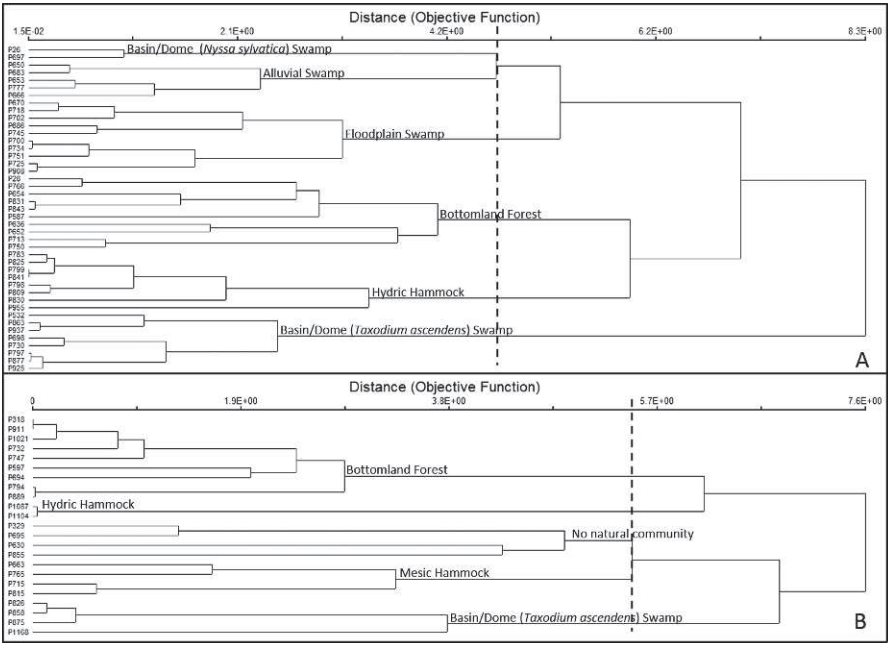

Figure 2. Cluster results for remnant (A) and emergent (B) groups scaled by Wishart's (1969) objective function.

frequency)/2]*100) strata. Those species that collectively accounted for ≥ 75% of the total species importance (species IV's were summed in order from greatest to least until an IV of at least 75% was reached) were considered dominant. Species composition and dominance within a cluster were then compared to FNAI descriptions of natural community types in Florida (FNAI 2010). Species described as being common to a natural community type by FNAI but with a range outside of central Florida (specific to south or north Florida) were not considered in this analysis.

Results

Cluster analyses. The cluster analysis of the remnant group resulted in 6 distinct clusters that resembled 5 natural community types, with one community type having two variations (Figure 2A). Four of the community clusters resembled alluvial forest, bottomland forest, floodplain swamp, and hydric hammock community types, respectively. The remaining two clusters resembled a combination of basin swamp and dome swamp community types. Both community types are similar in their species composition and dominance, but are distinguished by the presence of adjacent pyrogenic communities (dome swamps always occur adjacent to pyrogenic communities and basin swamps may or may not occur adjacent to such communities) and peat accumulation (basin swamps accumulate more peat than dome swamps) (FNAI 2010). Neither of these attributes were collected in this study, so both community clusters were characterized as basin/dome swamps, with one dominated by

Table 1. Importance values (IV) of dominant tree species for community clusters in the remnant group within the Tampa Bay Watershed, FL. Species not considered common to natural community types described by FNAI (2010) have a line under their IV. Community clusters that resembled natural community types are as follows: AF - alluvial forest, BDNS - basin/dome swamp (*Nyssa sylvatica*), BDTA - basin/dome swamp (*Taxodium ascendens*), BF - bottomland forest, FS - floodplain swamp, and HH - hydric hammock.

	AF	BDNS	BDTA	BF	FS	HH
Acer rubrum	12.0	22.9	4.9	9.2		
Callicarpa americana						21.6
Carya glabra				7.6		
Cephalanthus occidentalis	4.7					
Fraxinus spp.	46.3					
Liquidambar styraciflua				13.6		12.0
Magnolia virginiana		10.7				
Nyssa sylvatica		46.1			10.1	
Quercus laurifolia			14.8[a]	28.2	15.0	
Quercus nigra						8.1
Sabal palmetto				9.0		34.8
Taxodium ascendens			56.1			
Taxodium distichum	16.3			5.7	41.4	
Ulmus americana				5.8	11.8	

[a] Common to basin swamps (FNAI 2010)

Nyssa sylvatica; basin/dome swamp (*N. sylvatica*), and one dominated by *Taxodium ascendens*; basin/dome swamp (*T. ascendens*).

