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An Analysis of the Vegetation within the FAU Preserve as a Basis for Management of Scrub Habitat for *Gopherus polyphemus*

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Abstract

In Florida, urbanization has caused habitat fragmentation coupled with a major decline in the available habitat for native species. Native scrublands are of particular concern as they are deemed priority habitat by the Florida Fish and Wildlife Conservation Commission (FWC). Florida Atlantic University's Ecological Preserve—home to a keystone species, the gopher tortoise (*Gopherus polyphemus*)— is a prime example of such a fragmented, degraded scrub habitat. Our research focused on how fragmentation affected habitat suitability, as determined by the distribution of tortoise burrows in the preserve. We found significant correlations between higher burrow densities and minimal (< 50 %) shrub and canopy cover. Burrow densities were also higher in areas of greater herbaceous cover and organic soil content. These correlations were in agreement with previous findings reported in the literature. However, 23% of the preserve area was covered with invasive vines that, unless controlled, could further degrade the habitat. Our data suggest how a plan could be developed and implemented for the better management of gopher tortoises in the FAU Preserve.

Introduction

Our native scrub habitats are of particular concern for Florida as they are disappearing at an alarming rate (Myers 1990). Scrub is listed by FWC as a *priority habitat*, that is, one of special significance and/or purpose for one or more native species. Particularly, scrub habitats are home to a number of endemic species like the Florida scrub jay. Maintenance of biodiversity has been correlated to overall ecosystem health and function (Sodhi 2010), hence the importance of conservation of these unique habitats and their inhabitants. As a consequence of development, populations of these species have steadily declined. Urban development, such as in the highly urbanized Tri-county area of Southeastern Florida, has superseded preservation of these unique and diverse areas resulting in habitat loss for its numerous, and often endemic, inhabitants (Hall 2003).

Habitat fragmentation and close proximity to urbanized areas have resulted in a decline in natural fires and increased the necessity for anthropogenic methods of management. Scrub-type habitat, like that found on the FAU Preserve, is ideally maintained via prescribed burns (Myers 1990). Under the classical theory of succession, these regimented burns control the composition of the habitat by eradicating invasive species and reducing shrub and canopy cover (Krebs 2009). This reduction promotes the growth of grasses and other vegetation characteristics of scrub habitat that would otherwise be reduced due to shading by the canopy. Gopher tortoises prefer habitats containing a high proportion of herbaceous ground cover as forage. They also favor a reduced canopy for basking (thermo-regulation; MacDonald 1988).

The Florida Atlantic University (FAU) Ecological Preserve (Fig. 1) is an example of secondary succession in a fragmented habitat. This preserve was a regularly mowed lawn before 1970. At this time it was deemed a natural area and regular mowing ceased, allowing the land to begin successional development (Austin 1990). Presently, it stands as one of the limited and fragmented local conservation areas in South Florida featuring a variety of habitats, including primarily scrub and a growing population of oak hammocks (Austin 1990). A variety of species have since taken refuge in the preserve. The gopher tortoise (*Gopherus polyphemus*) and FAU's mascot, the burrowing owl (*Athene cunicularia*), are examples of two such species. Gopher tortoises and burrowing owls are native to scrub habitats and each is listed on the International Union for Conservation of Nature's Red List for Threatened Species (IUCN). Gopher tortoises in particular are of special significance as they are a threatened keystone species with declining populations. Their keystone designation is with regards to the 360 known species of animals that utilize and inhabit the burrows created by the gopher tortoise (McCoy 2005).

Although prescribed burns are commonly used to manage scrub habitat, this technique cannot be used in the FAU Preserve because of its close proximity to a local executive airport, university buildings, and a major highway (King 2005). As a result, invasive plant species such as earleaf acacia (*Acacia auriculiformis*), rosary pea (*Abrus precatorius*), brazilian pepper (*Schinus terebinthifolia*) and umbrella trees (*Schefflera actinophylla*) have become a source of concern for preserve managers, and are seriously affecting the local gopher tortoise population (Myers 1990; Hicklin 1994). The absence of fire or any other natural disturbances have resulted in an increase in the abundance of trees and canopy cover, as well as a decline in herbaceous ground cover as the two are negatively correlated (Menges 1993). This decrease in herbaceous ground cover negatively affects gopher tortoises by limiting the suitability of the area due, in part, to a decreased abundance of their food supply. Since the preserve is also surrounded by development on all sides, the tortoises cannot emigrate to a more suitable habitat (Steward 1991).

