27 Invasion of a Tall Upland Forest in Southeast Florida by the Exotic Tree *Syzygium cumini* (L.) Skeels— Stand Characteristics and Effects on Native Shrubs

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Abstract

While many exotic plants invade highly disturbed ecosystems, what may be less widely known is the exceptional ability of some exotic woody plants to invade the understory of relatively intact, tall-canopy forests. Stand characteristics of the tree *Syzygium cumini* (L.) Skeels in parts of Fern Forest Nature Center, Broward County, are reported here. In contrast to 13 native tree and shrub species reaching breast-height, *S. cumini* had high stem density and frequency, and the most successful degree of recruitment into larger diameter classes. Furthermore, there is some indication that the presence of individuals of *S. cumini* is adversely affecting the regeneration of native tree and shrub species.

Introduction

Syzygium cumini (L.) Skeels is a large Asian tree belonging to the family Myrtaceae. The large leaves are opposite, elliptic to ovate-lanceolate in shape, and borne on cream-colored twigs. The small, white flowers are born on spreading panicles approximately 10 cm in length. The edible fruits, for which the species is often cultivated, are broadly ellipsoid, about 1 to 3 cm long, ripen purple, and bear a prominent calyx rim. Large specimens of the tree have a thick trunk with yellow-brown, flaky bark; smaller ones may have smooth, light gray bark.

The species is found from India and Ceylon to south China, Malaysia, and the Pacific Islands, and is a common, large tree in dry zones throughout its range (Dassanayeke and Fosberg 1981). In southern Florida, *S. cumini* (jambolan plum) is typically found as a very large street tree, to 23 m in height (Broschat and Meerow 1991). The most recent flora of the state considers it rarely naturalized within disturbed hammocks (Wunderlin 1998). It is classified as a Category I inva-

sive exotic species ("potential to invade and disrupt native plant communities") by the Florida Exotic Pest Plant Council (Florida Exotic Pest Plant Council 1997).

Study Site and Methods

Fern Forest Nature Center is a county park of 102 ha within heavily urbanized north-central Broward County. It encompasses a portion of the Cypress Creek drainage system (Steinberg 1976), one of several short rivers that formerly breached the Atlantic Coastal Ridge and drained fresh water from the eastern edge of the Everglades (Lodge 1994). The park is recognized as a center of botanical diversity (Austin et al. 1979) and contains several plant communities, including subtropical hardwood hammock, bald cypress swamp, red maple swamp, and laurel oak/cabbage palm forest.

The laurel oak/cabbage palm community investigated in this study covers approximately 10% (about 10 ha) of the area of the park. The forest canopy averages about 16 m in height; canopy species are temperate and chiefly evergreen. Shrubs are primarily tropical hardwoods, and swamp fern (*Blechnum serrulatum* Rich.) forms a scanty herb layer. The soil is sandy and well-drained, with a thin litter layer of dry leaves varying in thickness from one to a few centimeters. The community is similar to the more southerly type of temperate broad-leaved evergreen forest described by Platt and Schwartz (1990). The area investigated borders several housing developments over 20 yr old and was known to contain *Syzygium cumini*.

To assess the composition and diameter class distribution of tree and shrub species, five 5 x 20 m plots were randomly located within the study area. Each plot was subdivided into four 5 x 5 m subplots. Within each subplot, every stem originating at ground level was identified to species and its diameter at breast height (dbh; breast height = 1.4 m) measured. Stems that did not reach breast height, including seedlings less than 10 cm in height, were identified and scored as saplings and not otherwise measured. The term "stem" will be used to indicate a plant stem that reached breast-height and was measured; "sapling" will be used to indicate a plant stem that did not reach breast height.

Species Composition

Cumulative data curves showing relationships of species numbers, stem densities, and basal area to area sampled are given in Fig. 1. A total of 28 species of native and exotic trees, shrubs, and palms were recorded in the five 5 x 20 m plots. However, other native and exotic species are known from the study area, and the park as a whole contains at least 68 tree and shrub species (D. Scofield, unpubl. data). Stems were dominated by the native tree *Quercus laurifolia*, the native shrubs *Ardisia escallonioides* and *Psychotria nervosa*, the exotic tree *Syzygium cumini*, and the na-