The cluster analysis for the emergent group resulted in 5 distinct clusters that resembled 4 natural community types: basin/dome swamp (*T. ascendens*), bottomland forest, hydric hammock, and mesic hammock (Figure 2B). The remaining cluster that did not resemble a natural community type was not analyzed further in this paper.

The cluster analysis for the altered group resulted in zero clusters that resembled natural community types. Like the cluster in the emergent group that did not resemble a natural community type, the entire altered group was not analyzed further in this paper.

Remnant group. The alluvial forest community cluster was composed of 9 total species, 8 of which were considered common to the alluvial forest community type (Tables 1 and 2, Appendices 1 and 2). All 8 species were present in the tree stratum and made up a cumulative IV of 95.3. All but 1 of the dominant species in this same stratum were common to the alluvial forest community type. In the shrub stratum 6 of the 7 species present were common to the alluvial forest community type and made up a cumulative IV of 45.7. All but 1 of the dominant species in the shrub stratum were common to the alluvial forest community type.

The basin/dome swamp (*N. sylvatica*) community cluster was composed of 14 total species, 11 of which were common to the basin/dome swamp community type (Tables 1 and 2, Appendices 1 and 2). Eight of the 11 species

Table 2. Importance values (IV) of dominant shrub species for community clusters in the remnant group within the Tampa Bay Watershed, FL. Species not considered common to natural community types described by FNAI (2010) have a line under their IV. Community clusters that resembled natural community types are as follows: AF - alluvial forest, BDNS - basin/dome swamp (*Nyssa sylvatica*), BDTA - basin/dome swamp (*Taxodium ascendens*), BF - bottomland forest, FS - floodplain swamp, and HH - hydric hammock.

	AF	BDNS	BDTA	BF	FS	HH
Acer rubrum		10.8	7.3	2.8	8.7	
Baccharis halimifolia			6.5			
Callicarpa americana				4.5		11.6
Cephalanthus occidentalis	54.3	22.2	14.8			
Fraxinus spp.	12.2				6.5	
Gleditsia spp.				3.2		
Itea virginica					15.9	
Liquidambar styraciflua				5.9		6.6
Ludwigia peruviana[†]			19.2			
Lyonia lucida		24.4	16.2			
Myrica cerifera		10.8	12.3	4.9		
Persea borbonia		8.5				3.4
Prunus serotina				3.4		
Quercus laurifolia					34.8	
Sabal minor				13.9		
Sabal palmetto				30.7	12.6	43.1
Serenoa repens				6.4		13.4
Taxodium distichum	11.3					

[†] Category I invasive species (FLEPPC 2013)

were present in the tree stratum and made up a cumulative IV of 97.4. Among these, 3 dominated this same stratum. In the shrub stratum 6 of the 8 species present were common to the basin/dome swamp community type and made up a cumulative IV of 83.6. All but 1 of the dominant species were common to the basin/dome swamp community type.

The basin/dome swamp (*T. ascendens*) community cluster was composed of 27 total species, 17 of which were common to the basin/dome swamp community type (Tables 1 and 2, Appendices 1 and 2). Sixteen of the 17 species were present in the tree stratum and made up a cumulative IV of 93.0. All dominant species in this same stratum were common to the basin/dome swamp community type. One category I invasive species, *Sapium sebiferum*, was also present in the tree stratum but had an IV <1. In the shrub stratum 9 of the 17 species present were common to the basin/dome swamp community type and made up a cumulative IV of 62.4. Two of the 6 dominant species in this stratum were not common to the basin/dome swamp community type, and included the category I invasive *Ludwigia peruviana* and the weedy native *Baccharis halimifolia* (Godfrey 1988). Though two additional category I invasives (*S. sebiferum* and *Schinus terebinthifolius*) were present in this community cluster, they made up just 3% of the species importance in the shrub stratum. However, this increased the total IV of category I invasives in this same stratum to 22.6.