The purpose of this study was to determine where gopher tortoises preferred to place their burrows, and then use these data to determine correlations between these behavioral (habitat) preferences and the distribution of soil organic matter and vegetation in the preserve. These correlations enabled us to identify the quantity and quality of scrub habitat available, and thus the overall "condition" of the preserve as a scrub habitat. These findings were used to suggest a management and restoration plan for the FAU Preserve, as well as similarly distressed and fragmented scrub habitat communities in Florida.

Research Methods

Study Site

Our study was conducted on a 90-acre conservation area in southeastern Florida (Fig. 1). The site was located on the northwestern corner of Florida Atlantic University's Boca Raton campus. The conservation area is barricaded and fragmented by the university, as well as Palm Beach State College, and the Boca Raton Airport. The site houses a variety of wildlife, including a gopher tortoise population of

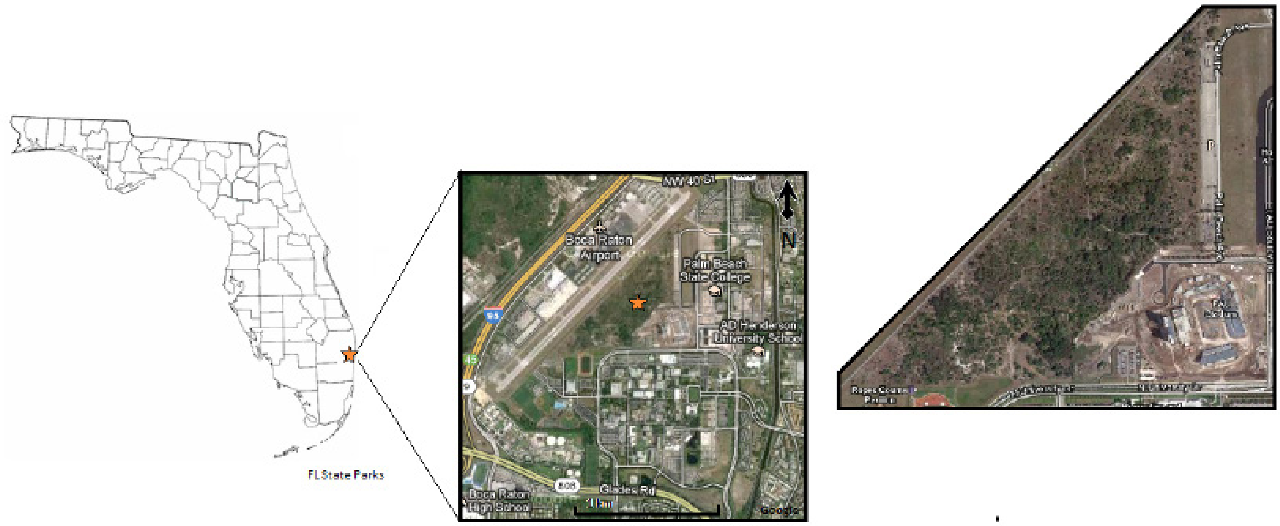

Figure 1. Study site location. Our study was conducted on the Florida Atlantic University (FAU) Boca Raton campus Conservation Area, know locally as the Preserve. The Preserve is a fragmented, island habitat sandwiched between FAU, Palm Beach State College, the Boca Raton Airport and I-95.

approximately 100 individuals for which burrow locations are known (Scholl et al. 2012). Habitats within the conservation area include palmetto scrub, oak hammock and a couple of stands of pine flatwoods.