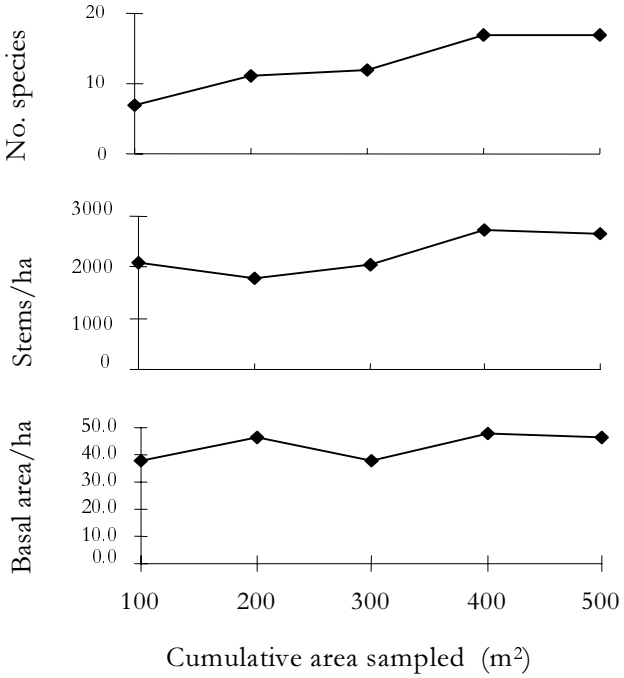

Figure 1. Cumulative stem data curves for the five 100 m² plots.

tive palm *Sabal palmetto* (Table 1). Saplings were dominated by *Sabal palmetto*, *Psychotria nervosa*, *P. sulzneri, Ardisia escallonioides*, and *Quercus laurifolia* (Table 2).

Native species with a high stem importance value also had a high sapling importance value. *Syzygium cumini* saplings, however, had much lower importance values than stems. This may indicate that, in contrast to native species, saplings of *S. cumini* are more successfully recruited into larger size classes.

Forest Structure

Forest stem structure was strongly two-tiered (Fig. 2). *Syzygium cumini* showed a particularly strong presence relative to other stems of other species between 3 and 7 cm dbh. The origin of the tiered effect is made clear when viewing the relative diameter distributions of stems belonging to different growth forms (Fig. 3). The greatest number of smaller stems belonged to native shrub species, with about 90% of stems less than 2 cm dbh. Native tree species had roughly half the number of stems as native shrubs; two-thirds of the trees had a dbh of 15 cm or

Table 1. Importance Values (I.V.) for tree, shrub, and palm stems in twenty 25 m² subplots. Species are arranged by I.V. (highest to lowest).

Species	Growth form	I.V. [2]	% of total	Relative		
				frequency	density	dominance
Quercus laurifolia Michx.	Tree	119.0	39.7	26.8	17.3	74.9
Ardisia escallonioides Schldl. & Cham.	Shrub	39.7	13.2	4.9	34.6	0.3
Psychotria nervosa Sw.	Shrub	27.9	9.3	9.8	18.0	0.1
Syzygium cumini (L.) Skeels [1]	Tree	25.8	8.6	14.6	10.5	0.6
Sabal palmetto (Walter) Schultes & Schultes f.	Palm	19.2	6.4	2.4	3.0	13.8
Pinus elliottii Engelm.	Tree	15.9	5.3	4.9	1.5	9.6
Simarouba glauca DC.	Tree	12.8	4.3	9.8	3.0	0.1
Myrcianthes fragrans (Sw.) McVaugh	Tree	6.5	2.2	4.9	1.5	0.1
Eugenia uniflora L. [1]	Shrub	6.4	2.1	4.9	1.5	0.0
Chrysalidocarpus lutescens H. Wendl.[1]	Palm	5.8	1.9	2.4	3.0	0.3
Eriobotrya japonica (Thunb.) Lindl.[1]	Tree	3.9	1.3	2.4	1.5	0.0
Acer rubrum L.	Tree	3.4	1.2	2.4	0.8	0.2
Eugenia axillaris (Sw.) Willd.	Shrub	3.2	1.1	2.4	0.8	0.0
Morus rubra L.	Tree	3.2	1.1	2.4	0.8	0.0
Nectandra coriacea (Sw.) Griseb	Tree	3.2	1.1	2.4	0.8	0.0
Bursera simaruba (L.) Sarg.	Tree	3.2	1.1	2.4	0.8	0.0
Persea borbonia (L.) Spreng.	Tree	0.8	0.2	0.0	0.8	0.0

[1] Naturalized exotic species.
[2] Sum of relative frequency, density, and dominance.

Table 2. Importance Values (I.V.) and densities for tree, shrub, and palm saplings in twenty 25 m² subplots. Species are arranged by I.V. (highest to lowest).