The bottomland forest community cluster was composed of 31 total species, 12 of which were common to the bottomland forest community type (Tables 1 and 2, Appendices 1 and 2). Ten of the 12 species were present in the tree stratum and made up a cumulative IV of 70.6. All but 1 of the dominant species were considered common to the bottomland forest community type. Six of the 24 species present in the shrub stratum were common to the bottomland forest community type and made up a cumulative IV of 30.5. All but 3 of the dominant species in this same stratum were considered common to the bottomland forest community type. In addition, 4 of the species present in the bottomland forest community cluster were non-native: *Citrus aurantium, Peltophorum pterocarpum, Cinnamomum camphora, and S. sebiferum,* with the latter two listed as category I invasives. Of these, all were present in the shrub stratum, though each had an IV <2, and only *P. pterocarpum* was also present in the tree stratum, though it contributed less than 3% to the total IV in this stratum.

The floodplain swamp community cluster was composed of 18 total species, 13 of which were common to the floodplain swamp community type (Tables 1 and 2, Appendices 1 and 2). Nine of the 13 species were present in the tree stratum and made up a cumulative IV of 94.2. Of these, 4 species dominated this same stratum. Eight of the 10 species present in the shrub stratum were also common to the floodplain swamp community type and made up a cumulative IV of 90.9. Of these, 6 species made up the dominant species in this same stratum.

The hydric hammock community cluster was composed of 26 total species, 14 of which were common to the hydric hammock community type (Tables 1 and 2, Appendices 1 and 2). Twelve of the 14 species were present in the tree stratum and made up a cumulative IV of 94.3. Among these, 4 species dominated the tree stratum. *C. aurantium*, a non-native species, was present in this stratum but contributed <1% of the total IV. Nine of the 16 species present in the shrub stratum were common to the hydric hammock community type and made up a cumulative IV of 76.5. All but 2 of the dominant species in this same stratum were considered common to the hydric hammock community type.

Emergent group. The basin/dome swamp community cluster (*T. ascendens*) was composed of 16 total species, 10 of which were common to the basin/dome swamp community type (Tables 3 and 4, Appendices 3 and 4). Eight of the 10 species were present in the tree stratum and made up a cumulative IV of 89.1. All but 1 of the dominant species in this same stratum were common to the basin/dome swamp community type. Eight of the 12 species present in the shrub stratum were common to the basin/dome swamp community type and made up a cumulative IV of 57.9. Ten species were dominant in this same stratum but only 6 were common to the basin/dome swamp community type. Two of the dominant species uncommon to basin/dome swamps included the weedy native *Rubus* spp. and the category I invasive *L. peruviana*.

Table 3. Importance values (IV) of dominant tree species for community clusters in the emergent group within the Tampa Bay Watershed, FL. Species not considered common to natural community types described by FNAI (2010) have a line under their IV. Community clusters that resembled natural community types are as follows: BDTA - basin/dome swamp (*Taxodium ascendens*), BF - bottomland forest, HH - hydric hammock, and MH - mesic hammock.

	BDTA	BF	HH	MH
Fraxinus spp.		6.0		
Liquidambar styraciflua				11.8
Magnolia virginiana	16.9			
Myrica cerifera		11.5		
Nyssa sylvatica		14.3		
Persea borbonia	10.3			
Pinus elliottii				18.6
Quercus geminata				6.6
Quercus laurifolia	11.9[a]	34.7		
Quercus nigra				28.1
Quercus virginiana			83.0	6.1
Sabal palmetto				8.8
Taxodium ascendens	44.3			
Taxodium distichum		12.7		

[a] Common to basin swamps (FNAI 2010)

The bottomland forest community cluster was composed of 26 total species, 10 of which were common to the bottomland forest community type (Tables 3 and 4, Appendices 3 and 4). Nine of the 10 species were present in the tree stratum and had a cumulative IV of 80.3. All but 1 dominant species were common to the bottomland forest community type. Five of the 17 species present in the shrub stratum were common to the bottomland forest community type and made up a cumulative IV of 47.1. Eight species were dominant in this same stratum but only 4 were common to the bottomland forest community type. One of the dominant species uncommon to bottomland forests was the weedy native *Rubus* spp. Two category I invasive species were also present; *L. peruviana* and *S. sebiferum*, with the former species contributing <2% to total shrub species importance and the latter species contributing <4% to total tree species importance.