Vegetation Surveys

Vegetation surveys were conducted from May to October 2012 using an existing, PVC-marked grid of 50 x 50 m points (Fig. 2). We performed 25 m belt transects, approximately six feet wide due north and south from each PVC marker using transect tape. Each northern 25 m transect should meet with the proceeding point's southern transect, and vice versa, to create continuous transects north and south. Collected data was species specific concerning shrub and canopy cover on a presence/absence basis at each meter. Any vegetation at or exceeding approximately 1.5 m in height was classified as a shrub. Any vegetation which could be measured via a Geographic Resource Solutions (GRS) densitometer (a tool used to measure overhead canopy) was classified as canopy.

At each point, ground cover was sampled using a 1 m^2 quadrat, which was centered using a compass and faced just east of the PVC marked point for consistency from sample to sample. The length of each quadrat was directed due north, south, east and west, respectively, using a compass. Within each quadrat, percent cover of bare ground, leaf litter and debris, saw palmetto, woody vegetation, grasses and other herbaceous cover were recorded using standard cover classes with a range of 0-6. Ground cover was measured as any vegetation less than a meter and a half in height within the quadrat, excluding any vegetation rooted outside of the boundaries of the quadrat. All methods for vegetation surveys were modified from the methods presented by the FWC (FWC 2010).

Using ArcGIS 9.3, we developed square buffer zones around each of the grid points to create 50 m quadrats around each point. After extrapolating the vegetation data collected within each quadrat, we overlaid the existing gopher tortoise burrow data from the previous year and were able to relate the placement of burrows to the vegetation within each of the quadrats in which they were found.

