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# Composition and change of maritime hammock flora in east-central Florida after 20 years

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# Composition and Change of Maritime Hammock Flora in East-Central Florida After 20 Years

By

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THESIS

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# ABSTRACT

The vegetation of eight east-central Florida maritime hammocks studied in 1997 were compared to similar data collected over 20 years ago. Study sites are located in the northern half of the Indian River Lagoon system mostly within Canaveral National Seashore and Merritt Island National Wildlife Refuge. The upland hammock vegetation throughout the state generally has an oak-palm association, but here these species dominate. Results show that sabal palm, live oak, laurel oak, and pignut hickory, the four dominant tree species in 1976-77, are still dominant in 1997; however, there has been a loss in tree species richness. Most shrub species found during both studies increased in dominance over the 20 years and there was almost a complete turnover in the composition of herbs.

Variability in winter freeze events has caused a unique mixture of plant species to occur here. Many of the maritime hammock's tropical plants are in the northern limit of their range, giving these hammocks a unique ecotonal character. Tropical invasive exotics have increased in frequency, density, and basal area and pose a threat to this diverse floral complex.

My education would not have been possible with out the love and support of my parents, Don and Peg. This Thesis is dedicated to them.
Thank you!

Think Globally – Act Locally

"Nothing in the world can take the place of persistence. Talent will not; nothing is more common than unsuccessful men with talent. Genius will not; unrewarded genius is almost a proverb. Education will not; the world is full of educated derelicts. Persistence and determination alone are omnipotent." –Calvin Coolidge

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# INTRODUCTION

Hammocks are a unique vegetational community that range from Cape Hatteras, North Carolina, west through the lower Piedmont to eastern Texas; this region includes the entire coastal area of the Carolinas, Florida, and the Gulf Coast (Harper, 1905; Platt and Schwartz, 1990). Throughout this range there is a wide variation in the floral composition. The simplest and most widely accepted community classification for the entire area can be described as a mixed hardwood temperate forest comprised of an association of oak-hickory-pine. The canopy trees of this community type are dominated by evergreens, but do contain a substantial proportion of deciduous species (Skeen et al., 1993).

This paper characterizes changes over 20 years in the floral complex of eight central Florida maritime hammocks located in southern Volusia County and northern Brevard County. This research follows up on data collected by Stout in 1976 and 1977 that was published under a National Aeronautics Space Administration contract, number NAS 10-8986 (1979a). Data were extracted from an extensive floral and faunal assay from several different communities. The data were developed into a technical publication to evaluate the impacts of residual rocket fuel exhaust on local ecosystems (Stout, 1979b).

Throughout the Southeast, the word "hammock" is used more in a colloquial manner than one denoting a specific community type. Many different vegetative associations have been called hammocks creating ambiguity in the nomenclature. In Florida, the term has acquired an official designation, but it is a word that still has a broad meaning. Some structural generalities can be made and include an ecosystem that is dominated by broad-leaved evergreen species, which usually has a moderate to high soil water content, and occurs between xeric and wetland communities (Platt and Schwartz, 1990). Since hammocks comprise a wide variety of species throughout their range, the term is often applied haphazardly. The Florida Natural Area Inventory (1990) officially described five different hammock types: xeric, hydric, mesic, tropical, and maritime. If these descriptive habitat designations consistently prefaced the word "hammock," it would abate questions about the location, hydrology, and dominant species of a particular hammock.

At the turn of this century, Florida was sparsely inhabited with 421,511 persons (Gannon, 1996). Statehood occurred 55 years earlier and Florida was still considered frontier territory. Though agriculture (e.g., citrus, indigo, rice, and tobacco) were important to Florida's economy, it was the construction of Henry Flagler's railroad that ushered in wealthy tourists, entrepreneurs, and adventurers (Gannon, 1996). These newcomers quickly settled throughout the state, began building an infrastructure, and describing Florida.

With the growth of a young American nation, the Floridian culture created new words and adapted some from the disappearing Seminole and aboriginal cultures. Hammock is a word unique to the Southeast but one that has no definitive origin. Harper (1905) attempted to trace the origin, synonyms, and misuses of the term hammock but could not attribute the term to any definitive origin. Harper (1905) noted that both the current literature and lore attribute both hummock and hammock to the aboriginals of the southeastern coastal plain. His research further revealed that "hammock" was commonly used in turn-of-the-century geographical references and by many southern communities. Harper (1905) stated, "a simple editorial conversion is likely responsible for the confusion." We will never truly know which word has priority, "hummock" or "hammock." The earliest written account of the word "hammock" comes from William Bartram in (1791). Bartram mentions hammocks while on the coast of Georgia south of Savannah in 1773, but he did not discuss the origin of the word. Bartram described a hammock as a spacious, covered forest of live oaks and palms with a rich organic soil.

In Florida there are many different types of vegetative communities and it is not always easy to distinguish among them or to decipher what the undisturbed natural community type was. To do so the investigator must take into consideration the soil, vegetation, hydroperiod, fire frequency, and the location within the landscape. Publications such as Ecosystems of Florida (Myers and Ewel, 1990) and the Guide to The Natural Communities of Florida (FNAI, 1990) are important and useful tools to aid in identifying and describing a community. However, attempting to describe a community solely by vegetation will lead to unending confusion due to the phenotypic plasticity of many species.

## Hammock Characterization

Each of Florida's hammock types may grade almost imperceptibly into a different community or they may occur along sharp ecotones. Ansley (1952) and Platt and Schwartz (1990) described hammocks as islands or strands of vegetation occurring between xeric and hydric communities. As described in the Guide to The Natural Communities of Florida (FNAI, 1990), xeric hammocks are characterized by low oaks with a sparse ground layer and represent a late successional state from either sandhill or scrub and have soils with some organic buildup. Hydric hammocks are characterized as lowlands associated with lakes, rivers, swamps, or springs. Hydric hammocks are most different from other hammocks due to a high organic and soil moisture content; these soils may also have a clay content allowing water to accumulate after heavy rains. Hammocks that fall between these two types are called mesic hammocks. This hammock type can be characterized as having a tall canopy, many shrubs and herbs, and by soils that have a well-developed humic layer; these soils do not usually support ponding. Tropical hammocks are dominated by evergreen trees and shrubs that have their origin in the West Indies and Caribbean (Platt and Schwartz, 1990). Tropical species are generally broad-leaved and are often found on sites where limestone is near the surface (Snyder et al., 1990). Maritime hammocks represent the fifth community; these hammocks are often discontinuous, narrow bands of trees occurring on barrier islands and the adjacent mainlands (Bourdeau and Oosting, 1959; Bellis and Keough, 1995). These hammocks are comprised of large, mostly broad-leaved, evergreen hardwood trees that together create a nearly complete canopy that may be sculpted by salt spray. Boyce (1954) reviewed the effect of salt spray on woody and herbaceous vegetation. He documented how the initial damage occurs, mechanism of necrosis, and morphological tolerance exhibited by many coastal species. Wells (1928, 1938, and 1939) and Hillestad et. al., (1975) described these coastal hammocks as salt-spray climax communities due to the proximity to the ocean. In central Florida, the northern limit of many tropical species occur in maritime hammocks.

In addition to the variation among the five types of hammocks, each hammock type shows variation within themselves and with latitudinal change. In the Florida Panhandle, land surveys between 1822 and 1835 classified less than 5% of the landscape as hammocks (Schwartz, 1990). Hammocks of the Panhandle contain both deciduous and evergreen species and are a logical extension of the Appalachian mixed forest system (Monk, 1967; Platt and Schwartz, 1990). Hammock research has been carried out in the Big Bend area and the Panhandle by Harper (1914), Laessle (1942), Lassle and Monk (1961), Monk (1965, 1967), Thompson (1980), and Clewell (1986). Species occurring in the Panhandle that are not common in the peninsula include: *Fagus grandifolia* (American beech), *Castanea pumila* (Chinquapin), *Acer saccharinum* (Sugar maple), and *Quercus alba* (White oak) (Myers and Ewel, 1990; Schwartz, 1990; Wunderlin, 1998). Hammocks of northeastern Florida have a lower proportion of deciduous species (Platt and Schwartz, 1990). Some species that do occur there are: *Magnolia grandiflora* (Southern magnolia), *Carya* spp. (hickories), *Quercus* spp. (oaks), and *Pinus tadea* (Loblolly pine) (Platt and Schwartz, 1990).

Hammocks in south Florida do not cover as extensive areas as they do in the Panhandle or central Florida (Snyder et al., 1990). In south Florida, tropical hammocks occur in the barrier islands and on relatively small outcroppings of limestone (Snyder et al., 1990). The tropical hammock community has been described by Phillips (1940), Ansley (1952), Alexander (1958, 1967), Hillsenbeck (1976), Austin (1977), A. Cox (1988), and Mack (1992). These forests are more correctly labeled tropical hammocks due to the historic origin of many species. The flora of tropical hammocks are largely derived from the West Indies and Caribbean (Mack, 1992; Skeen et al., 1990) and are dominated by broad-leaved evergreen species such as the *Mastichodendron foetidissimum* (Mastic), *Simarouba glauca* (Gumbo limbo), *Pithecellobium keyense* (Blackbead), and *Metopium toxiferum* (Poisonwood).

Hammocks of central Florida contain both temperate and tropical species (Poppleton et al.1977; Stout, 1979a; Norman, 1976, 1995; Greller, 1980; Schwartz, 1988). Small (1929) correlated the presence of tropical species in coastal central Florida to the shell mounds or "kitchen middens," he thought these features would retained heat therefore support tropical species. Tropical species that occur in north and central Florida and have been thoroughly mapped and primarily occur only in coastal areas (Norman, 1976, 1995; Schwartz, 1988; Johnson et al., 1993). Virnstein (1990) attributed the presence of tropical species to the nearness of the Gulf Stream currents. Schwartz (1988) created a map with isoclines depicting the northern and southern limits of many temperate and tropical species. From his map it is obvious that there are more temperate species present in south Florida than tropical ones in north Florida.

In review of this literature, I believe that the percent coverage of hammocks in east-central Florida is greater than that of north or south Florida. Due to the extensive coverage of the St. Johns River, the Indian River Lagoon, and Intracoastal Waterway there is a greater opportunity for the necessary environmental parameters to occur, thus allowing more hammocks to develop.

Of all the vegetational communities in Florida, hammocks contain the largest proportion of tropical species. Due to presence and absence these species, hammocks of central Florida reveal a vegetational transitional zone influenced by climate. The freeze line in Florida varies annually and the tropical vegetation of coastal central Florida is restricted by this wandering ecotone. While in Florida, Bartram (1791) described *Roystonea elata* (Royal palm), from a along the St. Johns River near Manhattan, Volusia County. Curtiss (1879) identified *Sageretia minutiflora* (Buckthorn), *Psychotria nervosa* (Wild coffee), and *Ardsia escallonioides* (Marlberry) on the Sister Islands, located near the mouth of the St. Johns River. As these early botanists have documented, tropical species have historically occurred much further north than they due today, these documentations are indicative of a warmer climate.

## Fire

Florida receives more lightning strikes than anywhere else in North America (Chen and Gerber, 1990). Over tens of thousands of years, many species have become evolutionarily adapted to periodic fires and many species only exist when it occurs. Over the past two decades fire has been recognized as a critical component in ecosystem management to maintain biological diversity and ecosystem health. Presumably, Florida's ecosystems burned whenever enough litter (fuel) accumulated to support and carry a fire. It is safe to say that the vegetative structure of Florida's ecosystems have been uniquely shaped by prehistoric geological processes and thousands of years of lightning-initiated fires. But, it is impossible to determine what the original vegetative composition of Florida was. Fires set by pre-Columbian and European settlers altered the original vegetative composition of Florida (Small, 1929; Robbins and Myers, 1992; Bratton, 1994).

The fire regime for hammocks is not well documented. The fire frequency of hammocks must have been infrequent to allow hardwood trees to become established and persist. In the maritime hammocks of Cumberland Island, Georgia, Bellis and Keough (1995) and Bratton (1994) reported that where fire occurs most frequently, pine stands are dominant. They also reported that in "mature" maritime hammocks when a low intensity fire has occurred, the dominant trees persist and the maritime community was maintained. Komarek (1974) cites the low combustibility of the leaf litter from hardwood trees as a mechanism that keeps fires to a minimum. He describes the morphology of leaves from oak-pine forests as non-conducive in carrying fire thus limiting the frequency in which fires occurs.

Because of the high moisture content of soils in many hammocks, it is not uncommon for land managers to burn adjacent communities (scrub, sandhill, or flatwoods) right up to the edge of a hammock. But, as observed from the winter of 1997-1998 to the summer of 1998, a strong El Niño period, the rainy season and dry season may not show typical trends. It is then conceivable that periods of extreme drought could change the dynamics of hammocks in relation to fire and that these community types could occasionally burn, especially when enough vegetation and debris has accumulated due to fire exclusion. The hammocks within the scope of this study have not been burned in the past two decades.

## Soils

De Vall (1943) notes that many researchers casually mention the relationship of plants and soils but often do not attempt correlate their results to changes in soil properties. Hughes (1994) highlights the lack of data on plant-soils relationships and urges the ecological community to put more emphasis into these relationships when developing ecosystem management policy.

Many plant species have a high level of gradient plasticity. But, there are also many species that exhibit clear geological relationships with soils throughout the world. Hughes (1994) further points out that natural communities do not end at the ground surface and to ignore the dynamics of nutrient movement and soil composition is to ignore the true history of an ecosystem and its origin.

Stout (1979a) recognized the importance of combining soil analyses with vegetation studies. The extra effort taken to include soil analyses into his research will allow stronger correlations to be made and will give future research a more in-depth research base from which to draw. The soils in which these hammocks occur range from well drained to poorly drained. The soils found within each hammock are listed below in their order of dominance: Castle Windy Hammock, Palm Beach Sand and Canaveral Complex; Enchanted Forest, Pompano Sand and Tomoka Muck; Happy Hammock, Ancolote Sand and Immokalea Sand; Indian Mound Hammock, Welaka Sand and Canaveral Complex; Jerome Road Hammock, Myakka Sand and Copeland Complex; Juniper Hammock, Pomello Sand and Cocoa Sand; Route 3 Hammock, Myakka Sand and Anoclote Sand; and Ross Hammock, Turnbull and Pompano (NRCS, 1972, 1969-77).

## Climate

Climate data for east-central Florida have been well documented (Norman 1976, 1995; Greller, 1980; Myers, 1986; Provancha et al., 1986; Virnstein, 1990; Bellis and Keough, 1995). What is clear from these data is that freeze lines in Florida vary dramatically from year to year. Greller (1980) drew a thermo-isocline from each coast that roughly followed the global 12° C line of North America; this line generally represents the northern limit of tropical species. This thermo-isocline coincides with the chilling stress temperature that Lynch (1990) identified as 10-15° C for some tropical species. Figure 1A depicts the 12° C isocline where extends from New Smyrna Beach and follows the coast closely until about 27° north latitude, here it cuts across the state, bends northward, and ends around the Pasco/Citrus county line. From unpublished data by Weishampel and Godin (1997), the freeze line along the east-coast of Florida has fluctuated from the Georgia-Florida border to Miami over the last 15 years. This is in contrast to the west-coast where the freeze line does not fluctuate as dramatically.

In a general sense, there is a climatic transition zone in central Florida. Climatic transition zones, such as ones that occur along mountain slopes (Whittaker, 1956; Slayter and Noble, 1992), are well studied and exhibit a change in vegetation with an increase in altitude. On a mountainside, species occur along a gradient affected by soils, water, and temperature, Figure 1B. Though the elevational gradient in central Florida is not as dramatic, there is an analogous climatological gradient. And, it is this gradient that restricts the northern distribution of tropical species just as temperature decreases with an elevational increase restricts the growth of species on a mountain side.

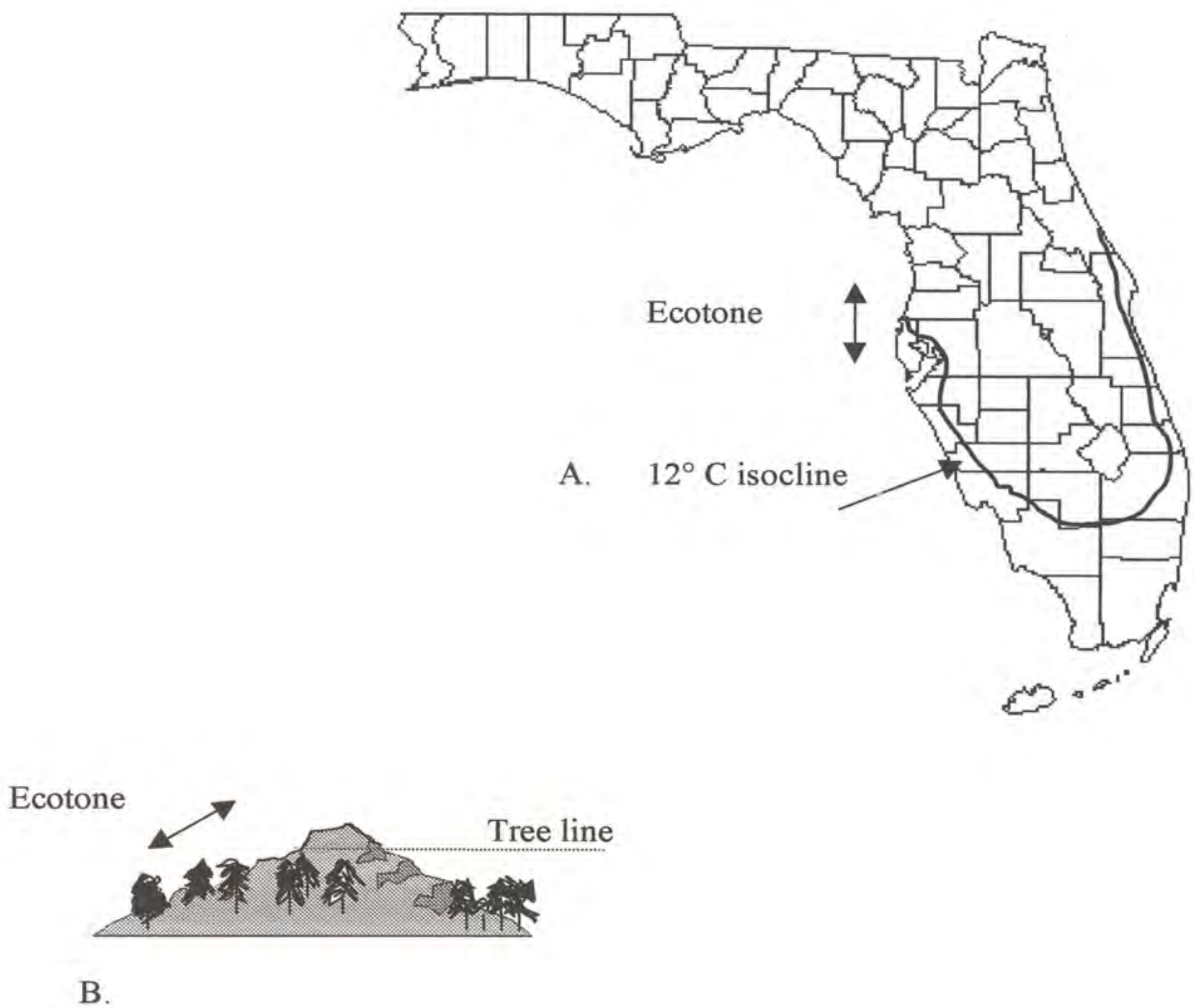


Figure 1. A. Approximate location of the 12° C isocline which generally delineates the northern limit of tropical species (from Greller, 1980). B. Climatological transition zone at a tree line limits the upward migration of vegetation as described by Whittaker (1956).