The hydric hammock community cluster was composed of 8 total species, 4 of which were common to the hydric hammock community type (Tables 3 and 4, Appendices 3 and 4). Two of the 4 were present in the tree stratum and made up a cumulative IV of 95.3. One species dominated this same stratum. Two of the 6 species present in the shrub stratum were common to the hydric hammock community type and made up a cumulative IV of 44.9. Of the 4 dominant species in this stratum, only 1 was common to the hydric hammock community type, and 2 others consisted of a weedy native (*B. halimifolia*) and a category I invasive (*C. camphora*).

The mesic hammock community cluster was composed of 21 total species, 12 of which were common to the mesic hammock community type (Tables 3 and 4, Appendices 3 and 4). Eight of the 12 were present in the tree stratum and

Table 4. Importance values (IV) of dominant shrub species for community clusters in the emergent group within the Tampa Bay Watershed, FL. Species not considered common to natural community types described by FNAI (2010) have a line under their IV. Community clusters that resembled natural community types are as follows: BDTA - basin/dome swamp (*Taxodium ascendens*), BF - bottomland forest, HH - hydric hammock, and MH - mesic hammock.

	BDTA	BF	HH	MH
Acer rubrum		4.0		
Baccharis halimifolia			13.4	
Callicarpa americana			33.0	
Cephalanthus occidentalis	5.6			
Cinnamomum camphora†			15.0	
Ilex cassine	5.6	4.4		
Liquidambar styraciflua				7.1
Ludwigia peruviana†	9.8			
Ludwigia spp.$				6.9
Lyonia lucida	12.4			
Magnolia virginiana	5.6			
Myrica cerifera	14.5	26.5		
Persea borbonia		4.1		
Quercus laurifolia		10.3		3.5
Rubus spp.	12.7	4.7		
Sabal palmetto	5.6	9.5		7.2
Salix caroliniana				3.9
Schinus terebinthifolius†				3.5
Serenoa repens	14.1	13.8	16.5	40.4
Taxodium ascendens	5.6			
Taxodium distichum				3.5
Vaccinium arboreum				4.3
Vaccinium corymbosum				3.5

† Category I invasive species (FLEPPC 2013)
$ No nativity status

made up a cumulative IV of 85.5. Of the 6 dominant species, all but 1 were considered common to the mesic hammock community type. Seven of the 15 species present in the shrub stratum were common to the mesic hammock community type and made up a cumulative IV of 69.0. Five of the 10 dominant species in this same stratum were common to the mesic hammock community type, with one of the dominant species uncommon to mesic hammocks being a category I invasive (*S. terebinthifolius*).

Discussion

All clusters in the remnant group and all but one cluster in the emergent group had a species composition and dominance that resembled natural community types described by FNAI (2010). By comparison, none of the clusters in the altered group had a species composition or dominance that resembled natural community types. The absence of natural community resemblance in the altered group was not surprising, since it was composed of sample plots that had actively maintained grass. Maintained grass implies management that inhibits natural forest dynamics not only by reducing woody recruitment

(Zipperer 2002a, Burton and Samuelson 2008) but also by removing existing vegetation (Sharpe et al. 1986) and replacing it with introduced species (Walker et al. 2009). Furthermore, maintained grass is associated with landcover that has either been completely changed or severely modified for anthropogenic uses (e.g. pastureland and developed lands such as those classified for residential and commercial purposes) (FNAI 2010).

While species composition and dominance of community clusters in both remnant and emergent groups concurred with that of natural community types described by FNAI (2010), variations in these same community characteristics were also observed. These variations may be attributed to species overlap between community types that naturally occur adjacent to or transition into one another, and/or may also be attributed to changes in disturbance regimes such as hydroperiods and fire frequency. For instance, *Serenoa repens* was a dominant component of the shrub stratum in the remnant bottomland forest and hydric hammock community clusters, in addition to all of the emergent community clusters (Tables 2, 3, and 4). While FNAI (2010) reports that *S. repens* is common only to the mesic hammock community type, they also recognize that *S. repens* can be found in transitional zones between mesic and hydric hammocks, the drier portions of hydric hammocks, and in mesic and hydric hammocks that occur adjacent to or within the drier portions (higher elevations) of bottomland forests. In addition, *S. repens* is common to pyrogenic community types that have basin/dome swamps interspersed within them (FNAI 2010), and may explain its presence and dominance in this community cluster as well.