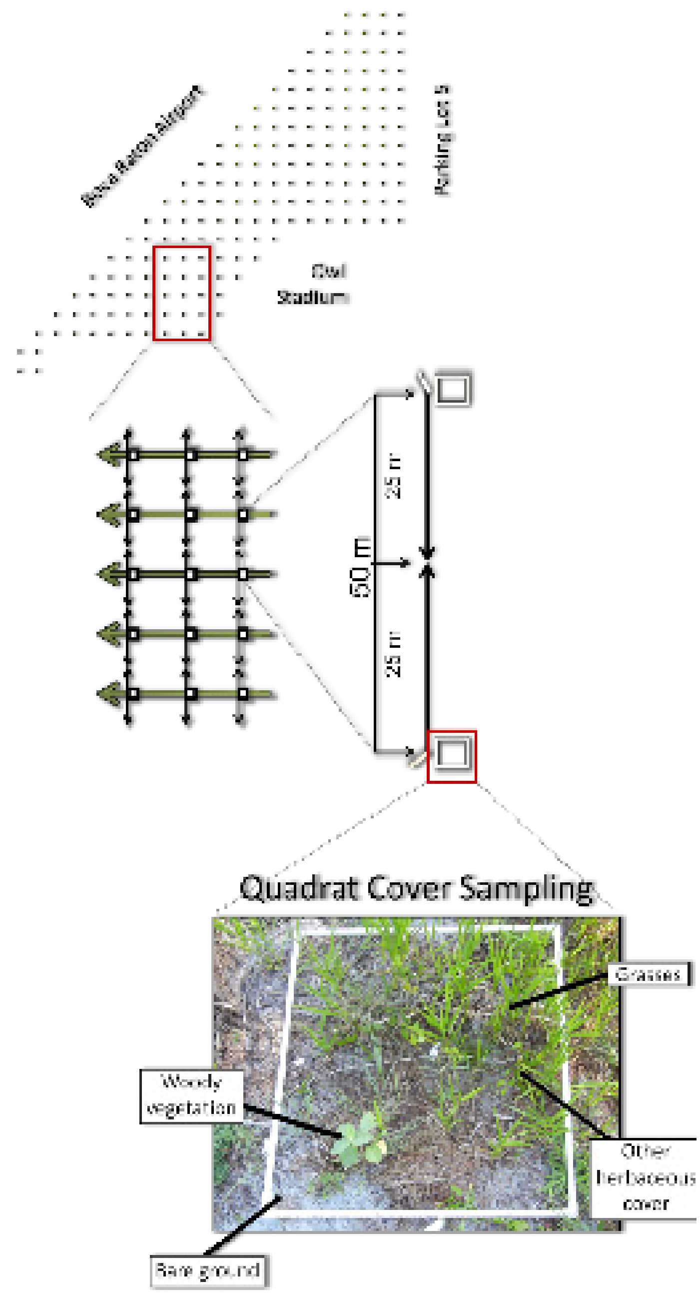

Figure 2. Vegetation Methods. We created a 50 m x 50 m grid of points over the FAU Preserve. At each point we conducted transects north and south to measure for shrub and canopy cover. We also conducted quadrat cover sampling using a $1m^2$ quadrat to measure ground cover.

Soil Surveys

We conducted soil surveys in August 2012 using stratified random sampling. Each of the strata was randomly sampled individually in order to proportionally represent the different vegetation types: xeric oak, grassland, live oak, upland shrub, brushland, and areas where acacia had been recently removed. Strata were defined using the Florida Land Use, Cover and Forms Classification System (FLUCCS). Each sample was collected using a 0.33 m^3 core sampler. Moisture content in each sample was obtained by comparing the weights of the sample before and after drying in an oven. Samples were then sifted using Kreck Sand Shaker soil sieve, which separated soil by particle size. The Wentworth grain size chart was used to determine the sieve sizes. The soil collected from each compartment in the sieve was weighted for each individual soil sample to determine the percent composition of each particle size in each sample by mass. Using a ball grinder, samples were grinded until homogenous. A muffle furnace was used to incinerate the biomass content in the soil. The weight of the sample before processing by the muffle furnace was compared to the weight after incineration to calculate the percent biomass in each sample.

Statistical Analysis

A test for simple, two-dimensional linear regression was performed on all of the collected data and burrow locations to analyze the significance of the burrow correlations. Linear regression was used to identify simple linear relationships between burrow placement and specific vegetation features. These tests were performed using the statistical software R. We used these correlation analyses to determine whether differences in burrow density were positively or negatively correlated with specific plant species, ground cover, and soil properties. We also checked for multi-collinearity using a variance inflation factor to test for multidimensional relationships between different vegetation features and burrow placement.