## Study Objectives

In addition to documenting successional trends that have occurred during the past 20 years, this research will attempt to describe some of the synecological relationships that occur within the maritime hammock community. Questions that this assay will attempt to answer are: 1) Has the species composition of the region changed in 20 years? 2) Have individual hammocks changed independent of each other? and 3) What proportion of the community is comprised of tropical species and how has that proportion changed?

# MATERIALS AND METHODS

## Study Sites

Study sites were located within publicly-owned lands in Volusia and Brevard counties, Figure 2. The Enchanted Forest is located in the northwest corner of S.R. 405 and US1 in Titusville and is managed by Brevard County. Castle Windy, Ross, and Route 3 Hammocks are located within Canaveral National Seashore; Happy, Juniper, Jerome Road, and Indian Mound Hammocks are located on Kennedy Space Center property and are managed by the U.S. Fish and Wildlife Service. Sampling in 1976-77 and 1997 occurred between July and September of each year. Locations and landscape characteristics are listed in Table 1. Additional descriptions regarding adjacent land use and soil characteristics for the hammocks are given in Table 2.

With the exception of Jerome Road Hammock, all investigations were carried out in the same areas of each hammock. The area of Jerome Road Hammock that Stout (1979a) studied has since been converted into an orange grove. Investigations of this hammock in 1997 were carried out in the remaining hammock. Stout (1979a) described this Jerome Road Hammock as being dry-mesic in character but since the creation of the orange grove, the remaining hammock can be best characterized as wet-mesic.

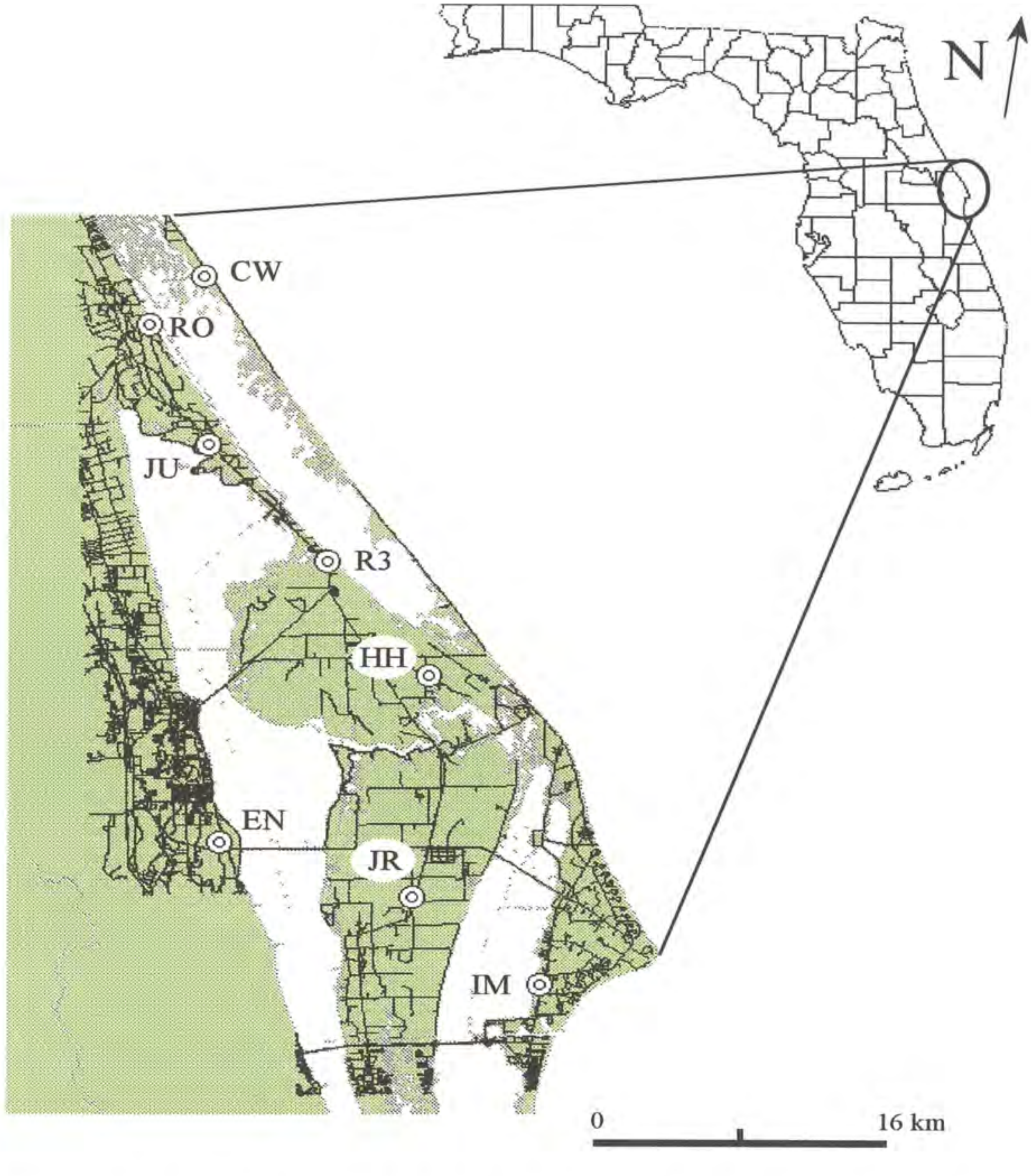


Figure 2. Site map. Location of the eight hammocks in the central Florida landscape. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

Table 1. Hammock characteristics for monitored sites.

| Hammock | Site code | Size (ha) | Distance (km) to ocean | Longitude and latitude | Canopy height (m) |
|---|---|---|---|---|---|
| Castle Windy | CW | 48.3 | 0.8 | 28° 52" 47' N<br>-80° 47" 40' W | 5.68 |
| Enchanted Forest * | EN | 15.44 | 20.2 | 28° 31" 50' N<br>-80° 47" 38' W | 19.33 |
| Happy | HH | 4.72 | 4.8 | 28° 37" 50' N<br>-80° 39" 40' W | 16.84 |
| Indian Mound | IM | 0.92 | 2.5 | 28° 26" 21' N<br>-80° 35" 53' W | 9.8 |
| Jerome Road | JR | 0.72 | 10 | 28° 29" 39' N<br>-80° 40" 30' W | 18.55 |
| Juniper | JU | 0.74 | 6.4 | 28° 46" 34' N<br>-80° 47" 40' W | 15.9 |
| Ross | RO | 0.48 | 5.5 | 28° 51" 03' N<br>-80° 49" 48' W | 11.97 |
| Route 3 | R3 | 0.42 | 5.3 | 28° 42" 07' N<br>-80° 43" 23' W | 13.77 |

* The Enchanted Forest was called Indian River Hammock in 1976-77.

Table 2. Topographic and surrounding characteristics of the eight hammocks.

| Hammock | Characteristics |
|---|---|
| Castle Windy | A near-dune site, dry soils with an undulating topography. Vegetation is salt-pruned and the canopy is lower toward the east. |
| Enchanted Forest | Occurring adjacent to a coquina outcropping, this hammock is at the bottom of a slope. Soils are poorly drained and ponding occurs due to S.R. 405 and US 1. |
| Happy | Located near Happy Creek, portions of the site are seasonally flooded. This narrow hammock is bisected by a dirt road. |
| Indian Mound | Located on the western most ridge of a barrier island. Soils are well drained and the canopy shows some pruning from salt spray. |
| Jerome Rd. | Occurring on the lower slope of historic coastal scrub which is now an active citrus grove. This linear hammock was ditched and is poorly drained. |
| Juniper | A mesic hammock adjacent to coastal scrub. Soils are well drained. |
| Ross | Occurring between heavily disturbed scrubby flatwoods and a salt marsh. Soils range from poorly drained to moderately well drained. |
| Route 3 | A linear hammock, bisected by Rt. 3 to the west and bordered by a fresh water marsh to the east and south and ruderal vegetation to the north. |

## Sampling Techniques

### Vegetation

Sampling procedures followed Stout (1979a) where a combination of techniques were used. The point centered quarter (PCQ) method (Cottam and Curtis, 1956) was used to sample trees where the diameter breast height (dbh), distance, and frequency were recorded. Occasionally when *Sabal palmetto* (Cabbage palm) were encountered, it was not possible to obtain an accurate dbh due to the presence of boots. When this problem was encountered, the dbh for all palms in that hammock without boots were averaged and that number substituted. Stem counts and frequency of shrubs within a 2 $m^2$ quadrat along with the percent cover and frequency of herbaceous vegetation within a 0.5 $m^2$ were also recorded. The height of the canopy trees was quantified with a range finder, approximately eight height measurements were taken per hammock.

In the larger hammocks, a quasi-random walk was used to navigate from point to point where points were spaced 15 meters apart. To begin the random walk, the approximate center of the hammock was located or a distance of at least 100 m from the edge was maintained. From the beginning point, a roll of a die determined the direction of the first sampling point and each proximate direction; if necessary the die was rerolled to avoid retracing steps. As described earlier hammocks are often linear, this posed a problem for the random walk method. In these situations, sampling began near one end of the hammock and the plotless method was applied through the center of the hammock while avoiding the edges. Cottam and Curtis (1956) recommended that 20 points be used when sampling. Species area curves were created for this study and showed that the 30 points used by Stout (1979a) were sufficient. Thirty sampling points were used in all but one hammock. Route 3 Hammock is a narrow and short hammock, I was only able to randomly locate 20 points. A species area curve for this hammock indicated that after point 17 species richness had leveled off.

There are many methods to sample vegetation. The PCQ method was used here so that comparisons with Stout (1979a) and statements about vegetation change could be confidently made. However, Hilsenbeck (1976) identified quadrat sampling as the best method to sample hammock vegetation. When 5 x 20 m quadrats were compared to PCQ, 5 x 5 m, and 10 x 10 m quadrats, the 5 x 20 m quadrat yielded the lowest level of variation between samples. Hilsenbeck (1976) also used a Monte Carlo analysis to confirm that PCQ sampling was not as effective as quadrat sampling.

At each sampling point, the PCQ methodology and quadrats were always oriented in a north-south manner and cardinal directions used to delineate each of the four quadrants for tree sampling, Figure 3. Within each cardinal quadrant the distance to the nearest tree and dbh were obtained. Trees were defined as having a dbh of 2.5 cm or greater. Within the 2 $m^2$ nested quadrat, a functional shrub-class was used. Stems of shrub and tree seedlings were counted if the dbh was less than 2.5 cm and if the plant was less than 1 m in height. Woody vines that were greater than 50 cm in height and that had a dbh of greater than 2.5 cm were also included with the shrubs. Percent cover for the functional herbaceous-class was obtained from the 0.5 $m^2$ nested quadrat. All non-

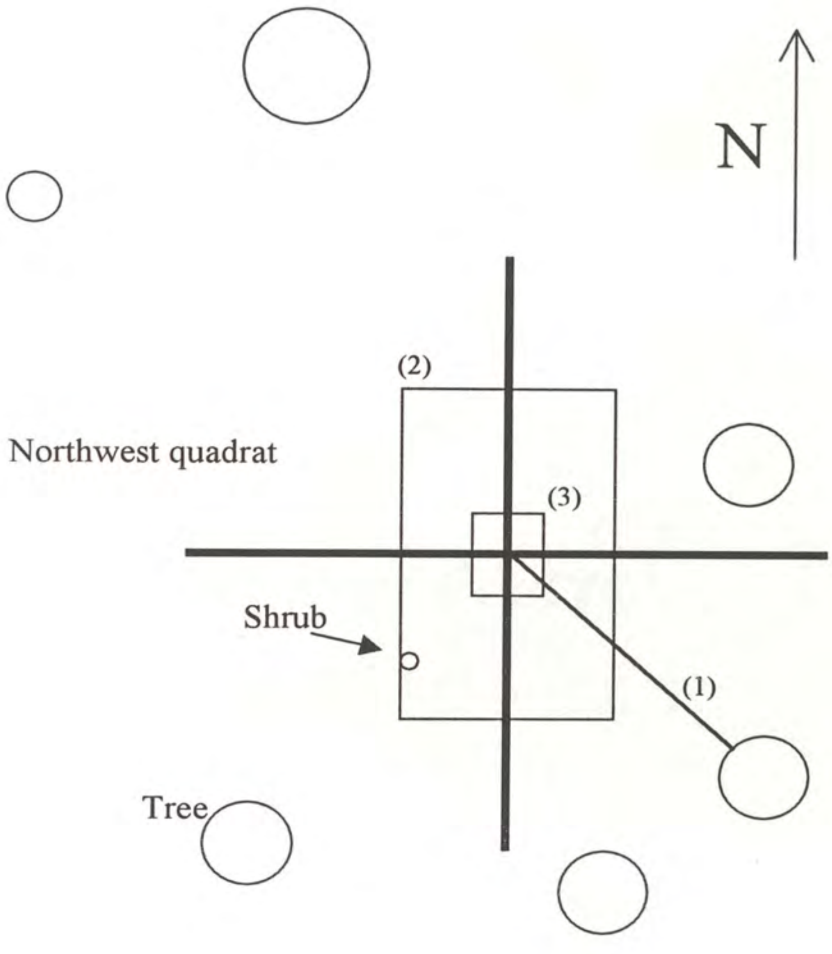


Figure 3. PCQ and quadrat sampling design. The line form the center point (1) represents method for distance sampling. The shrub (2) and herbaceous quadrats (3) were centered on the PCQ point.

woody plants were included within the herbaceous layer. Plant nomenclature follows Wunderlin (1998). When uncommon species were found, voucher specimens were collected and were deposited at the University of Central Florida Herbarium. Appendices A and B list all plants encountered during each sampling event and each list includes any additional species observed during sampling.

In Castle Windy and Indian Mound hammocks both *Quercus geminata* (Sand live oak) and *Q. virginiana* (Live oak) were identified, Stout (1979a) only recorded *Q. virginiana* as occurring these in hammocks. In order to compare the data sets, *Q. geminata* was combined with *Q. virginiana*.

From techniques described by Mueller-Dombois and Ellenberg (1974) a tree density per 100 $m^2$ was calculated for each hammock. This number was derived from a mean distance to all trees from all points within the hammock. From the density, frequency, and dbh obtained by PCQ, importance values (IV) were created as described by (Curtis and McIntosh, 1951). For trees (Equation 1):

$$IV = \text{Relative Density} + \text{Relative Dominance} + \text{Relative Frequency} \quad (1)$$

and for shrubs and herbs (Equation 2):

$$IV = \text{Relative Density} + \text{Relative Frequency}. \quad (2)$$

For each species, relative density was calculated from the occurrence of a species divided by the total possible occurrences. Relative density for herbs was calculated from percent cover. Relative dominance for trees equaled the basal area (BA), calculated from dbh, of a species divided by the total BA derived from all species within that sample. Relative frequency was calculated from the number of points or quadrats in which a species was found divided by total number of sampled points. The maximum IV for a tree species could be 300 and 200 for shrub and herb species.

From the calculated IVs, the Shannon diversity index was used to calculate the relative level of biological diversity. The Shannon diversity index was used on both the regional comparisons and within hammock comparison. The traditional Shannon equation was used to calculate the H', diversity (Equation 3) and J', evenness (Equation 4). In Equation 3 $P_i$ represents the proportion of each importance value and in equation four, S represents the richness found within each sample.

$$H' = -\sum P_i \ln P_i \qquad (3)$$

$$J' = \frac{H'}{\ln S} \qquad (4)$$

## Soils

Stout (1979a) measured eleven soil parameters. Due to budget constraints only six were measured in this study: cation exchange capacity (cec), calcium (Ca), phosphorus (P), magnesium (Mg), and pH. Soil samples were collected after the vegetation survey and sent to DB Laboratories, Rockledge, Florida, for analysis. Following Stout (1979a), four soil samples were collected from the interior of hammocks and combined to form a site composite that contained approximately 250 ml of soil. Sample collection points were determined by a random direction generator and were spaced at least 20 m apart. The humic layer was removed to expose the soil and a stainless steel soil corer was used to extract a 15 cm deep sample.

A major consequence of Florida's biogeography is leaching. Leaching is the removal of ions from the soil by percolating water. Most hammocks have a high sand component that facilitates leaching and thus the potential loss of essential and beneficial elements. Cation exchange capacity was chosen because of its role in the retention of nutrients in the soil (Taiz and Zeiger, 1991). Calcium was chosen because of its theoretical effect on tropical plants in central Florida. Small (1929) and Norman (1976, 1995) noted that tropical species often occurred on or near shell mounds. Since the evolutionary history of Florida's tropical plants are derived from the Caribbean where limestone is often found at or near the surface, it seems a logical explanation for the localized success of tropical species in central Florida and therefore warranted testing. Ordination of soil data collected by Stout (1979a) revealed that P and Mg accounted for the most variation among the hammock sites and therefore were included in this assay.

Cation exchange capacity was extracted and tested as described by the U.S. Environmental Protection Agency (U.S.E.P.A., 1986). Phosphorus was digested following procedures described in Corps of Engineer 3-227 and analyzed following EPA 365.2 guidelines. Magnesium, Ca, and pH were analyzed following solid waste (SW) 7140, SW 7450, and SW 9045 procedures, respectfully.

## Ordination

Data were ordinated using detrended correspondence analysis (DCA) using the software program, PC Ord® (McCune, 1995). Ordination is typically used to highlight species composition patterns in samples (Whittaker, 1978; Gauch, 1982). It has also been used to condense species information to detect successional patterns (Austin, 1977), as a tool to depict dissimilarity, and as a method to measure biotic integrity (Karr, 1991). Given a time series, ordination can illustrate directional changes such as those associated with successional tendencies of a communtiy (Phillipi et al., 1988; Schmalzer and Hinkle, 1992). Here it was used to detect trends in dynamics of hammocks associations.

One characteristic of DCA is that the species occur in ordination space closest to the hammock in which it had the highest IV. Pielou (1984) described this "weighting" as an effective way of detecting relationships. Species occurring in several hammocks were "pulled" in many directions but remained closest to the hammock(s) where the IV was the greatest. Just as species were weighted by IV, the lengths of the vectors connecting the hammocks were influenced by the IV. Lengths of the vectors represent the proportional change of species composition, density, and frequency between sampling events. Tick marks along each axis of the ordinated figures represent relative change.