Taxodium distichum was a dominant component of the tree stratum in the remnant alluvial forest community cluster and both the remnant and emergent bottomland forest community clusters. Though FNAI (2010) reports this species as being a minor component of both of these community types, they also describe *T. distichum* as being a dominant component of the tree stratum in floodplain swamps, a community type that occurs adjacent to or intermixed with both alluvial and bottomland forest community types (FNAI 2010). In addition, Godfrey (1988) described *T. distichum* as being typically found where surface water is present most of the time, a characteristic exhibited by floodplain swamps, versus the comparatively shorter hydroperiods of both alluvial and bottomland forest community types (FNAI 2010). Though hydroperiodicity was not measured in this study, *T. distichum* dominance in alluvial and bottomland forest community clusters may reflect longer hydroperiods for our sites than those observed by FNAI (2010).

Though *Quercus* spp. were considered common to every community type resembled in this study, their presence and dominance in both the remnant and emergent hydric hammock community clusters are notable. FNAI (2010) described hydric hammocks as having a canopy dominated by *Quercus laurifolia* and/or *Quercus virginiana*, with co-dominance commonly shared by *Sabal palmetto*. In the remnant hydric hammock community cluster, the most dominant tree species was *S. palmetto* (IV = 34.8), with *Q. laurifolia* and

Q. virginiana cumulatively making up just 12% of the tree species importance. By comparison, 95% of the tree species importance in the emergent hydric hammock community cluster was made up of both *Q. laurifolia* (12%) and *Q. virginiana* (83%), while *S. palmetto* was completely absent. Vince et al. (1989) noted that *Quercus* spp., particularly *Q. virginiana*, was most abundant in the less frequently inundated hydric hammocks they sampled, whereas *S. palmetto* can occur on sites with longer hydroperiods. Their observations suggest that the remnant hydric hammock community cluster in this study may be more frequently inundated than the emergent hydric hammock community cluster. In addition, it is possible emergent sites were used for agricultural purposes prior to abandonment, suggesting these sites may have been drier for a longer period of time during a given year.

Fire, or lack thereof, can also affect species composition and dominance of community types represented in this study. For instance, mesic hammocks naturally develop in fire protected areas (FNAI 2010). Though species composition and dominance of this community cluster resembled the mesic hammock community type described by FNAI (2010), *Q. virginiana* and *S. palmetto* are associated with older mesic hammocks, whereas *Quercus nigra* and *Quercus hemisphaerica* are associated with younger, more recently established mesic hammocks (FNAI 2010). In the mesic hammock community cluster, *Q. nigra* and *Q. hemisphaerica* had a greater cumulative IV (30.7) than *Q. virginiana* and *S. palmetto* (14.9). The greater importance of *Q. nigra* and *Q. hemisphaerica* suggests that this community cluster may have been more recently established. Furthermore, its presence solely in the emergent group further supports the notion that this mesic hammock was more recently established.

Our analysis also observed the presence of category I invasive species in the remnant basin/dome swamp (*T. ascendens*) and bottomland forest community clusters, and all community clusters in the emergent group. *C. camphora*, *L. peruviana*, *S. sebiferum*, and *S. terebinthifolius* are all known to inhabit disturbed wet sites (Godfrey 1988, Langeland and Burks 1998). However, *S. sebiferum* is the only category I invasive that did not exhibit dominance, while the other three species were a dominant component solely in the shrub stratum. The presence of category I invasives in both remnant and emergent groups raises concerns that species composition may become increasingly dominated by such over time, since category I invasives are known to alter native plant communities by out competing native species (FLEPPC 2013).

At least one of the following weedy native species: *B. halimifolia*, *Rubus* spp., and *Salix nigra*, was present in the shrub stratum of the remnant and emergent basin/dome swamp (*T. ascendens* and *T. distichum*) and bottomland forest community clusters, and the emergent hydric hammock community cluster. These weedy native species are known to colonize wet sites that have experienced some form of disturbance (Godfrey 1988). In addition, Gordon (1998) suggested that the presence of weedy native species would likely increase with the presence of invasive species. Interestingly, 83% of all community clusters with invasive species had the presence of weedy native species, while just 25% of all community clusters without invasive species had the presence of weedy native species. Such an occurrence suggests that species homogeneity may increase overtime and thus reduce species diversity (Gordon 1998) in the natural community types represented in this study.

Conclusion

Analysis from this study identified five discernible outcomes: 1) cluster analyses of forested groups resulted in a high degree of clusters that resembled natural community types described by FNAI (2010), 2) variation occurred in species composition and dominance between community clusters and the natural community types they resembled, 3) the absence of natural community clusters in the altered group, 4) the presence of category I invasive species, and 5) the presence of weedy native species.