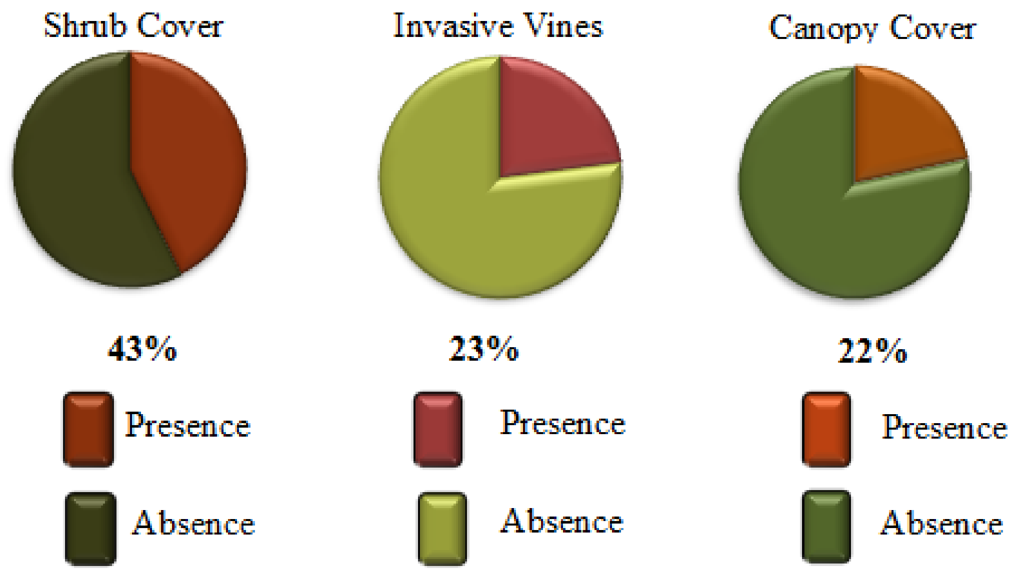

Figure 3. Total shrub and canopy cover. Of the sampled habitat, 43% consisted of shrub cover – 23% of the shrub cover was covered in invasive vines. The habitat consisted of 22% canopy cover which partially overlapped shrub cover. Total cover was just within the literature value of <50% total cover threshold for suitable gopher tortoise. The high proportion of shrub and canopy cover related to the literature range suggests that without proper, effective habitat management, the area may degrade to unsuitable habitat for gopher tortoise.

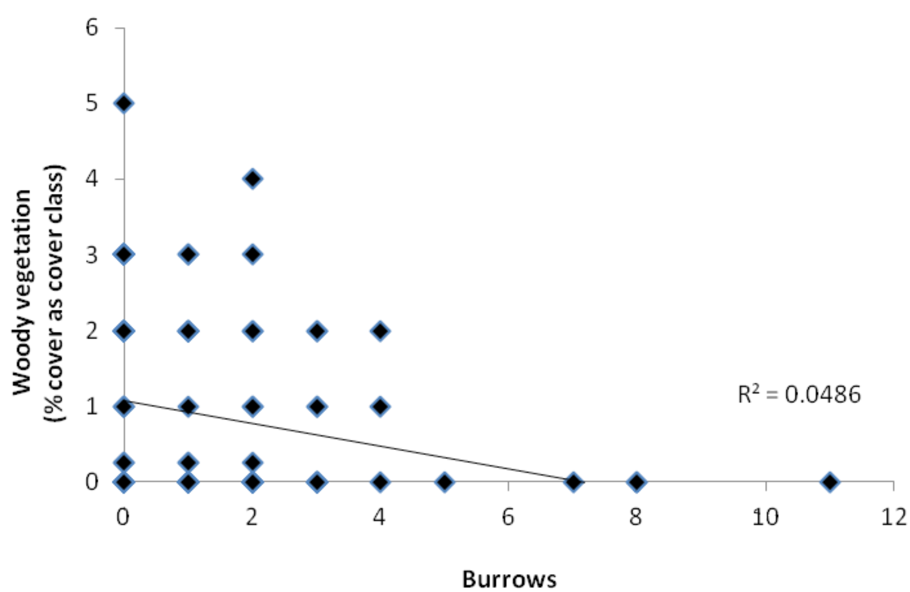

Figure 4. Woody Vegetation vs. Burrow Placement. The distribution of gopher tortoise burrows was negatively correlated with woody vegetation found within the 1m^2 quadrats sampled at each point with P = 0.014. Ground cover of woody vegetation was measured using standard cover classes to reduce sampling error. This negative correlation suggests gopher tortoises are selecting against areas with greater woody ground cover.