# RESULTS

## Regional Vegetative Dynamics

The primary concern of this study was to determine if the maritime hammocks of east-central Florida today differ from the same sites that were inventoried 20 years ago. Averaged IVs for all trees indicate that the four dominant species from 1976-77 are still dominant in 1997. This was not the case for the rest of the trees, shrubs, and herbs; their averaged IVs indicate a compositional change has occurred. At this composite hammock level, there were 96 species identified in 1976-77 and 72 species identified in 1997, a 25% decrease in species richness. Also, there were 44 species that were found in 1976-77 that were not present in 1997 and there were 23 species that occurred in 1997 that did not occur in 1976-77. When the importance values for all trees in each data set were summed, the top four species from 1976-77 comprised 64% of the entire value, and in 1997 the top four comprised 62%, this did not occur with the shrubs or herbs.

Figure 4 illustrates the Shannon diversity index for all trees in all hammocks at both time periods. The diversity and evenness levels from 1976-77 and 1997 were similar, the overall richness decreased by five species. Figure 5 is a comparison of shrub species for both time periods. Shrubs had a similar level of diversity and evenness the

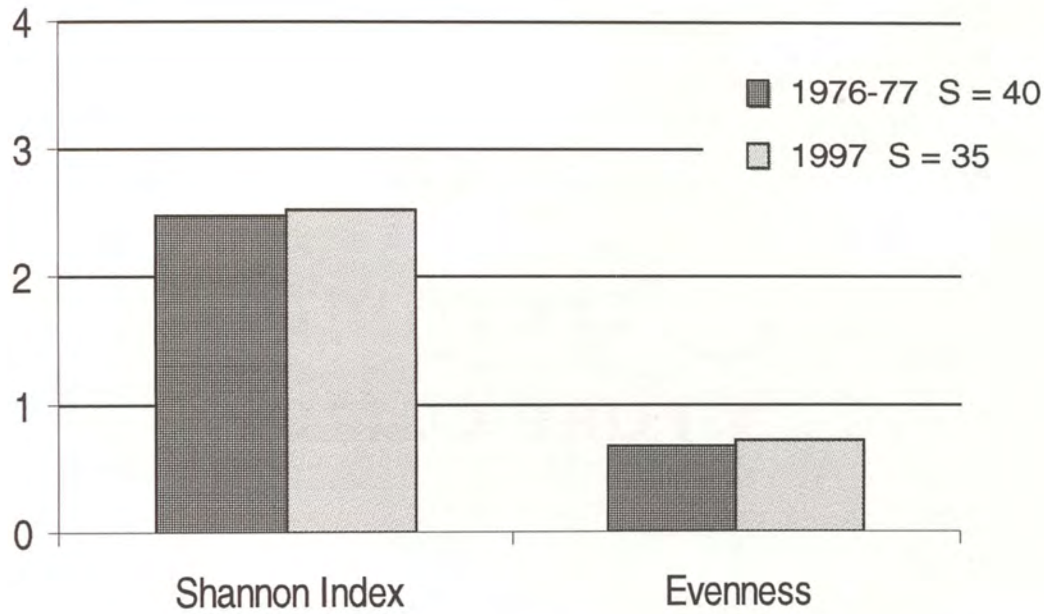


Figure 4. Average diversity and evenness of all tree species for all hammocks (S = richness).

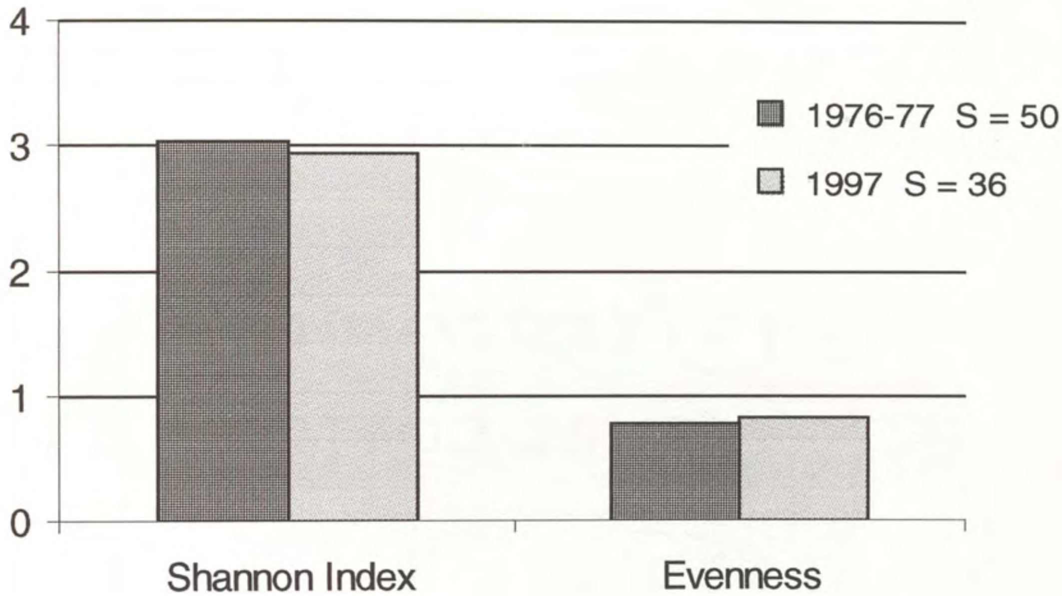


Figure 5. Average diversity and evenness of shrub species for all hammocks (S = richness).

but the richness decreased by 14 species. Figure 6 compares the herbaceous species for both time periods. Again the diversity and evenness measures were similar but the richness declined by 14 species. A special case t-test for diversity indices described by Hutchenson (1970) as reported in Zar (1996), revealed that none of the diversity indices were statistically significant.

## Strata Comparisons

### Trees

Table 3 presents the twelve highest averaged IVs of tree species from all hammocks sampled in 1976-77 and 1997. *Sabal palmetto*, *Quercus virginiana*, *Q. laurifolia* (Laurel oak), and *Carya glabra* (Hickory) comprise the top four in each time step. When the averaged IV from 1976-77 to 1997 are compared, *Sabal palmetto* decreased by 36% and *Carya glabra* by 14 % while *Quercus virginiana* increased by 49% and *Q. laurifolia* by 53%. One possible explanation for the larger IV of Sabal palmetto in 1976-77 were that the boots were included in the dbh measurements.

DCA (Figure 7) generated relatively long vectors for each hammock indicating a shift in the importance values of the species present. DCA ordination yielded one very interesting pattern that may help to explain some of the changes in distribution of species throughout the sites. In 1976-77, the hammocks tended to be more spread out in ordination space (occurred closer to the edges) than hammocks in 1997. This indicates

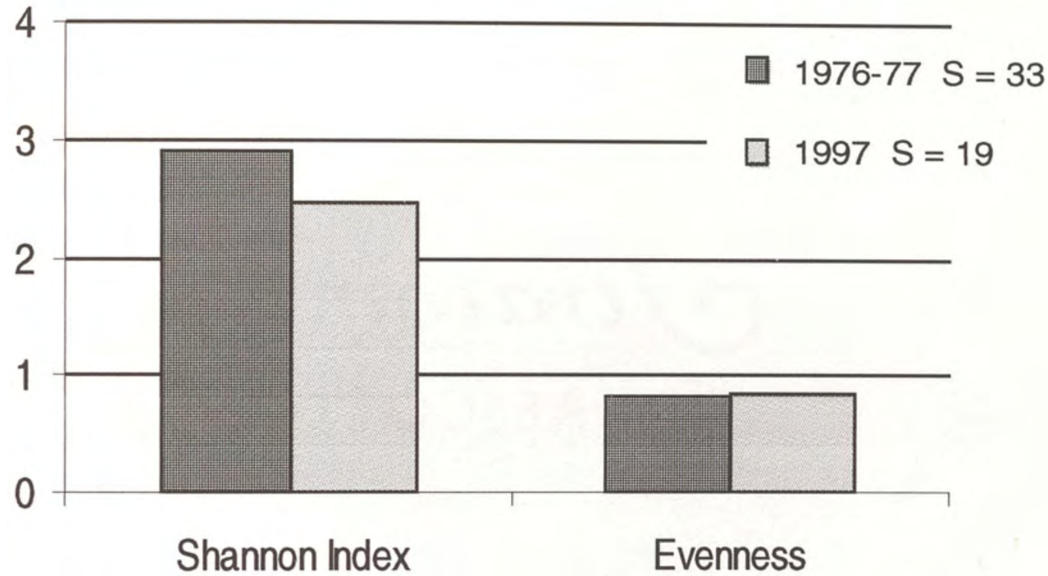


Figure 6. Average diversity and evenness of herbaceous species for all hammocks (S = richness).

Table 3. The twelve highest importance values of trees for each sampling period.

| 1976-77 | IV | 1997 | IV |
|---|---|---|---|
| *Sabal palmetto* (t) | 112 | *Sabal palmetto* (t) | 72 |
| *Quercus virginiana* | 43 | *Quercus virginiana* | 64 |
| *Persea borbonia* | 19 | *Quercus laurifolia* | 29 |
| *Quercus laurifolia* | 19 | *Persea borbonia* | 21 |
| *Carya glabra* | 14 | *Celtis laevigata* | 18 |
| *Ilex vomitoria* | 11 | *Carya glabra* | 12 |
| *Fraxinus pennsylvanica* | 11 | *Ilex vomitoria* | 10 |
| *Ocotea coriacea* (t) | 9 | *Myrcianthes fragrans* (t) | 9 |
| *Acer rubrum* | 6 | *Ulmus americana* | 9 |
| *Morus rubra* | 6 | *Morus rubra* | 9 |
| *Juniperus silicicola* | 5 | *Prunus caroliniana* | 8 |
| *Rapanea punctata* (t) | 5 | *Juniperus silicicola* | 6 |

tau indicates a tropical species.

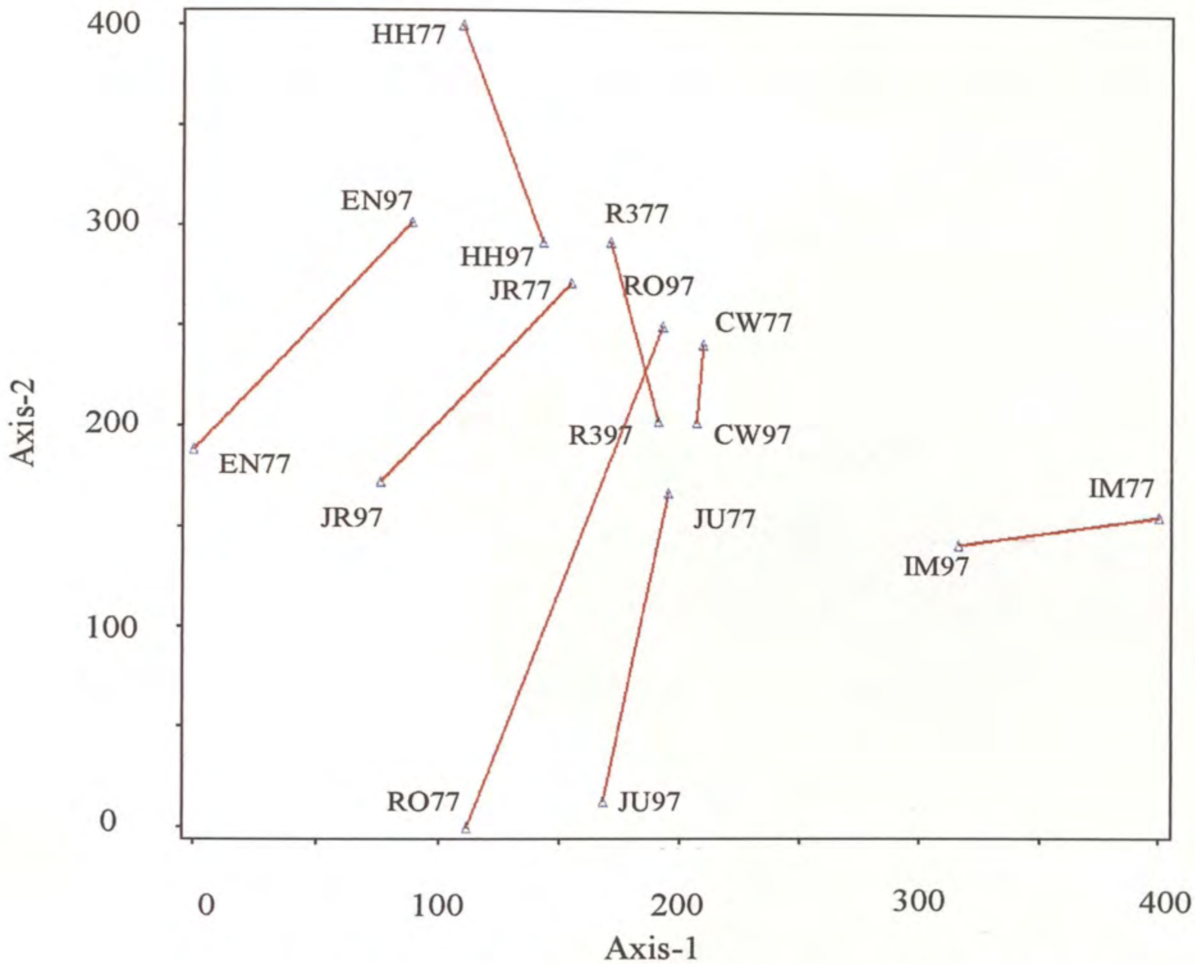


Figure 7. DCA analysis of tree species between 1976-77 and 1997. Vectors indicate the directional change of the eight hammocks after 20 years. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

that the vegetative complex of the hammocks were more dissimilar in 1976-77. The hammocks in 1997 reflect a decrease in gamma diversity, the richness in species in a range of habitats in a geographic area.

## Shrubs

Table 4 presents the top twelve averaged IVs for the shrubs. In comparing these averaged IVs, eight species were present in both data sets. All of the eight species increased from 1977 to 1997 except *Sabal palmetto*, which decreased by 41%. From 1976-77 to 1997, *Psychotria nervosa* (Wild coffee) and *Serenoa repens* (Saw palmetto) increased dramatically, 222% and 340%, respectively.

DCA (Figure 8) generated relatively long vectors for half of the hammocks indicating that some hammocks shifted greater than others. Ordination of the shrub composition showed a directional top to bottom shift from 1976-77 to 1997. From column one of Table 4, *Sabal palmetto*, *Quercus laurifolia*, *Q. virginiana*, and the vine *Toxicodendron radicans* all had much lower IVs. The first three shrub species from 1976-77 will be classified as trees when mature, the top three shrub species in 1997 will always be classified as shrubs in central Florida. Six of the eight hammocks in 1976-77 occur above the 200 tick mark on axis-2, this indicates a temporal shift between each data set. Additionally the richness from 1976-77 (S = 50) to 1997 (S = 36) decreased by about one third. The longest vector length occurs in Jerome Road Hammock and may be a result of a change in site characteristics. Much of the hammock had been converted to a

Table 4. Twelve highest importance values of shrubs and juvenile trees for each sampling period.

| 1976-77 | IV | 1997 | IV |
|---|---|---|---|
| *Sabal palmetto* (t) | 29 | *Psychotria nervosa* (t) | 29 |
| *Toxicodendron radicans* | 16 | *Serenoa repens* (t) | 22 |
| *Ardisia escallonioides* (t) | 13 | *Ardisia escallonioides* (t) | 19 |
| *Quercus virginiana* | 13 | *Sabal palmetto* (t) | 17 |
| *Ilex vomitoria* | 12 | *Prunus caroliniana* | 14 |
| *Quercus laurifolia* | 10 | *Ilex vomitoria* | 13 |
| *Psychotria nervosa* (t) | 9 | *Ocotea coriacea* (t) | 12 |
| *Ocotea coriacea* (t) | 9 | *Callicarpa americana* | 10 |
| *Prunus caroliniana* | 8 | *Rapanea punctata* (t) | 7 |
| *Myricanthes fragrans* (t) | 6 | *Myricanthes fragrans* (t) | 7 |
| *Rapanea punctata* (t) | 5 | *Celtis laevigata* | 7 |
| *Serenoa repens* (t) | 5 | *Cornus foemina* | 6 |

tau indicates a tropical species.

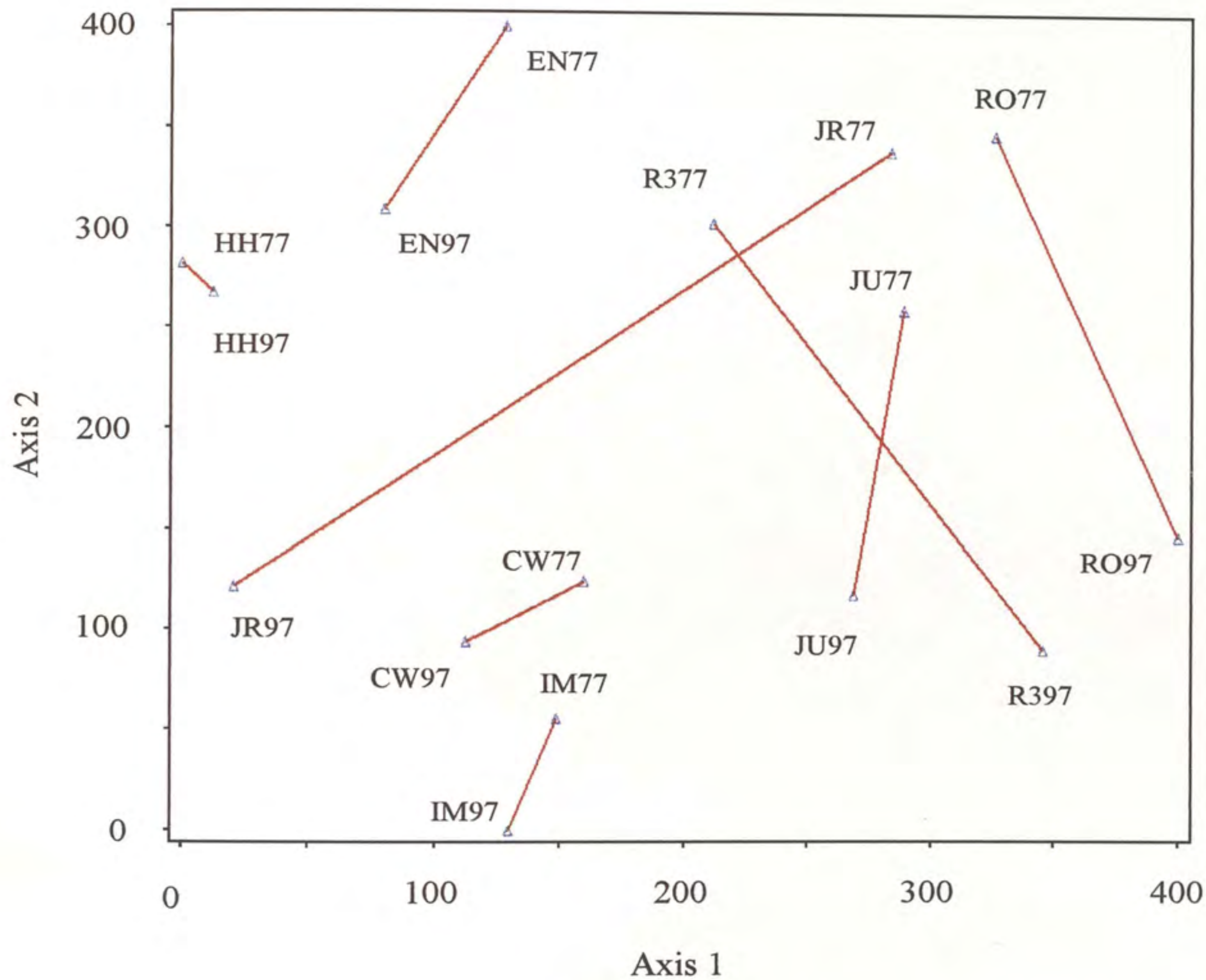


Figure 8. DCA analysis of shrubs and juvenile species between 1976-77 and 1997. Vectors indicate the directional change of the eight hammocks after 20 years. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

citrus grove, monitoring in 1997 occurred in the remaining hammock vegetation. When the shrub species from this hammock are compared to the shrub species of 1997, there only three species that occur in both data sets.