While all of the remnant community clusters and all but one of the emergent community clusters resembled natural plant communities, the presence of invasive and weedy native species suggests possible shifts in vegetation dynamics to communities associated with disturbances. This is further compounded by the possibility of changes in natural disturbance regimes such as lack of fire and altered hydroperiods, since both aid in reducing competition from other species that could otherwise establish themselves if the frequencies and intensities of these processes were to change (Wharton et al. 1982, Vince et al. 1989, USFWS 1999, Light et al. 2002, FNAI 2010).

The absence of natural community clusters in the altered group suggests that anthropogenic changes to the landscape have impacted natural plant community assemblages. Since natural communities near freshwater hydrological features play a critical role in water quality and availability by filtering pollution and excess nutrients and by recharging groundwater supplies (Sprague et al. 2006, Haag and Lee 2010), the absence of these communities in the altered group also suggests a loss of these ecosystem services.

Because population growth is ongoing in the Tampa Bay Watershed, it is important for policy and management to take a landscape approach at the watershed scale (Duryea and Hermansen 2002, FDEP 2008) and identify and implement strategies that ensure the presence and functionality of natural plant communities while minimizing human impacts on them, so that they continue to provide essential ecosystem services in the face of urbanization.

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Appendix 1. Importance values (IV) of remaining tree species for community clusters in the remnant group within the Tampa Bay Watershed, FL. Species not considered common to natural community types described by FNAI (2010) have a line under their IV. Community clusters that resembled natural community types are as follows: AF - alluvial forest, BDNS - basin/dome swamp (*Nyssa sylvatica*), BDTA - basin/dome swamp (*Taxodium ascendens*), BF - bottomland forest, FS - floodplain swamp, and HH - hydric hammock.

	AF	BDNS	BDTA	BF	FS	HH
Acer rubrum					7.6	0.1
Callicarpa americana						0.1
Carpinus caroliniana				2.4	1.0	
Carya aquatica	3.0			0.6	0.3	
Carya glabra					0.5	2.2
Celtis laevigata				3.4		1.1
Cephalanthus occidentalis		0.4	0.2			
Citrus aurantium[‡]						0.5
Cornus foemina			0.1[a]			
Cretaegus marshallii				0.5		
Fagus grandifolia						0.5
Fraxinus spp.				5.4	2.8	
Gleditsia spp.				0.8	0.6	
Ilex cassine		9.0	4.6	0.2	0.6	0.3
Ilex spp.[$]			0.3			
Liquidambar styraciflua			1.7[a]			
Lyonia lucida			0.1			
Magnolia grandiflora						0.3
Magnolia virginiana			0.6			3.2
Myrica cerifera		1.9	3.8		0.6	
Morus rubra						1.4
Nyssa sylvatica	3.8		3.0	1.3		0.3
Peltophorum pterocarpum[‡]				3.4		
Persea borbonia			3.2	0.5		
Persea palustris		3.5	1.1			
Pinus elliottii			0.6			
Prunus caroliniana			1.5			
Quercus laurifolia	5.9	2.9[a]				4.7
Quercus nigra			0.8[a]		3.1	
Quercus virginiana				0.8		7.6
Sabal palmetto			0.5			
Salix caroliniana	3.8		0.4[b]			
Sapium sebiferum[†]			0.5			
Taxodium ascendens				0.5	4.6	
Taxodium distichum		2.6	0.8			0.2
Ulmus americana	4.2		0.2			0.8
Viburnum obovatum				1.2		0.1

[†] Category I invasive species (FLEPPC 2013)
[‡] Non-native species
[$] No nativity status
[a] Common to basin swamps
[b] Common to dome swamps

Appendix 2. Importance values (IV) of remaining shrub species for community clusters in the remnant group within the Tampa Bay Watershed, FL. Species not considered common to natural community types described by FNAI (2010) have a line under their IV. Community clusters that resembled natural community types are as follows: AF - alluvial forest, BDNS - basin/dome swamp (*Nyssa sylvatica*), BDTA - basin/dome swamp (*Taxodium ascendens*), BF - bottomland forest, FS - floodplain swamp, and HH - hydric hammock.