Species	I. V.[3]	% of total	Relative		Saplings per ha
			frequency	density	
Sabal palmetto (Walter) Schultes & Schultes f.	45.9	22.9	21.8	24.0	2020
Psychotria nervosa Sw.	38.5	19.2	16.1	22.4	1880
Ardisia escallonioides Schldl. & Cham.	24.5	12.3	6.9	17.6	1480
Quercus laurifolia Michx.	21.2	10.6	6.9	14.3	1200
Psychotria sulzneri Small [2]	21.0	10.5	11.5	9.5	800
Cupaniopsis anacardioides (A. Rich.) Radlk. [1,2]	7.2	3.6	5.8	1.4	120
Syzygium cumini (L.) Skeels [1]	6.3	3.2	3.4	2.9	240
Eugenia uniflora L. [1]	4.6	2.3	3.4	1.2	100
Eugenia axillaris (Sw.) Willd.	3.0	1.5	2.3	0.7	60
Sideroxylon salicifolium (L.) Lam. [2]	3.0	1.5	2.3	0.7	60
Psidium guajava L. [1,2]	2.8	1.4	2.3	0.5	40
Callicarpa americana L. [2]	2.8	1.4	2.3	0.5	40
Eriobotrya japonica Lindl. [1]	2.8	1.4	2.3	0.5	40
Schinus terebinthifolius Raddi [1,2]	2.8	1.4	2.3	0.5	40
Itea virginica L. [2]	1.9	0.9	1.2	0.7	60
Acer rubrum L.	1.6	0.8	1.2	0.5	40
Zanthoxylum fagara (L.) Sarg. [2]	1.6	0.8	1.2	0.5	40
Simarouba glauca DC.	1.4	0.7	1.2	0.2	20
Persea borbonia (L.) Spreng.	1.4	0.7	1.2	0.2	20
Bischofia javanica Blume [1,2]	1.4	0.7	1.2	0.2	20
Morus rubra L.	1.4	0.7	1.2	0.2	20
Ficus aurea Nutt. [2]	1.4	0.7	1.2	0.2	20
Schefflera actinophylla (Endl.) Harms [1,2]	1.4	0.7	1.2	0.2	20
Myrcianthes fragrans (Sw.) McVaugh	0.2	0.1	0.0	0.2	20

[1] Naturalized exotic species.
[2] Present in study area as sapling only.
[3] Sum of relative frequency and density.

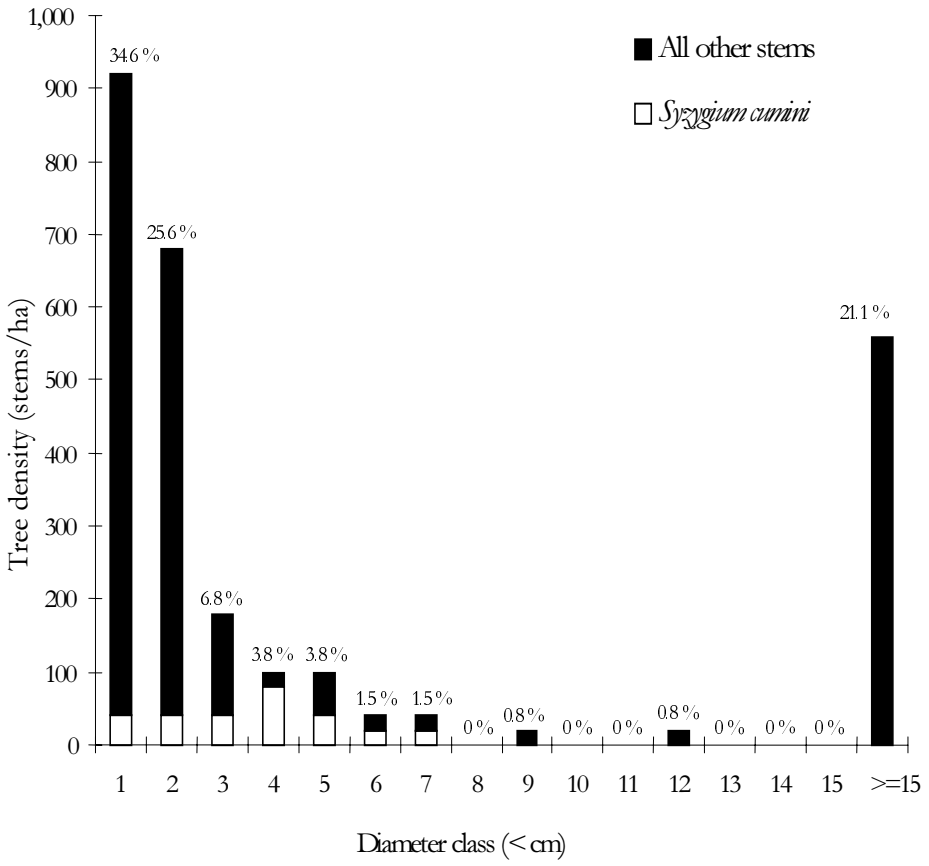

Figure 2. Distribution of stem diameters for trees, shrubs, and palms in the five 100 m^2 plots.

greater.