## Herbs

Table 5 presents the top twelve averaged IVs for herbaceous species. There are only two species occurring in both data sets, *Salvia coccinea* (Red sage), which increased by 200%, and *Nephrolepsis cordifolia* (Boston fern), which decreased by 80% from 1977 to 1997.

DCA (Figure 9) yielded long vectors between sampling periods for each hammock except Castle Windy Hammock. Examination of the raw data suggests that vector lengths along axis-1 are associated with the change in species composition. The shift, like those found with the shrubs, was directional and indicates temporal similarity among hammocks. Vectors oriented along axis-2 are influenced by the amount of difference between species IVs in each hammock. The herbaceous species of the Enchanted Forest in 1997 occurred in similar densities and proportions to the herbs of 1976-77; the herbs in Jerome Road Hammock did not and exhibit are larger Axis-2 change. One peculiarity of DCA is that the program can only be used when values greater than zero were recorded. Stout (1979a) did not find any herbaceous species in Indian Mound Hammock. Even though herbs were found in 1997, there were no data to

Table 5. Twelve highest importance values of herbs and seedling species for each sampling period.

| 1976-77 | IV | 1997 | IV |
|---|---|---|---|
| *Nephrolepis cordifolia* * | 30 | *Blechnum serrulatum* | 33 |
| *Oplismenus setarius* | 26 | *Dichanthelium sp.* | 31 |
| *Pavonia spinifex* | 18 | *Scleria sp.* | 29 |
| *Andropogon virginicus var. glomeratus* | 11 | *Osmunda cinnamomea* | 20 |
| *Ipomoea tuba* | 8 | *Verbesina virginica* | 18 |
| *Vernonia gigantea* | 8 | *Salvia coccinea* (t) | 15 |
| *Panicum polycaulon* | 7 | *Physalis sp.* | 10 |
| *Blechnum serrulatum* | 5 | *Sansevieria hyacinthoides* *(t) | 9 |
| *Mikania scandens* | 5 | *Pteridium aquilinum* | 7 |
| *Salvia coccinea* (t) | 5 | *Nephrolepis cordifolia* * | 6 |
| *Pteridium aquilinum* | 4 | *Thelypteris* sp. (t) | 4 |
| *Rhus copallina* | 4 | *Murdannia keisak* | 3 |

Asterisk indicates an exotic species and tau indicates a tropical species.

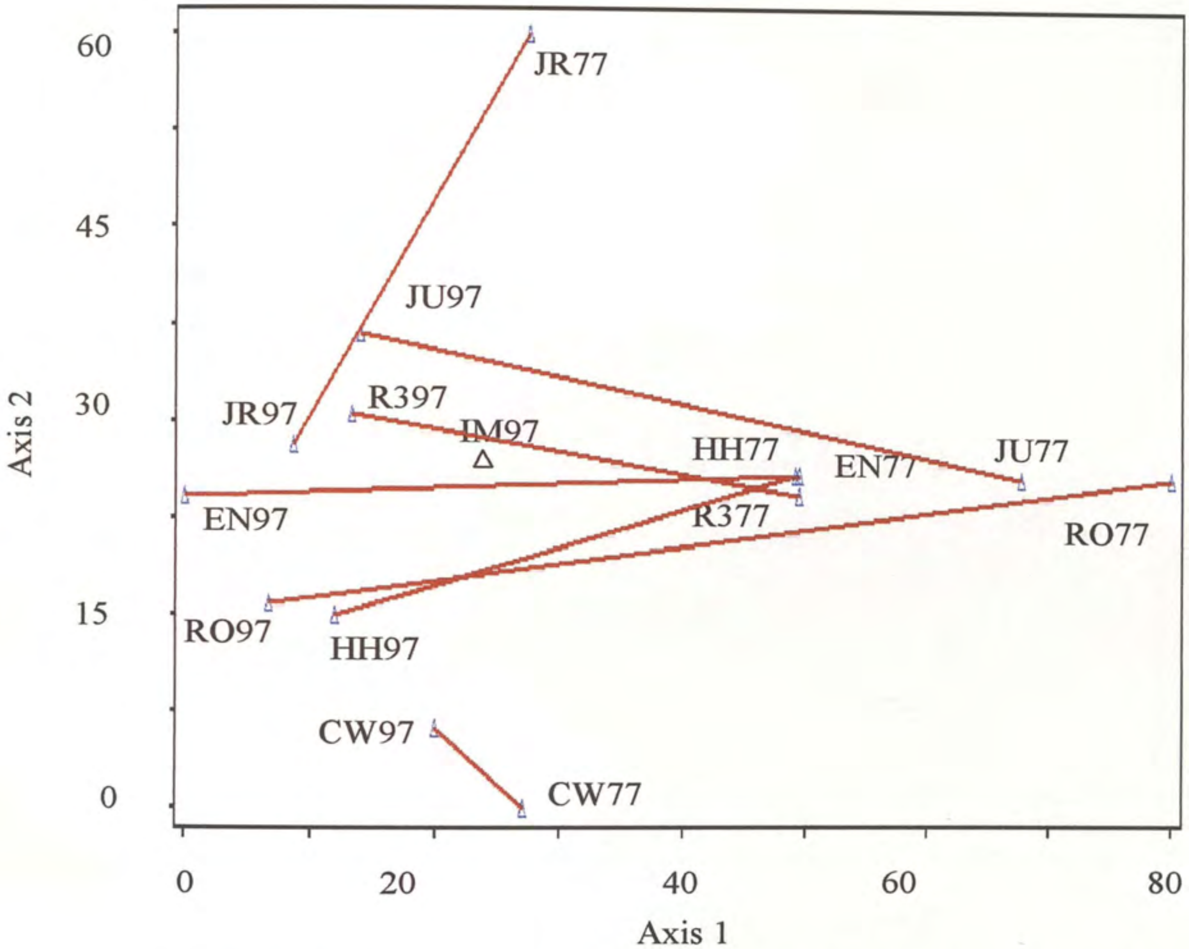


Figure 9. DCA analysis of herbs and seedling species between 1976-77 and 1997. Vectors indicate the directional change of the eight hammocks after 20 years. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

compare them to. For this reason, figures depicting herbs in Indian Mound Hammock are absent.

## Within Hammock Dynamics

### Trees

Species diversity for the trees was calculated from averaged importance values using the Shannon index. From this calculation, the diversity (Figure 10) evenness, (Figure 11) and richness (Figure 12) were calculated. Both the diversity and richness differed significantly ($P < 0.05$) based on paired t-tests. The evenness among each of the hammocks did not differ statistically. The mean species diversity, evenness, and richness all increased over the 20 years.

### Shrubs

Species diversity for the shrubs was calculated from averaged importance values using the Shannon index. The species diversity and evenness between the two samples did not yield a significant difference between 1976-77 and 1997 (Figures 13 and 14), but the richness (Figure 15) did based on a paired t-test. Of the seven shrub species that increased (Table 4), five of them are tropical indicating a possible recovery in the recent absence of freezes.

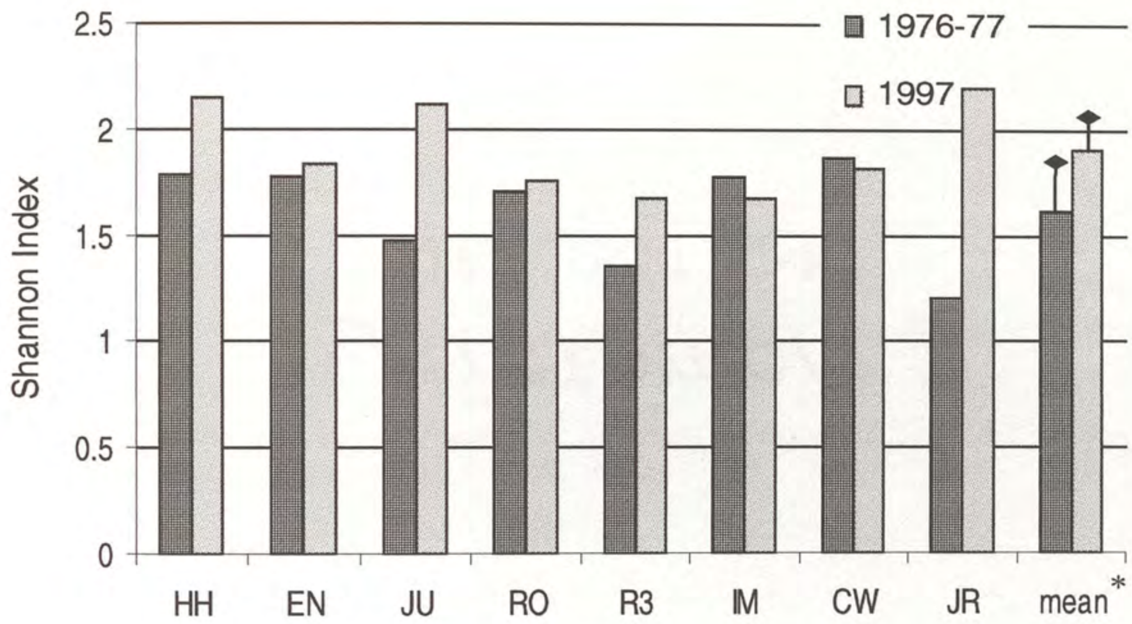


Figure 10. Within hammock tree species diversity for 1976-77 and 1997. Asterisk indicates a significant difference ($P < 0.05$). Error bars above mean equal one standard deviation. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

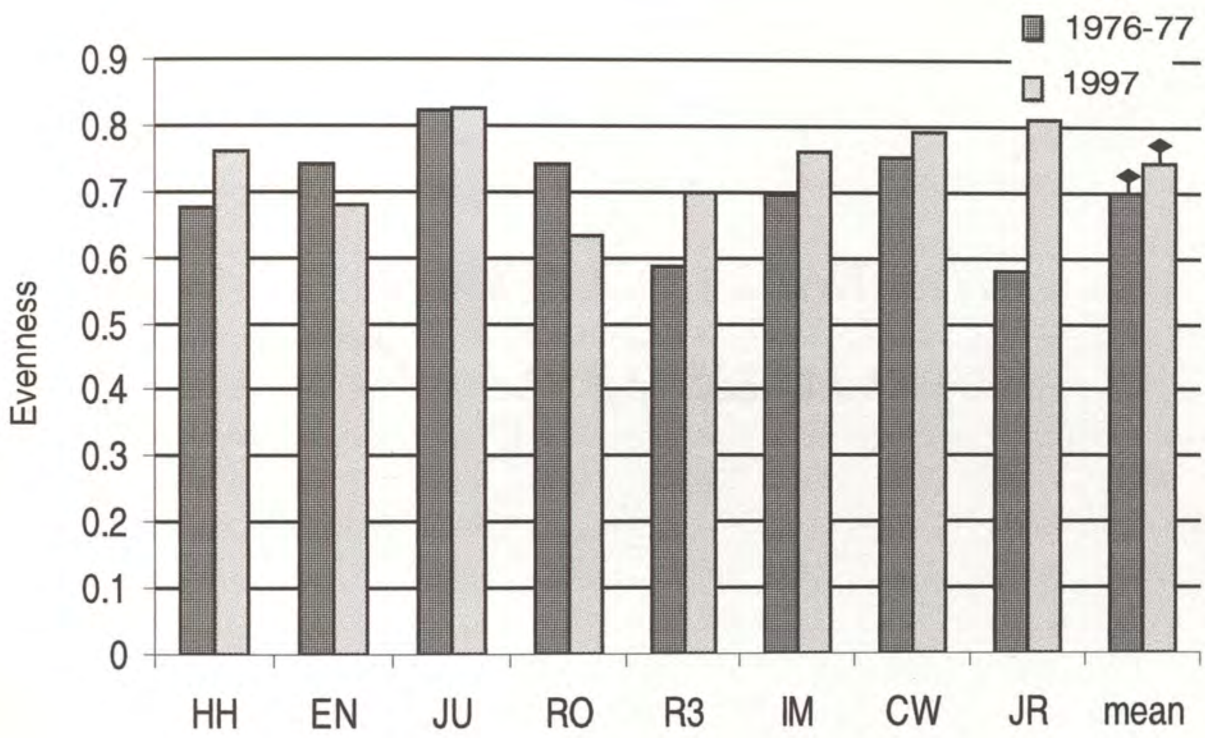


Figure 11. Within hammock tree evenness measure. There was no statistical difference between average tree evenness between 1976-77 and 1997. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

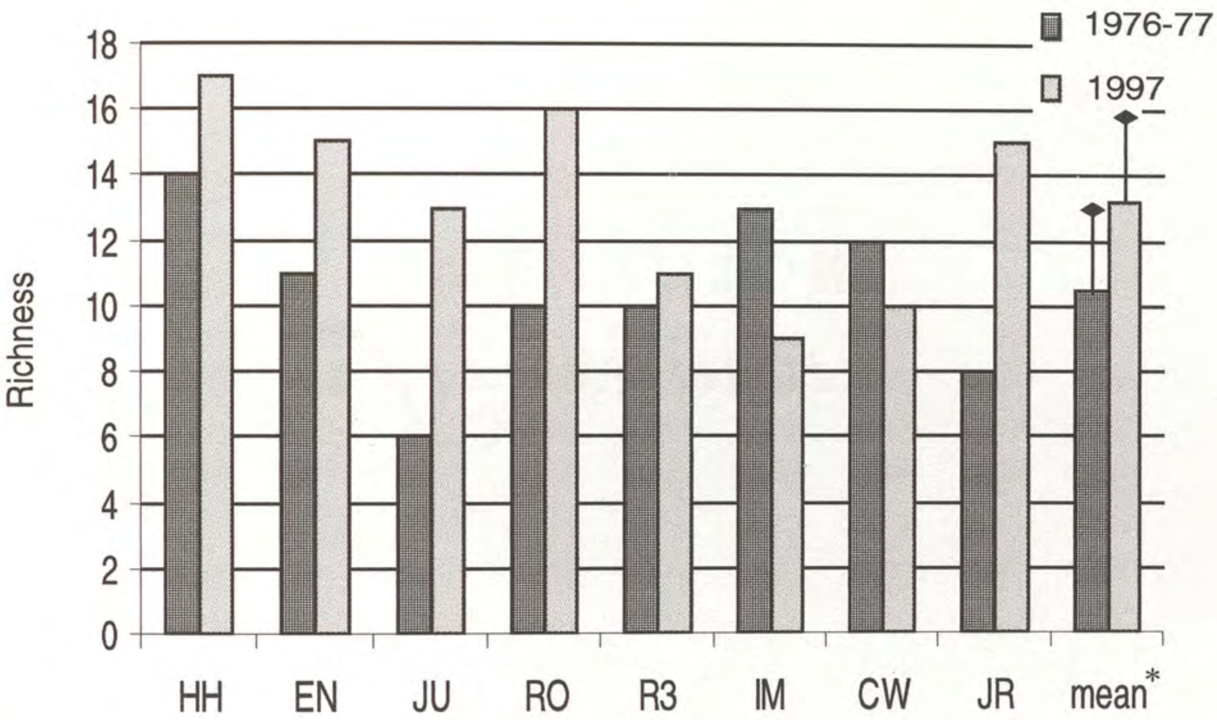


Figure 12. Within hammock tree richness for 1976-77 and 1997. Asterisk indicates a significant difference ($P < 0.05$). Error bars above mean equal one standard deviation. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

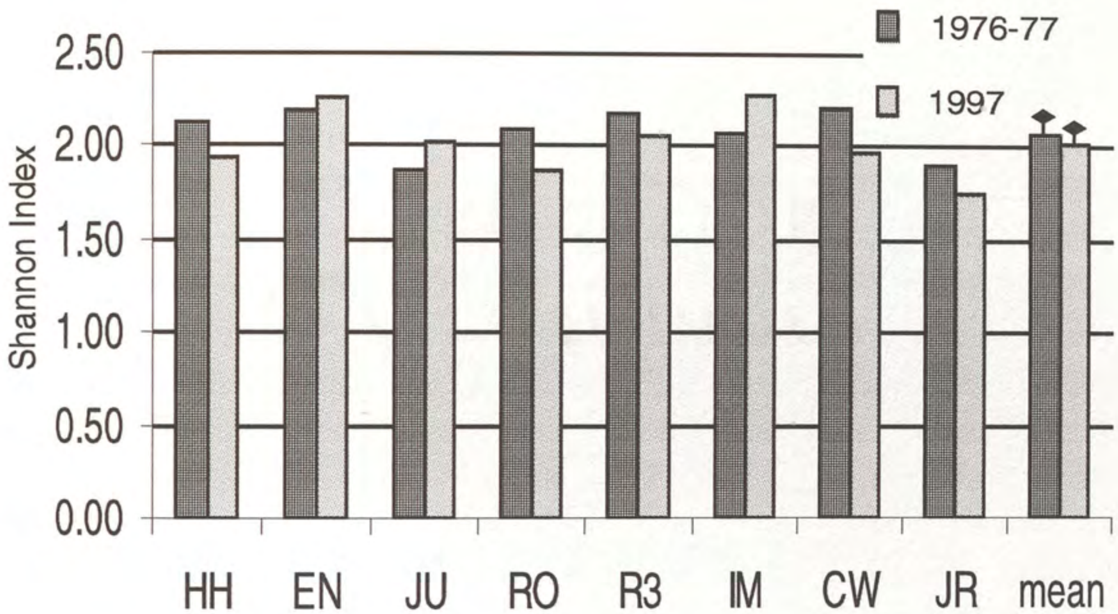


Figure 13. Within shrub species diversity. There was no statistical difference between average shrub diversity between 1976-77 and 1997. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