	AF	BDNS	BDTA	BF	FS	HH
Acer rubrum	5.3					
Baccharis halimifolia				1.3		
Callicarpa americana					4.0	
Carpinus caroliniana						3.3
Carya aquatica				1.8		
Carya glabra				1.6		
Celtis laevigata				1.4		1.6
Cephalanthus occidentalis					4.4	
Citrus aurantium[‡]				1.8		
Cinnamomum camphora[†]				1.8		
Cretaegus spp.				1.4		
Cretaegus marshallii				1.4		
Fraxinus spp.				1.8		
Gleditsia spp.					4.0	
Gordonia lasianthus		7.8				
Ilex cassine						1.7
Itea virginica		7.6	5.3			
Magnolia virginiana						2.1
Myrica cerifera					5.1	1.7
Peltophorum pterocarpum[‡]				1.8		
Persea borbonia			1.8	1.6		
Persea palustris			1.8			
Prunus caroliniana				1.8		
Quercus hemisphaerica						1.7
Quercus laurifolia	5.3					1.7
Quercus nigra			1.4[a]			3.2
Sabal minor						1.6
Sabal palmetto			3.9			
Salix caroliniana	5.3		1.8[b]			
Sambucus nigra		7.8	1.8			
Sapium sebiferum[†]			1.6	1.8		
Schinus terebinthifolius[†]			1.4			
Taxodium ascendens			1.5			
Taxodium distichum			1.4			1.7
Ulmus americana	6.3			1.6	4.0	
Vaccinium arboreum						1.6
Viburnum obovatum				1.8		

[†] Category I invasive species (FLEPPC 2013)
[‡] Non-native species
[a] Common to basin swamps
[b] Common to dome swamps

Appendix 3. Importance values (IV) of remaining tree species for community clusters in the emergent group within the Tampa Bay Watershed, FL. Species not considered common to natural community types described by FNAI (2010) have a line under their IV. Community clusters that resembled natural community types are as follows: BDTA - basin/dome swamp (*Taxodium ascendens*), BF - bottomland forest, HH - hydric hammock, and MH - mesic hammock.

	BDTA	BF	HH	MH
Acer rubrum	1.4	2.7		
Callicarpa americana		0.6		
Cinnamomum camphora[†]			4.7	
Cretaegus marshallii		0.2		
Diospyros virginiana				0.3
Ilex cassine	4.7			
Ilex vomitoria		0.1		
Liquidambar styraciflua		0.4		
Lyonia lucida		1.3		
Myrica cerifera	3.6			
Persea borbonia		4.2		
Persea palustris	3.5			
Pinus palustris		0.4		
Prunus caroliniana	0.6			
Quercus hemisphaerica				2.6
Quercus laurifolia			12.3	2.9
Quercus nigra	2.8[a]			
Quercus virginiana		0.2		
Sabal palmetto		4.1		
Salix caroliniana				1.2
Sapium sebiferum[†]		3.2		
Schinus terebinthifolius[†]				1.4
Taxodium distichum				1.5
Ulmus americana		3.3		
Vaccinium arboreum				4.2
Vaccinium corymbosum				5.1
Viburnum obovatum				0.9

[†] Category I invasive species (FLEPPC 2013)
[a] Common to basin swamps
[b] Common to dome swamps

Appendix 4. Importance values (IV) of remaining shrub species for community clusters in the emergent group within the Tampa Bay Watershed, FL. Species not considered common to natural community types described by FNAI (2010) have a line under their IV. Community clusters that resembled natural community types are as follows: BDTA - basin/dome swamp (*Taxodium ascendens*), BF - bottomland forest, HH - hydric hammock, and MH - mesic hammock.

	BDTA	BF	HH	MH
Baccharis halimifolia		3.7		
Callicarpa americana		2.4		3.2
Diospyros virginiana		1.5		
Hypericum spp.		3.9		
Ludwigia peruviana†		1.9		
Lyonia ferruginea				3.3
Lyonia lucida		3.3		
Myrica cerifera				3.3
Nyssa sylvatica		1.8		
Persea palustris	4.4			
Prunus caroliniana			10.3	
Quercus laevis				3.3
Quercus laurifolia	4.4[a]			
Quercus nigra			11.8	
Sambucus nigra		2.0		
Viburnum obovatum				3.3
Viburnum odoratissimum‡		2.1		

† Category I invasive species (FLEPPC 2013)
‡ Non-native species
[a] Common to basin swamps