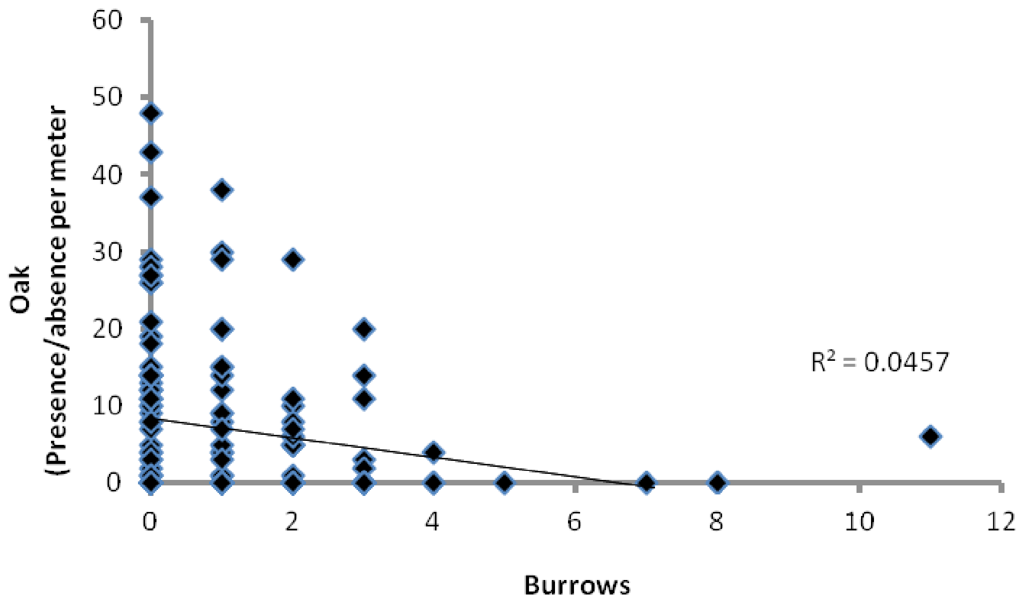

Figure 5. Oak Canopy vs. Burrow Placement. The distribution of gopher tortoise burrows was negatively correlated with oak canopy found in transects on a presence/absence basis at each meter with p = 0.0347. The negative correlation between oak canopy and the presence of gopher to rtoise burrows suggests that the tortoises are selecting for areas with less oak canopy cover.

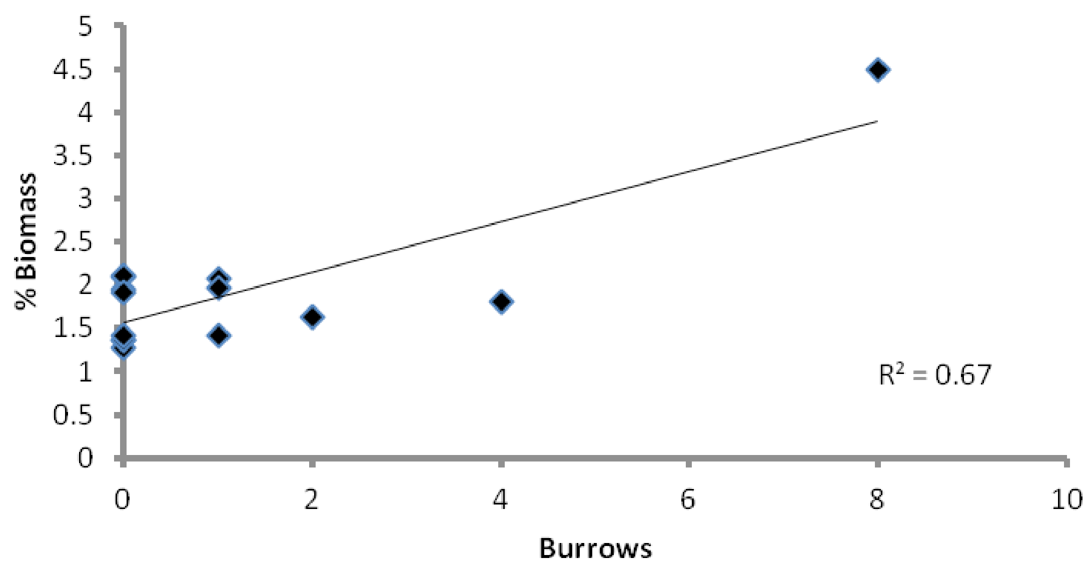

Figure 6. Biomass content versus burrow placement. Percent biomass measured in soil samples from 15 points compared to the quantity of gopher tortoise burrows in that 50m^2 quadrat with p = 0.00376. This was a significant, positive correlation suggesting that tortoises prefer areas of high biomass content. However, this result is driven primarily by a single outlier. Additional sampling should be performed in order to confirm this correlation.

Results

In general, 43% of the area surveyed contained shrub cover. An independent 23% of the 43% shrub was covered in invasive vines including *Smilax, Vitis* and *Cassytha* species. Another 22% canopy cover was measured within the sampled area. Canopy and shrub cover often overlapped and hence are not additive (Fig. 3). The total cover was just within the range of the < 50% literature value associated with suitable gopher tortoise habitat.