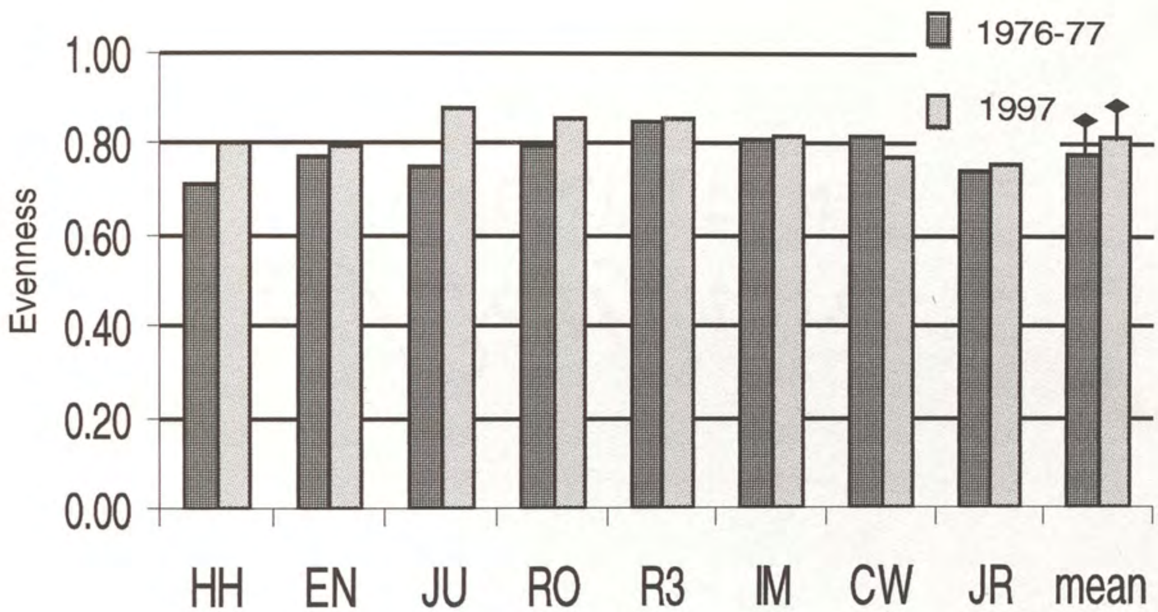


Figure 14. Within hammock shrub evenness. There was no statistical difference between average shrub evenness between 1976-77 and 1997. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

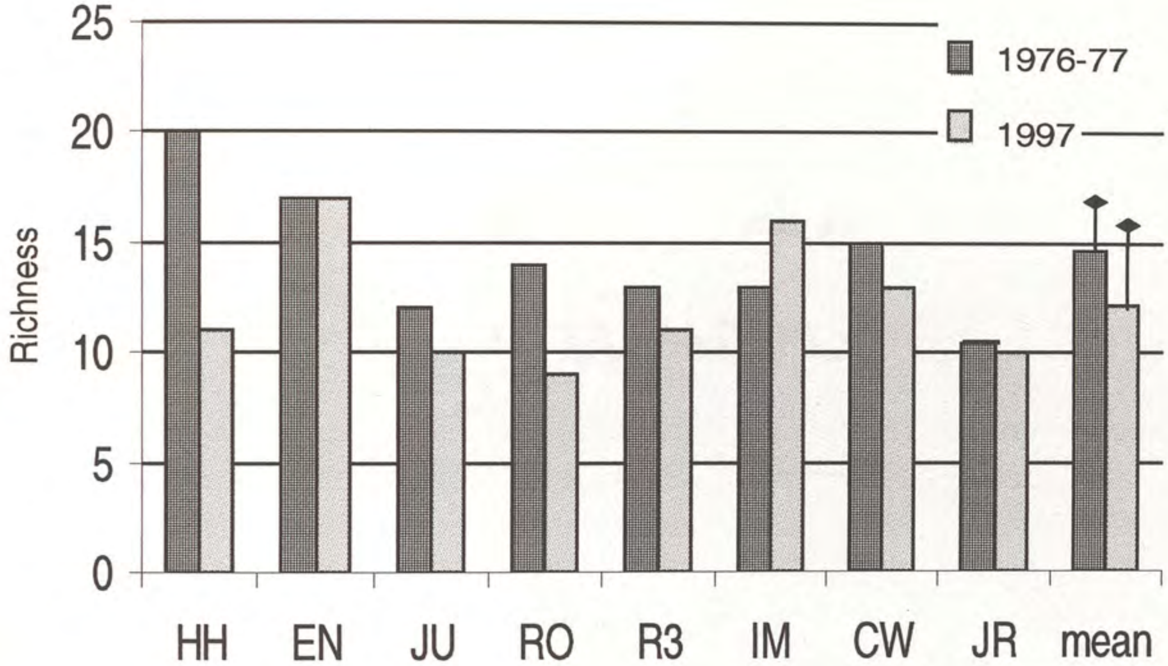


Figure 15. Within hammock shrub richness for 1976-77 and 1997. Asterisk indicates a significantly difference ($P < 0.05$). Error bars above mean equal one standard deviation. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

## Herbs

Species diversity for the herbs was calculated from averaged importance values using the Shannon index. A paired t-test between all hammocks (Figure 16) did not yield a significant difference, but a t-test between Jerome Road and Juniper Hammocks from both data sets did yield a significantly difference ($P < 0.05$). Figures 17 and 18 illustrate the evenness, and richness for each data set, only the richness yielded a significant difference ($P < 0.05$).

## Soils

Soils throughout all sites contained greater than 50% sand within the soil matrix. In Happy Hammock, Ross Hammock, Jerome Road Hammock, Enchanted Forest, and portions of Route 3, there were enough organic bodies or muck present to be classified as a wetland soils as defined by section 62-340.450, Florida Administrative Code from the Department of Environmental Protection (Gilbert et al., 1995). In each of the hammocks there was always leaf litter present; bare spots were uncommon.

Table 6 lists the five tested soil parameters and how they differed from 1976-77 to 1997. From a paired t-test, only P and pH did not yielded a significant difference between samples ($P < 0.05$). A correlation of both data sets showed that pH, cec, and Ca were significantly related ($P < 0.05$). Table 7 is a matrix developed from Table 6. Using a Spearman's non-parametric test, cec-pH and cec-Ca produced significant correlations. DCA of soil data are illustrated in Figure 19. Soils separated along axis-1 primarily due

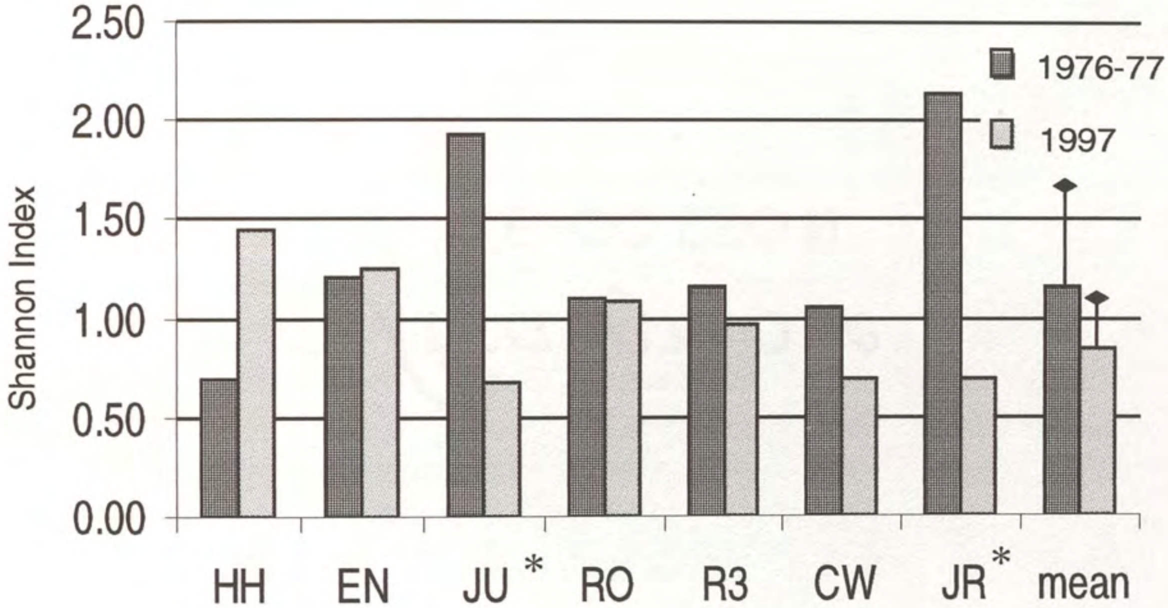


Figure 16. Within hammock herbaceous species diversity for 1976-77 and 1997. Asterisk indicates a significant difference, P< 0.05. Error bars above mean equal one standard deviation. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

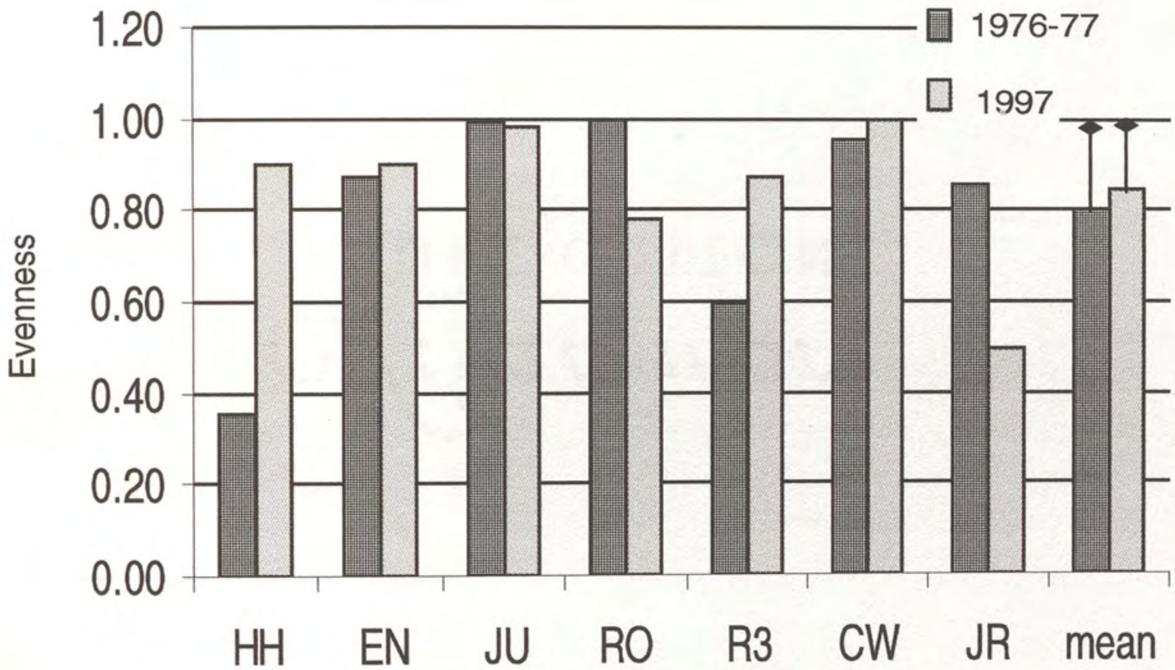


Figure 17. Within hammock herbaceous evenness was not statistically different between 1976-77 and 1997. Error bars above mean equal one standard deviation. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

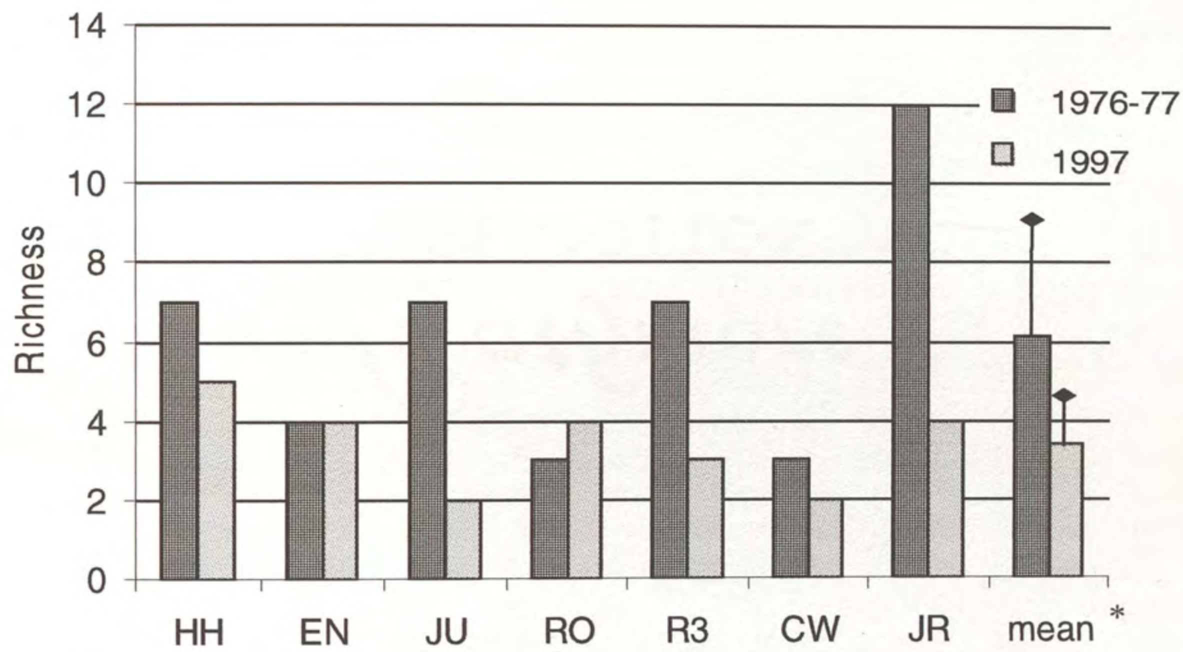


Figure 18. Within hammock herbaceous richness for 1976-77 and 1997. Asterisk indicates a significant difference (P < 0.05). Error bars above mean equal one standard deviation. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

Table 6. Soil characteristics. Results are given as parts ppm of dry weight of soils expressed as mg/kg for Ca, P, and Mg. Cation exchange capacity data are reported as meq/100g. Results for pH were obtained from a 1:1 slurry of soil to deionized water. Asterisks indicates significant t-test, ($P < 0.05$), tau indicates a significant regression, ($P < 0.05$).

| Hammock | pH $^{\tau}$ | | Cation Exchange Capacity * $^{\tau}$ | | Calcium * $^{\tau}$ | | Phosphorus | | Magnesium * | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1977 | 1997 | 1977 | 1997 | 1977 | 1997 | 1977 | 1997 | 1977 | 1997 |
| Castle Windy | 7.0 | 7.3 | 14.3 | 13.2 | 3200 | 7500 | 512 | 160 | 8 | 400 |
| Enchanted Forest | 6.7 | 7.4 | 29.9 | 27.0 | 5600 | 39000 | 1.8 | 330 | 192 | 400 |
| Happy | 8.2 | 7.0 | 21.2 | 20.5 | 1999 | 29000 | 6.9 | 840 | 758 | 1200 |
| Indian Mound | 6.9 | 6.7 | 23.5 | 7.9 | 520 | 3500 | 8.6 | 130 | 44 | 200 |
| Jerome Rd. | 6.7 | 7.5 | 10.6 | 13.2 | 3200 | 12000 | 1.4 | 200 | 116 | 700 |
| Juniper | 7.2 | 6.0 | 17.4 | 8.0 | 1999 | 2800 | 17.0 | 200 | 583 | 300 |
| Ross | 4.6 | 4.2 | 1.0 | 1.0 | 40 | 2250 | 1.0 | 110 | 16 | 200 |
| Route 3 | 6.2 | 5.8 | 16.6 | 12.4 | 1999 | 6500 | 36.5 | 1500 | 350 | 300 |
| $r^2$ | 0.55 | | 0.57 | | 0.53 | | 0.03 | | 0.37 | |

Table 7. Correlation of soil properties. Spearman's correlation among soil parameters for 1977 and 1997. Asterisks indicates significant relationships ($P < 0.05$).

| | | 1977 | | | | |
|---|---|---|---|---|---|---|
| | | pH | cec | Ca | P | Mg |
| 1997 | pH | 1 | 0.66 | 0.12 | 0.12 | 0.62 |
| | cec | 0.74 * | 1 | 0.41 | 0.11 | 0.31 |
| | Ca | 0.54 | 0.93 * | 1 | 0.09 | 0.11 |
| | P | 0.07 | 0.27 | 0.16 | 1 | 0.33 |
| | Mg | 0.47 | 0.53 | 0.56 | 0.25 | 1 |

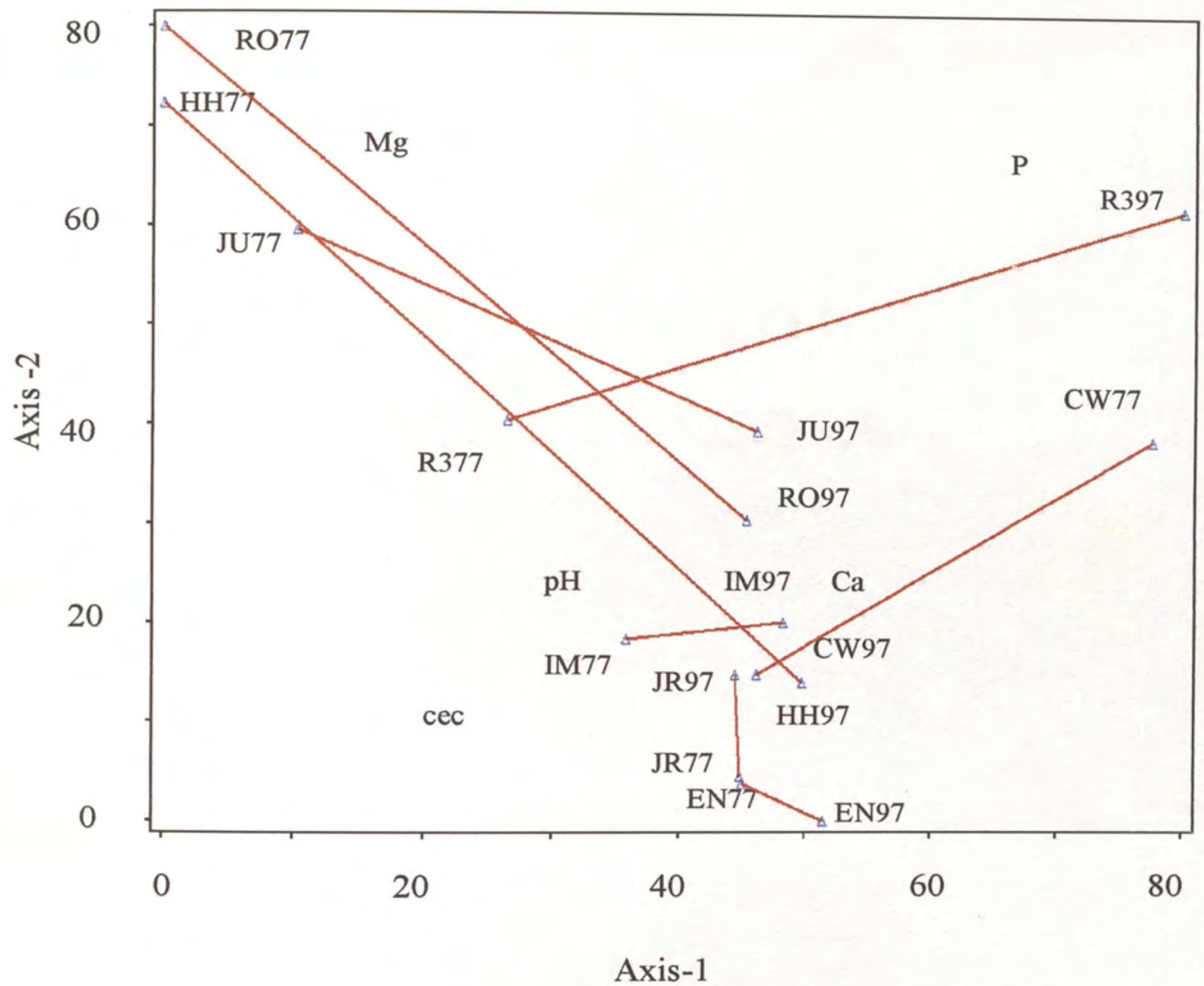


Figure 19. DCA analysis of soil samples between 1976-77 and 1997. Vectors indicate the directional change after 20 years. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

to the differences in concentrations of P and Mg. Also, the 1976-77 samples tended to align themselves primarily toward the left of 1997 samples indicating a shift in the ratio of Mg and P.

## Additional Community Components

### Temperate and Tropical Species

Table 8 lists percent occurrence of tropical and temperate species for both data sets. The data indicates that there was a larger fluctuation in temperate species than tropical species. For each stratum, there were always more species in 1976-77. The overall number of tropical species differed by six while the number of temperate species differed by 27 species.

Table 8 also shows that both the temperate and tropical trees differed very little in each study. The largest change in species richness occurred in the shrub and herb strata; and, the greatest variation occurred among temperate species. Although there were two more tropical shrub species in 1976-77, tropical shrubs in 1997 occurred in a greater density and generally had larger IVs (Table 4). Although tropical shrubs are restricted by temperature, they seem to be reattaining tree status in the recent absence of freeze events. There is no explanation why temperate herb and shrub species have declined.

Table 8. Tropical and temperate species comparisons.

| | N for 1976-77 | 1976-77 | N for 1997 | 1997 |
|---|---|---|---|---|
| Tropical | | | | |
| Trees | 14 | 35% | 11 | 31% |
| Shrubs | 16 | 32% | 14 | 39% |
| Herbs | 5 | 15% | 4 | 21% |
| Temperate | | | | |
| Trees | 26 | 65% | 24 | 69% |
| Shrubs | 34 | 58% | 22 | 61% |
| Herbs | 28 | 85% | 15 | 79% |

## Exotic species

The main exotic tree species encountered in 1997 were *Casuarina equisetifolia* (Australian pine), *Schinus terebinthifolius* (Brazilian pepper), and *Citrus aurantium* (Sour orange). *Casuarina equisetifolia* occurred throughout Jerome Road Hammock though it only appeared within four quadrants. In the shrub layer, *Schinus terebinthifolius* occurred within the quadrats of Indian Mound and Jerome Road Hammocks but occurred in Ross Hammock and the Enchanted Forest. *Citrus aurantium* occurred in all hammocks and was present in seven out of the eight hammock samples. Within the herbaceous layer only two species occurred in quadrats, *Sansevieria hyacinthoides* (Mother-in-laws tongue), and *Nephrolepis cordifolia* (Boston fern). From Stout's (1979a) study there in Castle Windy Hammock and as a tree in Castle Windy, Happy, and Route 3 Hammocks. *Nephrolepis cordifolia* was the only exotic species in the herbaceous layer in 1976-77 and it occurred in Happy Hammock and Indian Mound Hammock. At many of the sites, exotic species were found along the edge. In the case of Indian Mound Hammock, five exotics have thoroughly entrenched themselves in and along the edge: *Catharanthus roseus* (Periwinkle), *Agave neglecta* (Century plant), *Lantana camera* (Lantana), *Abrus precatorius* (Cat's eye), and *Kalanchoe pinnata* (Life plant).

It is clear that there was a dramatic increase in the amount of exotic species. Each of the species listed above is classified as invasive by the Exotic Pest Plant Council (EPPC, 1995). From Stout (1979a) and this study, the following species are listed as Category 1: *Abrus precatorius, Lantana camera, Schinus terebinthifolius, Casuarina equisetifolia,* and *Sansevieria hyacinthoides.* Category 1 species actively invade and disrupt native plant communities in Florida (EPPC, 1995). In twenty years the number and percent occurrence of exotic species increased faster than native species.

## Comparison of Dynamics

Figure 20 illustrates the relationship among vegetation strata and soil changes among the hammocks. A non-parametric test of the Euclidian vector lengths indicated that only trees and herbs were significantly correlated ($P < 0.05$). The large shrub spike in Jerome Road Hammock is most likely due to disturbances associated with the narrow

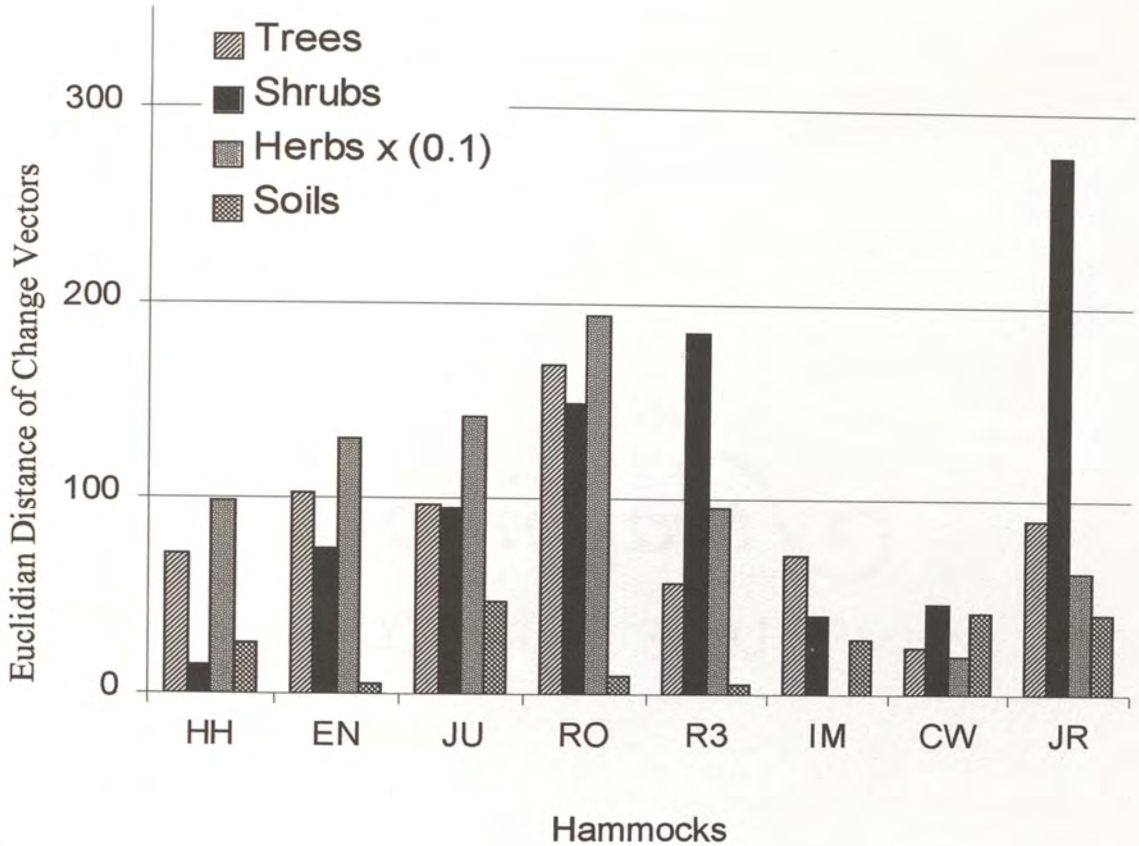


Figure 20. Comparison of Euclidian distance changes from ordination vectors. Change in herbaceous data was large and skewed the data. Herb values were multiplied by 0.1 for a visualization purposes. The missing histogram for herbaceous species in Indian Mound Hammock is due to no species present in 1976-77. HH = Happy Hammock, EN = Enchanted Forest, JU = Juniper Hammock, RO = Ross Hammock, R3 = Route 3 Hammock, CW = Castle Windy Hammock, JR = Jerome Road Hammock.

hammock, citrus grove management, and the large proportion of exotic shrub species. The herbaceous stratum of Indian Mound Hammock was left out of Figure 20 because no herbs were reported by Stout (1979a); therefore, the data could not be ordinated.

The most interesting observation from Figure 20 are the low values for Indian Mound Hammock and Castle Windy Hammock. The overall vegetative changes, indicated by histogram length, within these two hammocks are lower than the rest of the hammocks. This lack of change means that these two hammocks have been the most stable over the past 20 years. Table 9 lists the distances to the ocean and summed Euclidian vector lengths for trees, shrubs, and herbs in each of the eight hammocks and percent composition of tropical species.

Castle Windy Hammock and Indian Mound hammock are nearer the ocean than the other hammocks and have undergone the least change in terms of species composition. During non-storm events, Randall (1970) recorded salt spray transport as occurring as far as 200 m inland, Castle Windy Hammock occurs within this range. During storm events, salt spray is transported well beyond 200 m, indicating that hammocks closer to the ocean would be more vulnerable to salt spray deposition. Wells (1928, 1938, and 1939) characterized maritime hammocks as stable communities, resistant to change and dominated by sclerophilic oaks. Oaks were found to be among the dominant species in each of these hammocks; however, *Persea borbonia* (Red bay) and *Sabal palmetto* were also prevalent. These hammocks could be exhibiting stability due to salt spray, but other factors such as soils and disturbance regimes could be important.

In addition to the stability of Castle Windy and Indian Mound, these hammocks also support the largest proportion of tropical species. Happy Hammock, Jerome Road Hammock, and the Enchanted Forest all had standing water in portions of the hammock. Juniper Hammock and Ross Hammock had the lowest levels of soil moisture and have the lowest proportion of tropical plants. It seems that the presence of water and soil moisture may also determine the extent of tropical species present in a hammock. A regression analysis indicated that distance to the ocean and the percent tropicals was negatively correlated as was the Euclidian length and percent tropicals. Neither analysis was significant but the latter was close, ($P = 0.06$). The distance to ocean and Euclidian vector length were not correlated.

Table 9. Hammock change in comparison to distance to ocean.

| Hammock | CW | IM | HH | R3 | RO | JU | JR | EN |
|---|---|---|---|---|---|---|---|---|
| Distance to ocean in km | 0.8 | 2.5 | 4.8 | 5.3 | 5.5 | 6.4 | 10 | 20.2 |
| Summed Euclidian vector lengths | 113 | 141 | 211 | 248 | 326 | 240 | 409 | 181 |
| Percent tropical species | 43 | 53 | 36 | 24 | 15 | 14 | 25 | 29 |

# DISCUSSION

Results indicate that the dominant trees of the east-central Florida maritime hammocks have not changed significantly over 20 years. The four dominant species comprised nearly identical proportions of the overall importance values from each data set. Of the regional tree data, there was an overall reduction in richness of sub-dominant species. There were 26 temperate and 14 tropical trees in 1976-77 and there were 24 temperate and 11 tropical trees in 1997. Both temperate and tropical trees in this study experienced a reduction in richness, but of the 11 tropical trees that did occur in 1997 three of those were exotic invaders. Only three of the 14 tropical trees in 1976-77 did not occur as a tree or shrub in 1997, this may be due to a prior freeze event. The species diversity and evenness in 1997 were greater than the diversity and evenness from 1976-77 even though there was a reduction in richness. This indicates that these forests as a whole are becoming more similar in composition and more evenly proportioned. By definition, hammocks in 1997 were more diverse, but there has been an overall loss of variability in the region.

Shrub richness changed along with a change in dominant species. The most important shrubs in 1976-77 were juvenile trees while the most important species in 1997 were true shrubs. Of the 23 shrub species that did not occur in 1997, 14 were juvenile trees and 7 were vines. From this it seems like there may have been a reduction in seed germination. Barring natural death, the absence of large-scale disturbances will limit the amount and size of canopy gaps. During the sampling of 1976-77 there may have been some canopy gaps, which would explain the presence of seedlings, juvenile trees, and the presence of several vine species. Vines are opportunistic and are most abundant on edges and in disturbed areas such as canopy gaps.

Herbaceous vegetation showed a statistically significant change in richness; however, the diversity and evenness did not show a significant change even though there was almost a complete turnover in species composition. The sampling occurred during the same season for each study, thus reducing the likely hood of a temporal explanation. There were three times as many grasses, sedges, and vines in 1977 as there were in 1997. There were also twice as many dicotyledons in 1976-77 as recorded in 1997.

When the change in trees, shrubs, and herbs are evaluated at the regional level, change occurred mostly in the composition of temperate species. Only five tropical species from 1976-77 did not show up in 1997 while there were 17 temperate species from 1976-77 that did not occur at all in 1997. The substantial change in species richness is primarily due to the change in temperate species.

There is no clear explanation for the overall increase in concentration of nutrients between 1976-77 and 1997. It is clear from the data that changes have occurred. There are three possible explanations for the differences: 1) samples were not taken in the same spot; 2) the soils are highly heterogeneous or; 3) the analytic methods are more accurate and quality control is more stringent today. Conversations with George Husk (1998), from D.B. Environmental Laboratories, also indicated that the analytic methods in 1976-77 may have used different digestion and extraction techniques than are used today and could have contributed to the variation in results.

There was a hard freeze in 1976 (Norman, 1995) just after the initial sampling event (Stout, 1979a). Hard freezes also occurred in 1981, 1983, 1985 (Provancha et. al., 1986; Norman, 1995) and 1989 (Norman 1995). It has been seven years since the last hard freeze but this may not have been long enough for tropical species to reattain tree status. Over the 20 years, IVs of some temperate species have increased while most tropical species have decreased in frequency, density, and dominance.

Explanations for the variation in subdominant species remain problematic. Fire has been equally excluded throughout the 20 years. No clear explanation exists for the disappearance or decrease in many temperate species, but variation in local temperature is the most likely explanation for the reduction in tropical species. Due to a scarcity in repetitive hammock research, limited extrapolations can be made to assist in answering these questions.

## Statewide Comparisons

Hammocks occur throughout the state and many studies have been carried out to examine the species composition, succession, and diversity within this community type. In north Florida, Laessle (1942) characterized the vegetation of the Welaka area as a bay-oak-hickory-ilex association. Ansley (1952), Monk (1960) and Laessle and Monk (1961) found that *Quercus laurifolia* and *Magnolia grandiflora* dominated, supporting Laessle's (1942) claims. Also in north Florida, Ansley (1952) found *Acer saccharum* to be an important species where the soils were moist and Monk (1960) identified *Carpinus caroliniana* and *Ostrya virginiana* (Hornbeam) as important components of the hammock shrub layer. From the Big Bend area on the St. Mark's National Wildlife Refuge, Thompson (1980) found *Sabal palmetto*, *Quercus laurifolia, Q. virginiana,* Acer *rubrum* (Red maple), and *Magnolia virginiana* (Sweetbay) to have the highest importance values, respectively. And from north-east Florida, Monk (1968) found *Quercus virginiana* to be the most dominant species in the coastal areas south of St. Augustine.

From west-central Florida, Genelle and Fleming (1978) identified *Celtis laevigata* (Sugarberry), *Prunus serotina* (Black cherry), *Quercus virginiana*, *Acer rubrum*, and *Carya glabra* as the dominant species in Dunedin, Florida. Species in the shrub layer were *Sabal palmetto*, *Prunus caroliniana* (Carolina cherry), *Citrus aurantium, Serenoa repens*, *Ardisia escallonioides* (Marlberry), and *Psychotria nervosa*. In Highlands State Park, Stalter et al. (1981) found the following species, in decreasing order of importance, *Quercus virginiana*, *Sabal palmetto*, *Carya glabra*, and *Liquidambar styraciflua*

(Sweetgum). At Alafia River, Clewell et al. (1982) found *Quercus virginiana, Q. nigra, Q. hemisphaerica* (Diamond-leafed oak), *Sabal palmetto*, and *Liquidambar styraciflua* to be the dominate species.

In south Florida, Alexander (1958) found *Quercus virginiana, Q. laurifolia* and *Persea borbonia* to occur in the Miami and Pinecrest area but these species were not dominant. *Coccoloba diversifolia* (Pigeon plum), *Ardisia escallonioides, Ocotea coriacea* (Lancewood), *Lysiloma bahamensis* (False tamarind), and *Psychotria nervosa* were the most dominant canopy species. Austin et al. (1977) identified the tropical species *Mastichodendron foetidissimum*, *Bursera simaruba*, *Simarouba glauca* (Paradise tree), *Eugenia axillaris* (White stopper), and *E. foetida* (Spanish stopper) as the dominate trees in the Boca Hammock. *Sabal palmetto* was found to occur but only at lower elevations between the hammock and mangrove communities. Mack (1992) found *Ocotea coriacea*, *Simarouba glauca*, *Prunus myrtifolia* (West Indian cherry), and *Coccoloba diversifolia* to be dominant in Castellow Hammock south of Miami.

Johnson et al. (1993) published an assessment of the overall occurrences of plants from the foredune to the maritime hammock for the Florida Natural Area Inventory. In the section on the Southeast vegetation, the researchers systematically reviewed the coast from Cape Canaveral to Key Biscayne. Their data shows that the dominance of the temperate oaks yielded to tropical trees near Cocoa Beach. It is in this is area *Coccoloba uvifera* (Sea grape) first becames common in the canopy.

Wells (1928, 1938, and 1939) described the successional trends of maritime forests and states that *Quercus virginiana* is the climax dominant and that this community type is perpetuated by the presence of salt spray. Part of his reasoning was that this species of oak occurs inland, but there it does not dominate. Studies by Bourdeau and Osting (1959), Stalter (1974), and Stalter and Dial (1984) support the findings of Wells but they noted that the maritime forest also contained *Ilex vomitoria* (Yaupon holly), *Myrica cerifera* (Wax myrtle), *Persea borbonia*, *Juniperus virginiana* (Red cedar), *Osmanthus americanus* (Wild olive), and *Sabal palmetto*. Whether this community is salt spray maintained alone or if some other environmental parameter is involved is yet to be fully explored. In addition to the maritime hammocks, Poppleton et al. (1977) visited several mesic hammocks in the Merritt Island area. Their study enumerated as many species as possible but did not list their abundance. The majority of the species identified were temperate in origin.

The results from these studies indicate that the vegetation of the maritime hammocks of east-central Florida are more closely associated with temperate forests than tropical ones. As earlier researchers have described (Small, 1929; Norman, 1976 and 1995; Greller, 1980; Schwartz, 1988; and Johnson and Barbour, 1990), the southern portion of Volusia County currently supports the northern limit of many tropical species.