We related the placement of burrows to various ground cover categories, including herbaceous, leaf litter, debris, bare ground and woody vegetation. We found a significant negative correlation between the placement of burrows and woody vegetation (Fig. 4).

A significant negative correlation was found between oak canopy and the distribution of gopher tortoise burrows. The negative relationship between the distribution of burrows and oak canopy cover suggests that gopher tortoises prefer areas with less oak canopy (Fig. 5).

We also tested for correlations between the placement of gopher tortoise burrows and soil features. We found a positive correlation between the placement of burrows and biomass content.

Multicollinearity in all of the data collected in the vegetation and soil surveys was tested using a variance inflation factor (VIF). The VIF test returned values under 5 for each of the variables indicating no multicollinearity.

Discussion

The primary objective of this research was to investigate the composition of the vegetation related to habitat suitability for gopher tortoises, as well as identify the areas in need of greater management to increase the level and abundance of suitable scrub habitat for the species. As a keystone species, management of gopher tortoise habitat will affect the scrub habitat ecosystem as a whole.

The data illustrate the influx in the environment of oaks and sable palm causing an increase in canopy as well as a high density of shrubs. By the standards for shrub and canopy cover outlined in the literature, the FAU Preserve may be deemed suitable for gopher tortoise habitat. However, the now greater abundance of oaks both in canopy and shrub cover serve as evidence of succession of the scrub into an oak-dominated habitat unsuitable for gopher tortoises.

Gopher tortoise burrow distribution illustrated a significant negative correlation with areas consisting of high percentage of oak canopy cover. Herbaceous ground cover is generally negatively correlated with canopy cover. Although not clearly evident from this study, it can be deduced that herbaceous cover is positively correlated with the distribution of gopher tortoise burrows. We believe this correlation may not have been measured due to the degradation of the habitat. Herbaceous ground cover is relatively sparse throughout the FAU Preserve.

Our data suggests a positive correlation between burrow placement and greater biomass in the soil. This relationship suggests that gopher tortoises prefer soils with greater biomass content. However, this result is based on a small subsample and is driven by a single outlier (Fig. 6). Additional samples should be collected and analyzed for more definitive evidence.

Due to the relatively low percentage of canopy cover in this area, management might best be achieved by concentrating on the population of shrubs. The current management regime of the Preserve is based on mechanical removal of invasive vegetation and pesticides (Team 4 2005). We have observed that in areas managed through mechanical removal invasive species, such as *Phytolacca americana* and *Eupatorium capillifolium*, have increased. Based on the collected vegetation data, we suggest that a prescribed fire regime be put into place as this is the most effective, natural and cost effective way to manage scrub habitat (Myers 1990). Due to the high degree of fragmentation and proximity to the Boca Raton Airport, Florida Atlantic University and Interstate 95, smaller, highly regulated burns are suggested. By manually removing excess fuels we would be able to conduct small fires with a minimal amount of resulting smoke using the pre-existing Tortuga Trail as a basis for a fire line. Similar preserves in the Palm Beach county area use fire to maintain the habitat, such as Blazing Star Preserve – which is also in close proximity to I-95.

We speculate that the use of fire as a tool for habitat management will increase and maintain the habitat suitability for gopher tortoises, and in turn will provide viable scrub habitat for numerous native species. Fire regimes would also be of benefit for the university and surrounding facilities, both as a preventative measure and as an effective use of land. If a wild fire was to occur on the FAU Preserve, the build-up of excess fuels would result in a larger, less manageable fire. Also, an increase in suitable habitat would increase the carrying capacity of the area. This would allow for the transfer of animals from areas where their presence is less desirable. However, this undertaking would require the assistance of trained wild-fire fighters. It is suggested that FAU faculty contact local state parks, for example Jonathan Dickinson State Park, and consult with their park rangers to discuss this possibility.

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