When the above hammock studies are compared to the results of this study, the absence of some temperate species and inclusion of some tropical species indicates that in this part of Florida a climatic transition exists where temperate and tropical species mix. Some temperate trees such as *Carpinus caroliniana* and *Acer saccharum* are absent, while tropical trees such as *Eugenia axillaris* and *Ocotea coriacea* exist. The maritime hammocks described in this study are at the northern limit of tropical species, and this may help to explain why the species richness of temperate vegetation can vary more but still dominate the tree canopy stratum.

## Succession

Hammocks are usually thought of as stable systems where little or no change is occurring. It seems justifiable at a quick glance, and hammocks are often misinterpreted as a forest in a state of Clementsian climax (Clements, 1916). Gano (1917) watched abandoned fields in north Florida succeed through a pine stage to hardwoods (*Quercus falcata* and *Q. stellata*) and finally to a mature hardwood system where magnolia and beech were occurring in the understory. Gano (1917) did not relate what the final species composition would be, the time that each sere lasted, nor did she indicate the length of time to reach the expected "climax" forest.

Understanding succession is challenging in its own right, and due to events such as logging, ditching, reduction in fire frequency, understanding the successional state or history of a site is very difficult. Repetitive studies in some of Florida hammocks have been conducted and provide some insight as to the successional trends of this community. In north Florida, Laessle (1942), Monk (1968), and Veno (1976) compiled data from the Welaka area and showed that xeric habitats succeed into mesic hammocks with the exclusion of fire. This could be occurring in Juniper, Route 3, and Ross hammocks due to the reduction in pines and the prolification of oaks and hickories. In south Florida, Alexander (1967) revisited Castellow Hammock 24 years after Phillips (1940) and found that the richness had decreased throughout but the dominant species in 1940 were still dominant in 1964. Alexander (1967) noted that the tropical hammock had not been subjected to any major disturbances and that succession had led to a reduction in shade-intolerant pioneer species. Almost 30 years later, Mack (1992) visited Castellow Hammock and found that the dominance of the tropical trees had shifted from the earlier studies. *Bursera simaruba* and *Ocotea coriacea* increased, while the once dominant *Coccoloba uvifera* and *Lysiloma latisiliquum* decreased.

Relative to vegetative studies that have been carried out in Florida over the past 57 years, hammocks in this study support a species composition more similar to that of north Florida than of south Florida. In the absence of disturbance, these data suggests that hammocks may proceed towards a community dominated by oaks, palms, and hickories. The literature also indicates that not all hammock communities are comprised of the same species. These variations in species composition may occur due to random events, giving one or a few species an advantage in the community. The disturbance-driven species assemblages may persist or be replaced following the next disturbance event or when a new canopy gap occurs. This type of disturbance regime may explain the vegetative variations that often exist in communities.

At all sites in this study, *Quercus* spp. and *Sabal palmetto* dominated the hammocks. But, during my sampling I became particularly interested in the "vegetative character" of each hammock. For one reason or another some sub-dominant species were present in high densities in some hammocks but were absent or found in low densities in others. Castle Windy and Route 3 Hammocks had large occurrences of *Ilex vomitoria*; Indian Mound Hammock, *Persea borbonia*; Juniper Hammock, *Carya glabra*; Ross Hammock, *Morus rubra* (Red mulberry); Jerome Road Hammock, *Ulmus americana* (American elm); Happy Hammock, *Ulmus americana*, *Myrcianthes fragrans* (Nakedwood), and *Acer rubrum*; and the Enchanted Forest, *Celtis laevigata*. What are the factors that enable some species to occur in higher densities than other species where there is seemingly little difference in water, soil nutrient composition, or temperature?

The variation in species composition along environmental gradients is one of the keystone questions involving the individualistic and continuum concepts. McIntosh (1967) proposes that the continuum concept is the best method for describing vegetation communities, as described by Whittaker (1956) in the Smoky Mountains. Gleason (1926) puts forth the notion that plant associations within a geographic region will vary hence the individualistic nature of each locality.

In a world where variability is the norm, defining the limits of the question is of paramount importance. Wiens (1989) and Levin (1992) address the scaling problem by stating the importance of accurately defining the scale of the study. To compare an observed pattern with others' research, similar spatial temporal scales must be used. Deviations in scale may yield different patterns, and the data may not be comparable.

At both the regional and local scale, the non-equilibrium theory by Platt and Schwartz (1990) seems to be the best explanation for variability between seemingly similar communities. In the Panhandle they found that the temperate hardwood forests show no clear successional patterns. Hurricanes, floods, droughts, and tornadoes do not affect the entire landscape at the same time or in the same way. These abiotic disturbances change the biotic aspect of the landscape and its position in a successional context.

In contrast to abiotic effects, plants that produce fleshy fruits could experience elevated levels of seed dispersal by frugivorus birds. Through endozoochory, birds could influence the dispersal of plants and their involvement could greatly enhance the success or failure of a species in a particular area (Schupp, 1993). Because many variables, alone or in combination, influence the composition of a community, it seems unlikely that any two hammocks could ever be at the same state of successional development. Hammocks throughout the landscape are going through different successional processes at any given point in time; change is occurring, albeit at a very slow pace.

## Exotic species

Putz (1998) suggests naming the current epoch the Homogeocene. He notes the lack of understanding about the structure and composition of native ecosystems and that today's landscape is changing at an unprecedented rate within the past 10,000 years. Putz (1998) identifies the greatest threat to Florida's ecosystems as the exclusion of fire, which is causing an overall reduction in diversity and creating landscape dominated by the same species. In addition to the replacement of pines by oaks, fire exclusion allows exotic species to become established. Schmalzer et al. (1996) documented the overall change in land use for the Courtenay quadrangle, Merritt Island, Florida. From aerial imagery over a 70-year period, their results indicate that exotic species have not been a problem until recently. Invasive exotic species now occupy approximately 2% (308 ha) of 12,300 ha of the upland landscape in the Courtenay quadrangle. There was also in excess of 600 ha of land that was classified as disturbed or cleared. This type of landscape is especially susceptible to invasion by exotics.

## Seed Dispersal

How did these hammock species get here in the first place? Humans are no different than other animals in that we are very good at dispersing seeds. Whether by land or sea, the floral diversity of Florida was influenced by Colombian and pre-Columbian explorers. The original explorers probably carried seeds with them for subsistence and possibly for agriculture as they migrated, explored, and settled Florida.

In addition to people, migrating birds probably have been moving seeds from Neotropical areas to Florida for millennia. Once established in Florida, winter visitors and residents increased the distribution of tropical plants throughout the landscape. The evolution of morphological adaptations driven by plant-animal interactions may have allowed fruit-bearing plants to spread throughout the globe at a faster rate than did their predecessors, the pteridophytes and gymnophytes (Murray, 1986). Skeate (1987) found that in a north Florida hammock, fruit-producing plants set seed in late summer and early winter which corresponds to the arrival of many Neotropical migrants.

Of the plant species found in this study, 31% are tropical in origin. Of the tropical species, 81% have fleshy fruit that are suitable for birds consumption. This proportion is comparable to the 77-98% production of fleshy fruit in Neotropical forests (Murray, 1986). Only 54% of the temperate trees in these hammocks produce fleshy fruit suitable for birds. In contrast to the tropical component of hammocks, Cockfield et al. (1980) listed acorns, nuts, and fruit as the available food for avian species in maritime hammocks of South Carolina. The species they identified are similar to avian species found to occur in central Florida hammocks (Stevenson and Anderson, 1994). This indicates that some birds may prefer hammocks during migration and are able to shift their diets according to plant species present. Martin and Finch (1995) noted that Neotropical migrants use a wide variety of habitat types. But, when migrants utilize forests they tend to choose large unfragmented mature communities (Cox, J., 1988).

Birds are important dispersers of seeds and with the decline of avian residents and migrants, tropical plant diversity of central Florida may be negatively affected. The islands of natural areas that remain protected will undoubtedly provide an important refuge for the Neotropical migrants and for tropical plants. Future research into the vegetative character and plant-animal interactions could lead to some interesting studies. Throughout Florida's landscape, comparisons to MacArthur and Wilson's (1967) theories on island biogeography could be made and the findings used to make better management decisions and to help maintain and understand the biological diversity occurring in Florida's ecosystems.

# CONCLUSIONS

Much of the variation in community nomenclature can be attributed to non-uniform species composition throughout the range of hammocks in Florida. East-central Florida exists in the zone of transition from temperate to tropical and the geographic origin of the trees that can occur will vary from hammock to hammock in a north-south as well as in an east-west direction. It is this unique geographic-climatic relationship that could be an important bioindicator of climate change. The historic ranges of vegetation in Florida has been documented to be different from present day vegetation distributions. Both Bartram (1791) and Curtiss (1879) documented tropical plant species occurring well north of their current ranges.

There is no a shortage of interest in vegetative change, whether it be globally or locally. Volume 7, issues 2 and 3, of the 1996 The Journal of Vegetation Science was dedicated to identifying global vegetation groups and the importance of repetitive vegetation monitoring and interpretation. The importance of repetitive monitoring can not be over emphasized. Changes in species composition are both useful retrospectively and prospectively (Bakker, et al., 1996; Philippi et al., 1998) and provide land managers, ecologists, teachers, and politicians with tangible information. Changes in species composition provide knowledge that relates directly to succession, invasion by exotics, and the effects of changing abiotic conditions, whether they are directly related to human actions or not.

Declining biodiversity is occurring and it is a global problem. In a global vegetative study one out of eight plants are threatened with extinction (Suplee, 1988). Widespread extinctions are cutting across all plant families. The proliferation of a monocultural forest stand poses one of the largest threats to biological diversity. These threats come in the form of reduced genetic variability, reduced structural variability, extinction of the less populous, and habitat fragmentation (Myers, 1997). Palmer and Maurer (1997) researched monocultures and polycultures. Their data showed that when monocultures are selected for, the overall diversity declines; when polycultures are selected for, biodiversity increases. Though this experiment was carried out with crops and weeds, it demonstrates that if we want a biologically diverse biosphere, we must manage for diversity.

Our biosphere is naturally cyclical and the Floridian landscape has oscillated between pinelands and oaks for centuries (Delcourt and Delcourt, 1977; Clewell, 1981; Webb, 1990). Human mitigated natural processes such as reduced fire frequency and intentionally drained lands have affected vegetative communities; but it is the omnipresence of nature that will ultimately determine the extent and characteristics of ecosystems. The question of this study is not necessarily to ascertain whether humans or the biosphere are responsible for the changes in the vegetative composition in these hammocks; but has change occurred and how has the vegetation composition changed over time. Only through repetitive monitoring can we begin to better understand the dynamics of community change. Through repetitive monitoring we may be able to discover whether the current climatic forces will push tropical species farther south or if tropical species will one day occupy their former ranges. I hope the information from this study will aid in understanding of the temporal dynamics of the flora of Florida. Only if local research is encouraged and funded will we be able to be a part of the scientific community, at both the local and global level.

# Appendix A
Species List for 1976-77

| Species | Class | Common Name | Family |
|---|---|---|---|
| | Polypodiopsida | | |
| *Asplenium platyneuron* (L) Britton et al. | | Spleenwort | Aspleniaceae |
| *Blechnum serrulatum* Rich. | | Swamp fern | Blechnaceae |
| *Nephrolepis cordifolia* (L.) C. Presl. * | | Boston fern | Davalliaceae |
| *Pteridium aquilinum* (L.) Kuhn | | Bracken fern | Pteridaceae |
| *Thelypteris kunthii* (Desv.) Morton | | Shield fern | Aspidiaceae |
| | Pinopsida | | |
| *Juniperus virginiana* L. | | Red cedar | Cupressaceae |
| *Pinus elliottii* Engelm. | | Slash pine | Pinaceae |
| | Liliopsida | | |
| *Andropogon glomeratus* var. *glaucopsis* (Elliott) C. Mohr | | Bushy bluestem | Poaceae |
| *Arisaema triphyllum* (L.) Schott. | | Jack-in-the-pulpit | Araceae |
| *Chasmanthium laxum* var. *sessiliflorum* (Poir.) Wipff & S.D. Jones | | Longleaf chasmanthium | Poaceae |
| *Cladium jamaicense* Crantz. | | Sawgrass | Cyperaceae |
| *Cyperus sp.* | | Sedge | Cyperaceae |
| *Cyperus tetragonus* Ell. | | Sedge | Cyperaceae |
| *Dichanthelium communtatum* (schultz) Gould | | Witchgrass | Poaceae |
| *Dichanthelium strigosum* var. *glabrescens* (Griseb.) Freckmann | | | Poaceae |
| *Habenaria floribunda* Lindl. | | Orchid | Orchidaceae |
| *Oplismenus hirtellus* (L.) P. Beauv. | | Basketgrass | Poaceae |
| *Ponthieva racemosa* (Walt.) Mohr | | Shadow witch | Orchidaceae |
| *Panicum strigosum* (Muhl. ex Elliott) Freckmann | | | Poaceae |
| *Sabal palmetto* (Walter) Lodd. Ex Schult. & Schult. f. | | Sabal palm | Arecaceae |
| *Serenoa repens* (W. Bartram) Small | | Saw palmetto | Arecaceae |
| *Smilax bona-nox* L. | | Cat's brier | Smilacaceae |
| | Magnoliopsida | | |
| *Acer negundo* L. | | Box-elder | Aceraceae |
| *Acer rubrum* L. | | Red maple | Aceraceae |
| *Amorpha fruticosa* L. | | Bastard indigo | Fabaceae |
| *Ampelopsis arborea* (L.) Koehne | | Pepper vine | Vitaceae |
| *Ardisia escallonioides* Schlecht. & Cham. | | Marlberry | Myrsinaceae |
| *Asimina parviflora* (Michx.) Dunal | | Pawpaw | Annonaceae |
| *Boehmeria cylindrica* (L.) Sw. | | False nettle | Urticaceae |

* Indicates an exotic species.

## APPENDIX A Continued

| Species | Common Name | Family |
|---|---|---|
| *Sideroxylon reclinatum* Michx. | Buckthorn | Sapotaceae |
| *Sideroxylon tenax* (L.) | Buckthorn | Sapotaceae |
| *Bursera simaruba* (L.) Sarg. | Gumbo limbo | Burseraceae |
| *Callicarpa americana* L. | Beautyberry | Verbenaceae |
| *Carya aquatica* (F. Michx.) Nutt. | Water hickory | Juglandaceae |
| *Carya floridana* Sarg. | Scrub hickory | Juglandaceae |
| *Carya glabra* (Mill.) Sweet | Pignut hickory | Juglandaceae |
| *Celtis laevigata Willd.* | Sugarberry | Ulmaceae |
| *Chiococca alba* (L.) Hitchc. | Snowberry | Rubiaceae |
| *Citrus sinensis* (L.) Osbeck * | Orange tree | Rutaceae |
| *Elephantopus elatus* Bertol. | Elephant's foot | Asteraceae |
| *Eryngium prostratum* Nutt. Ex. D.C. | Snakeroot | Fabaceae |
| *Erythrina herbacea* L. | Coralbean | Fabaceae |
| *Eugenia* axillaris (Sw.) Willd. | Spanish stopper | Myrtaceae |
| *Eugenia foetida* Pers. | White stopper | Myrtaceae |
| *Ficus aurea* Nutt. | Strangler fig | Moraceae |
| *Forestiera segregata* (Jacq.) Krug & Urban | Florida privet | Oleaceae |
| *Fraxinus pennsylvanica* Marsh. | Ash | Oleaceae |
| *Galactia elliottii* Nutt. | Milk pea | Fabaceae |
| *Hedyotis procumbens* (J.F. Gmel.) Fosberg | Innocence | Rubiaceae |
| *Ilex cassine* L. | Dahoon holly | Aquifoliaceae |
| *Ilex vomitoria* Ait. | Yaupon holly | Aquifoliaceae |
| *Ipomoea alba* L | Morning-glory | Convolvulaceae |
| *Ipomoea indica* (Burm. f.) Merr. | Moonflowers | Convolvulaceae |
| *Ipomoea violacea* L. | Morning-glory | Convolvulaceae |
| *Itea virginica* L. | Virginia willow | Saxifragaceae |
| *Kosteletzkya virginica* (L.) Presl ex. A. Gray | Saltmarsh mallow | Malvaceae |
| *Krugiodendron ferreum* (Vahl) Urban | Ironwood | Rhamnaceae |
| *Magnolia grandiflora* L. | Southern magnolia | Magnoliaceae |
| *Magnolia virginica* L. | Sweetbay | Magnoliaceae |
| *Matelea gonocarpus* (Walter) Shinners | | Rubiaceae |
| *Mikania scandens* (L. f.) Willd. | Hempvine | Asteraceae |
| *Morus rubra* L. | Red mulberry | Moraceae |
| *Myrcianthes fragrans* (Sw.) Mc Vaugh | Nakedwood | Myrtaceae |
| *Myrica cerifera* L. | Wax myrtle | Myricaceae |
| *Ocotea coriacea* (Sw.) Britt. | Lancewood | Lauraceae |
| *Osmanthus americanus* (L.) benth. & Hook. F. ex. A. Gray | American olive | Oleaceae |
| *Parthenocissus quinquefolia* (L.) Planch. | Virginia creeper | Vitaceae |
| *Pavonia spinifex* (L.) Cav. | Passion flower | Malvaceae |

* Indicates an exotic species.

| Species | Common Name | Family |
|---|---|---|
| *Persea borbonia* Spreng. | Red bay | Lauraceae |
| *Persea palustris* (Raf.) Sarg. | Swamp bay | Lauraceae |
| *Phoebanthus grandiflorus* (Torr. & Gray) Blake | Phoebanthus | Asteraceae |
| *Prunus caroliniana* (Mill.) Aiton | Carolina cherry | Roasaceae |
| *Psychotria nervosa* Sw. | Wild coffee | Rubiaceae |
| *Psychotria sulzneri* Small | Wild coffee | Rubiaceae |
| *Quercus laurifolia* Michx. | Laurel oak | Fagaceae |
| *Quercus nigra* L. | Water oak | Fagaceae |
| *Quercus virginiana* Mill. | Live oak | Fagaceae |
| *Rapanea punctata* (Lam.) Lundell | Myrsine | Myrsinaceae |
| *Rhus copallinum* L. | Winged sumac | Anacardiaceae |
| *Rivina humilis* L. | Rouge plant | Solanaceae |
| *Rubus trivialis* Michx. | Dewberry | Rosaceae |
| *Sageretia minutiflora* (Michx.) Mohr | Buckthorn | Rhamnaceae |
| *Salvia coccinea* Buchoz. ex Etl. | Red sage | Lamiaceae |
| *Sambucus canadensis* L. | Elderberry | Caprifoliaceae |
| *Schinus terebinthifolius* Raddi * | Brazilian pepper | Anacardiaceae |
| *Scleria triglomerata* Michx. | Nut sedge | Cyperaceae |
| *Toxicodendron radicans* (L.) Kuntze | Poison ivy | Anacardiaceae |
| *Ulmus americana* L. | American elm | Ulmaceae |
| *Valeriana scandens* L. | Valerian | Valerianaceae |
| *Vernonia gigantea* (Walt.) Trel. | Ironweed | Asteraceae |
| *Vitis sp.* | Grape | Vitaceae |
| *Zanthoxylum clava-herculis* L. | Hercules club | Rutaceae |
| *Zanthoxylum fagara* (L.) Sarg. | Wild lime | Rutaceae |

* Indicates an exotic species.

# APPENDIX B
Species List for 1997

| Species | Class | Common Name | Family |
|---|---|---|---|
| | Polypodiopsida | | |
| *Acrostichum danaeifolium* Langsd. & Fisch. | | Leather fern | Pteridaceae |
| *Blechnum serrulatum* Rich. | | Swamp fern | Blechnaceae |
| *Campyloneurum phyllitidis* (L.) C. Presl. | | Birds nest fern | Polypodiaceae |
| *Nephrolepis cordifolia* (L.) C. Presl * | | Boston fern | Davalliaceae |
| *Osmunda cinnamomea* L. | | Cinnamon fern | Osmundaceae |
| *Phlebodium aureum* (L.) J. Sm. | | Golden serpent fern | Polypodiaceae |
| *Polypodium polypodioides* var. *michauxiana* (Weath.) E.G. Andrews & Windham | | Resurrection fern | Polypodiaceae |
| *Pteridium aquilinum* (L.) Kuhn | | Bracken fern | Pteridaceae |
| *Thelypteris* sp. | | Shield fern | Aspidiaceae |
| *Vittaria lineata* (L.) Sm. | | Shoestring fern | Vittariaceae |
| | Cycadopsida | | |
| *Zamia pumila* L. | | Coontie | Cycadaceae |
| | Pinopsida | | |
| *Juniperus virginiana* L. | | Red cedar | Cupressaceae |
| *Pinus elliottii* Engelm. | | Slash pine | Pinaceae |
| | Liliopsida | | |
| *Agave neglecta* Small * | | Century plant | Agavaceae |
| *Arisaema dracontium* (L.) Schott | | Green dragon | Araceae |
| *Bromelia balansae* Mez * | | Bromeliad | Bromeliaceae |
| *Cyperus* sp. | | Sedge | Cyperaceae |
| *Dichanthelium* sp. | | Dichanthelium | Poaceae |
| Graminoid | | Grass | Poaceae |
| *Murdannia keisak* (Hassk.) Hand.-Mazz. | | Dewflower | Commelinaceae |
| *Sabal palmetto* (Walter) Lodd. ex Schult. & Schult. f. | | Sabal palm | Arecaceae |
| *Sansevieria hyacinthoides* (L.) Druce * | | Mother-in-law's tongue | Agavaceae |
| *Serenoa repens* (W. Bartram) Small | | Saw palmetto | Arecaceae |
| *Setaria magna* Griseb. | | Setaria | Poaceae |
| *Scleria* sp. Bergius | | Nut sedge | Cyperaceae |
| *Tillandsia fasciculata* Sw. | | Wild pine | Bromeliaceae |
| *Tillandsia recurvata* (L.) L. | | Ball moss | Bromeliaceae |
| *Tillandsia usneoides* (L.) L. | | Spanish moss | Bromeliaceae |

* Indicates an exotic species.

APPENDIX B Continued

| Species | Class | Common Name | Family |
| --- | --- | --- | --- |
| | Magnoliopsida | | |
| *Acer rubrum* L. | | Red maple | Aceraceae |
| *Amyris elemifera* L. | | Torchwood | Rutaceae |
| *Ardisia escallonioides* Schiede & Deppe ex Schldl. & Cham. | | Marlberry | Myrsinaceae |
| *Asimina parviflora* (Michx.) Dunal | | Pawpaw | Annonaceae |
| *Baccharis* sp. L. | | False myrtle | Asteraceae |
| *Berchemia scandens* (Hill) K. Koch | | Rattan vine | Rhamnaceae |
| *Bursera simaruba* (L.) Sarg | | Gumbo limbo | Burseraceae |
| *Callicarpa americana* L. | | Beautyberry | Verbenaceae |
| *Capsicum frutescens* L. * | | Wild pepper | Solanaceae |
| *Carica papaya* L. | | Papaya | Caricaceae |
| *Carya aquatica* (F. Michx.) Nutt. | | Water hickory | Juglandaceae |
| *Carya glabra* (Mill.) Sweet | | Hickory | Juglandaceae |
| *Casuarina equisetifolia* L.* | | Australian pine | Casuarinaceae |
| *Celtis laevigata* Willd. | | Sugarberry | Ulmaceae |
| *Chiococca alba* (L.) Hitchc. | | Snow berry | Rubiaceae |
| *Cissus trifoliata* L. | | Marine vine | Vitaceae |
| *Citrus aurantium* L. * | | Orange tree | Rutaceae |
| *Cornus foemina* Mill. | | Swamp dogwood | Cornaceae |
| *Cynanchum* sp. L. | | Old man's beard | Asclepiadaceae |
| *Erythrina herbacea* L. | | Coral bean | Fabaceae |
| *Eugenia axillaris* (Sw.) Willd. | | Spanish stopper | Myrtaceae |
| *Eugenia foetida* Pers. | | Stopper | Myrtaceae |
| *Ficus aurea* Nutt. | | Strangler fig | Moraceae |
| *Forestiera segregata* (Jacq.) Krug & Urb. | | Wild olive | Oleaceae |
| *Gaylussacia dumosa* (Andrews) Torr. & A. Gray | | Huckleberry | Ericaceae |
| *Heliotropium angiospermum* Murray | | Seaside heliotrope | Boraginaceae |
| *Ilex glabra* (L.) A. Gray | | Gallberry | Aquifoliaceae |
| *Ilex vomitoria* Aiton | | Yaupon holly | Aquifoliaceae |
| *Iva frutescens* L. | | Marsh elder | Asteraceae |
| *Kalanchoe pinnata* (Lam.) Pers.* | | Life plant | Crassulaceae |
| *Lycium carolinianum* Walter | | Christmas berry | Solanaceae |
| *Lyonia ferruginea* (Walter) Nutt. | | Rusty lyonia | Ericaceae |
| *Maclura pomifera* (Raf.) C.K. Schneid. * | | Osage orange | Moraceae |
| *Magnolia grandiflora* L. | | Southern magnolia | Magnoliaceae |
| *Magnolia virginica* L. | | Sweetbay | Magnoliaceae |
| *Mentzelia floridana* Nutt. Ex Torr. & A. Gray | | Poorman's patch | Loasaceae |
| *Morinda royoc* L. | | Indian mulberry | Rubiaceae |
| *Morus rubra* L | | Red mulberry | Moraceae |

* Indicates an exotic species.

APPENDIX B Continued

| Species | Common Name | Family |
|---|---|---|
| *Myrcianthes fragrans* (Sw.) McVaugh | Nakedwood | Myrtaceae |
| *Myrica cerifera* L. | Wax myrtle | Myricaceae |
| *Ocotea coriacea* (Sw.) Britton | Lancewood | Lauraceae |
| *Opuntia stricta* (Haw.) Haw. | Prickly-pear Cactus | Cactaceae |
| *Osmanthus americana* (L.) Benth. & Hook. f. ex A. Gray | American olive | Oleaceae |
| *Parthenocissus quinquefolia* (L.) Planch. | Virginia creeper | Vitaceae |
| *Passiflora suberosa* L. | Passion flower | Passifloraceae |
| *Persea borbonia* Spreng. | Red bay | Lauraceae |
| *Physalis* sp. L. | Ground cherry | Solanaceae |
| *Plumbago scandens* L. | Leadwort | Plumbaginaceae |
| *Poinsettia cyathophora* (Murray) Bartl. | Painted leaf | Euphorbiaceae |
| *Prunus caroliniana* (Mill.) Aiton | Carolina cherry | Rosaceae |
| *Prunus serotina* Ehrh. | Black cherry | Rosaceae |
| *Psychotria nervosa* Sw. | Wild coffee | Rubiaceae |
| *Psychotria sulzneri* Small | Wild coffee | Rubiaceae |
| *Quercus geminata* Small | Sand live oak | Fagaceae |
| *Quercus laurifolia* Michx. | Laurel oak | Fagaceae |
| *Quercus myrtifolia* Willd. | Myrtle oak | Fagaceae |
| *Quercus virginiana* Mill. | Live oak | Fagaceae |
| *Rapanea punctata* (Lam.) Lundell | Myrsine | Myrsinaceae |
| *Rhus copallinum* L. | Winged sumac | Anacardiaceae |
| *Rivina humilis* L. | Rouge plant | Phytolaccaceae |
| *Sageretia minutiflora* (Michx.) C. Mohr | Buckthorn | Rhamnaceae |
| *Salvia coccinea* Buc'hoz ex Etl. | Red sage | Lamiaceae |
| *Sambucus canadensis* L. | Elderberry | Caprifoliaceae |
| *Schinus terebinthifolius* Raddi * | Brazilian pepper | Anacardiaceae |
| *Sideroxylon tenax* L. | Tough bumelia | Sapotaceae |
| *Toxicodendron radicans* (L.) Kuntze | Poison ivy | Anacardiaceae |
| *Ulmus americana* L. | American elm | Ulmaceae |
| *Vaccinium stamineum* L. | Deerberry | Ericaceae |
| *Verbesina virginica* L | Frostweed | Asteraceae |
| *Viola* sp. L. | Violet | Violaceae |
| *Vitis* sp. L. | Grape | Vitaceae |
| *Ximenia americana* L. | Hog plum | Oleaceae |
| *Zanthoxylum clava-herculis* L. | Hercules club | Rutaceae |
| *Zanthoxylum fagara* (L.) Sarg. | Wild lime | Rutaceae |

* Indicates an exotic species.

# APPENDIX C
Importance Values for 1976-77

| Trees | IV | Trees | IV |
|---|---|---|---|
| *Sabal palmetto* | 112 | *Myrica cerifera* | 3 |
| *Quercus virginiana* | 43 | *Zanthoxylum clava-herculis* | 2 |
| *Quercus laurifolia* | 19 | *Forestiera segregata* | 1 |
| *Persea borbonia* | 19 | *Eugenia axillaris* | 1 |
| *Carya glabra* | 14 | *Bursera simaruba* | 1 |
| *Ilex vomitoria* | 11 | *Zanthoxylum fagara* | 1 |
| *Fraxinus pennsylvanica* | 11 | *Citrus aurantium* | 1 |
| *Ocotea coriacea* | 9 | *Ficus aurea* | 1 |
| *Acer rubrum* | 6 | *Osmanthus americana* | 1 |
| *Morus rubra* | 6 | *Carya floridana* | 1 |
| *Juniperus virginiana* | 5 | *Carya aquatica* | 0 |
| *Rapanea punctata* | 5 | *Rhus copallina* | 0 |
| *Pinus elliottii* | 5 | *Persea palustris* | 0 |
| *Ulmus americana* | 4 | *Sideroxylon tenax* | 0 |
| *Myrcianthes fragrans* | 4 | *Chiococca alba* | 0 |
| *Ardisia escallonioides* | 4 | *Eugenia foetida* | 0 |
| *Magnolia grandiflora* | 3 | *Ilex cassine* | 0 |
| *Magnolia virginica* | 3 | *Quercus nigra* | 0 |
| *Celtis laevigata* | 3 | *Acer negundo* | 0 |
| *Prunus caroliniana* | 3 | *Sideroxylon reclinata* | 0 |

| Shrubs | IV | Shrubs | IV |
|---|---|---|---|
| *Sabal palmetto* | 29 | *Quercus nigra* | 1 |
| *Toxicodendron radicans* | 16 | *Rivina humilis* | 1 |
| *Ardisia escallonioides* | 13 | *Ampelopsis arborea* | 1 |
| *Quercus virginiana* | 13 | *Zanthoxylum fagara* | 1 |
| *Ilex vomitoria* | 12 | *Ulmus americana* | 1 |
| *Quercus laurifolia* | 10 | *Sageretia minutiflora* | 1 |
| *Psychotria nervosa* | 9 | *Kosteletzkya virginica* | 0 |
| *Ocotea coriacea* | 9 | *Citrus sinensis* | 0 |
| *Prunus caroliniana* | 8 | *Asimina parviflora* | 0 |
| *Myrcianthes fragrans* | 6 | *Zanthoxylum clava-herculis* | 0 |
| *Rapanea punctata* | 5 | *Schinus terebinthifolius* | 0 |
| *Serenoa repens* | 5 | *Mikania scandens* | 0 |
| *Smilax bona-nox* | 5 | *Matelea gonocarpus* | 0 |
| *Vitis* sp. | 4 | *Valeriana scandens* | 0 |
| *Parthenocissus quinquefolia* | 4 | *Sambucus canadensis* | 0 |

APPENDIX C Continued

| Shrubs | IV | Shrubs | IV |
|---|---|---|---|
| *Acer rubrum* | 3 | *Rhus copallina* | 0 |
| *Persea borbonia* | 3 | *Persea palustris* | 0 |
| *Eugenia axillaris* | 2 | *Pinus elliottii* | 0 |
| *Erythrina herbacea* | 2 | *Morus rubra* | 0 |
| *Rubus trivialis* | 2 | *Magnolia grandiflora* | 0 |
| *Celtis laevigata* | 2 | *Krugiodendron ferreum* | 0 |
| *Psychotria sulzneri* | 2 | *Itea virginica* | 0 |
| *Carya glabra* | 2 | *Ipomoea alba* | 0 |
| *Myrica cerifera* | 2 | *Callicarpa americana* | 0 |
| *Galactia elliottii* | 1 | *Amorpha fruticosa* | 0 |

| Herbs | IV | Herbs | IV |
|---|---|---|---|
| *Nephrolepis cordifolia* | 30 | *Cyperus sp.* | 3 |
| *Oplismenus setarius* | 26 | *Panicum sp.* | 3 |
| *Pavonia spinifex* | 18 | *Unknown sedge* | 3 |
| *Andropogon virginicus* var. *glomeratus* | 11 | *Dichanthelium commutatum* | 3 |
| | | *Eryngium prostratum* | 2 |
| *Ipomoea violaceae* | 8 | *Arisaema triphyllum* | 1 |
| *Vernonia gigantea* | 8 | *Cyperus tetragonus* | 1 |
| *Panicum strigosum* | 7 | *Elephantopus elatus* | 1 |
| *Blechnum serrulatum* | 5 | *Habenaria floribunda* | 1 |
| *Mikania scandens* | 5 | *Hedyotis procumbens* | 1 |
| *Salvia coccinea* | 5 | *Ipomoea indica* | 1 |
| *Pteridium aquilinum* | 4 | *Phoebanthus grandiflora* | 1 |
| *Rhus copallina* | 4 | *Scleria triglomerata* | 1 |
| *Thelypteris kunthii* | 3 | *Asplenium platyneuron* | 1 |
| *Chasmanthium laxum* var. *sessiliflorum* | 3 | *Boehmeria cylindrica* | 1 |
| | | *Ipomoea alba* | 1 |
| *Cladium jamaicense* | 3 | *Ponthieva racemosa* | 0 |
| *Cyperus sp. #2* | 3 | | |

# APPENDIX D
Importance Values for 1997

| Trees | IV | Trees | IV |
|---|---|---|---|
| *Sabal palmetto* | 72 | *Schinus terebinthifolius* | 3 |
| *Quercus virginiana* | 39 | *Forestiera segregata* | 2 |
| *Quercus laurifolia* | 29 | *Lyonia ferruginea* | 2 |
| *Persea borbonia* | 21 | *Casuarina equisetifolia* | 1 |
| *Celtis laevigata* | 18 | *Magnolia grandiflora* | 1 |
| *Quercus geminata* | 15 | *Magnolia virginica* | 1 |
| *Carya glabra* | 12 | *Osmanthus americana* | 1 |
| *Ilex vomitoria* | 10 | *Ocotea coriacea* | 1 |
| *Morus rubra* | 9 | *Pinus elliottii* | 1 |
| *Myrcianthes fragrans* | 9 | *Prunus serotina* | 1 |
| *Ulmus americana* | 9 | *Rhus copallina* | 1 |
| *Quercus geminata* | 9 | *Ximenia americana* | 1 |
| *Prunus caroliniana* | 8 | *Carya aquatica* | 0 |
| *Juniperus virginiana* | 6 | *Sideroxylon tenax* | 0 |
| *Myrica cerifera* | 4 | *Bursera simaruba* | 0 |
| *Cornus foemina* | 3 | *Ilex glabra* | 0 |
| *Acer rubrum* | 3 | *Rapanea punctata* | 0 |
| *Citrus aurantium* | 3 | *Zanthoxylum clava-herculis* | 0 |

| Shrubs | IV | Shrubs | IV |
|---|---|---|---|
| *Psychotria nervosa* | 29 | *Myrica cerifera* | 2 |
| *Serenoa repens* | 22 | *Rhus copallina* | 2 |
| *Ardisia escallonioides* | 19 | *Schinus terebinthifolius* | 2 |
| *Sabal palmetto* | 17 | *Baccharis* sp. | 1 |
| *Prunus caroliniana* | 14 | *Berchemia scandens* | 1 |
| *Ilex vomitoria* | 13 | *Eugenia foetida* | 1 |
| *Ocotea coriacea* | 12 | *Gaylussacia dumosa* | 1 |
| *Callicarpa americana* | 10 | *Osmanthus americana* | 1 |
| *Celtis laevigata* | 7 | *Quercus* sp. | 1 |
| *Myrcianthes fragrans* | 7 | *Sambucus canadensis* | 1 |
| *Rapanea punctata* | 7 | *Toxicodendron radicans* | 1 |
| *Cornus foemina* | 6 | *Ulmus americana* | 1 |
| *Persea borbonia* | 5 | *Vaccinium stamineum* | 1 |
| *Quercus virginiana* | 4 | *Ximenia americana* | 1 |
| *Psychotria sulzneri* | 3 | *Sideroxylon tenax* | 0 |
| *Zanthoxylum clava-herculis* | 3 | *Eugenia axillaris* | 0 |
| *Asimina parviflora* | 2 | *Quercus myrtifolia* | 0 |
| *Erythrina herbacea* | 2 | *Vitis* sp. | 0 |

APPENDIX D Continued

| Herbs | IV | Herbs | IV |
|---|---|---|---|
| *Blechnum serrulatum* | 33 | *Thelypteris* sp. | 4 |
| *Dichanthelium* sp. | 31 | *Arisaema dracontium* | 3 |
| *Scleria* sp. | 29 | *Graminoid* | 3 |
| *Osmunda cinnamomea* | 20 | *Murdannia keisak* | 3 |
| *Verbesina virginica* | 18 | *Cyperus* sp. | 2 |
| *Salvia coccinea* | 15 | *Rivina humilis* | 2 |
| *Physalis* sp. | 10 | *Campyloneurum phyllitidis* | 1 |
| *Sansevieria hyacinthoides* | 9 | *Cynanchum* sp. | 1 |
| *Pteridium aquilinum* | 7 | *Acrostichum danaeifolium* | 1 |
| *Nephrolepis exaltata* | 6 | | |

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