The relative diameter distribution of *S. cumini* stems did not resemble either the native tree or native shrub distribution (Fig. 3). Its largest stem was nearly twice the diameter of the largest native shrub stem, and its number of stems in the middle size classes exceeded that of native trees. While no stem measured approached the size of the larger native trees, at least one *S. cumini* individual in the forest reached 10 m tall. When considered together, the native tree and *S. cumini* diameter distributions appear similar to those in forests where a vigorous understory (in this case, of *S. cumini*) eventually overtakes the existing canopy (Barbour et al. 1987). This progression may be interrupted if canopy species have sporadic reproductive success, such as that facilitated by disturbance (Barbour et al. 1987). Fire is not a typical disturbance for this type of forest (Platt and Schwartz 1990), and

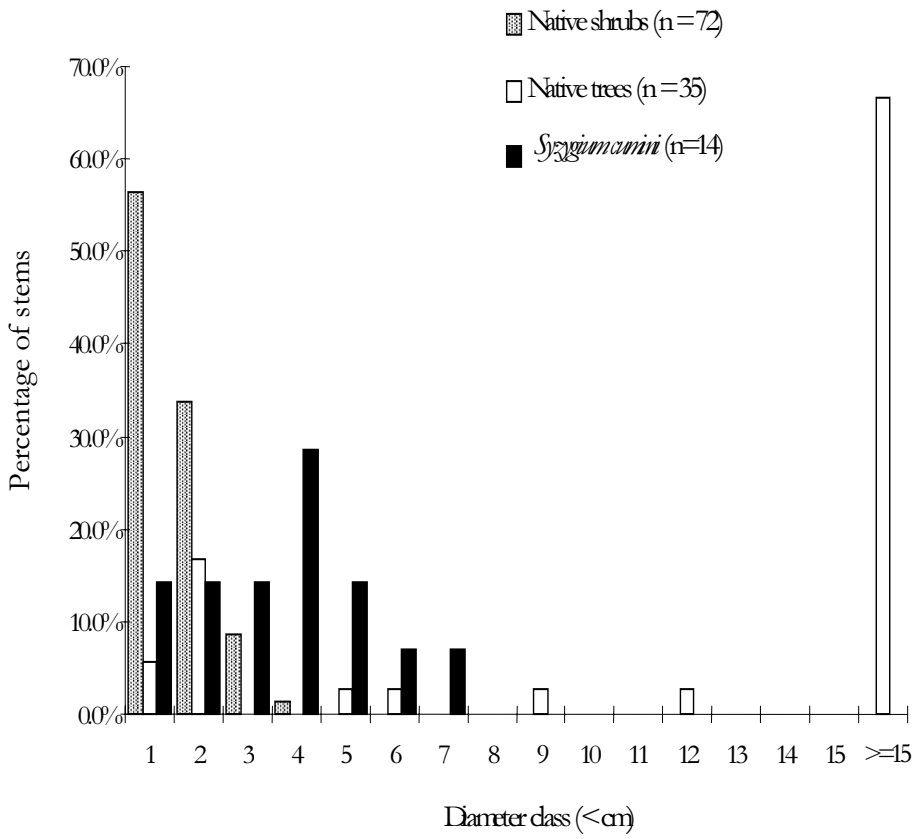

Figure 3. Relative distribution of stem diameters for native trees, shrubs, and *Syzygium cumini* in the five 100 m^2 plots (palms have been excluded).

any recovery from hurricane-level disturbance is likely to be confounded by many other exotic species (Horvitz et al. 1998).

Effects of *Syzygium cumini* on Stem and Sapling Density and Diversity

The presence of a large *Syzygium cumini* individual (dbh ≥ 3 cm) in a subplot was correlated with a decrease in native shrub stem density, sapling density, and a decrease in species richness of both native shrub stems and saplings, within that subplot, when compared to neighboring subplots in the same plot (Figs. 4 and 5). *Psychotria nervosa* and *Ardisia escallonioides* were well represented by both stems and saplings and exhibited this decrease at both sizes. Reduction in species richness was most striking at the sapling level. Subplots containing no or small *S. cumini* indi-

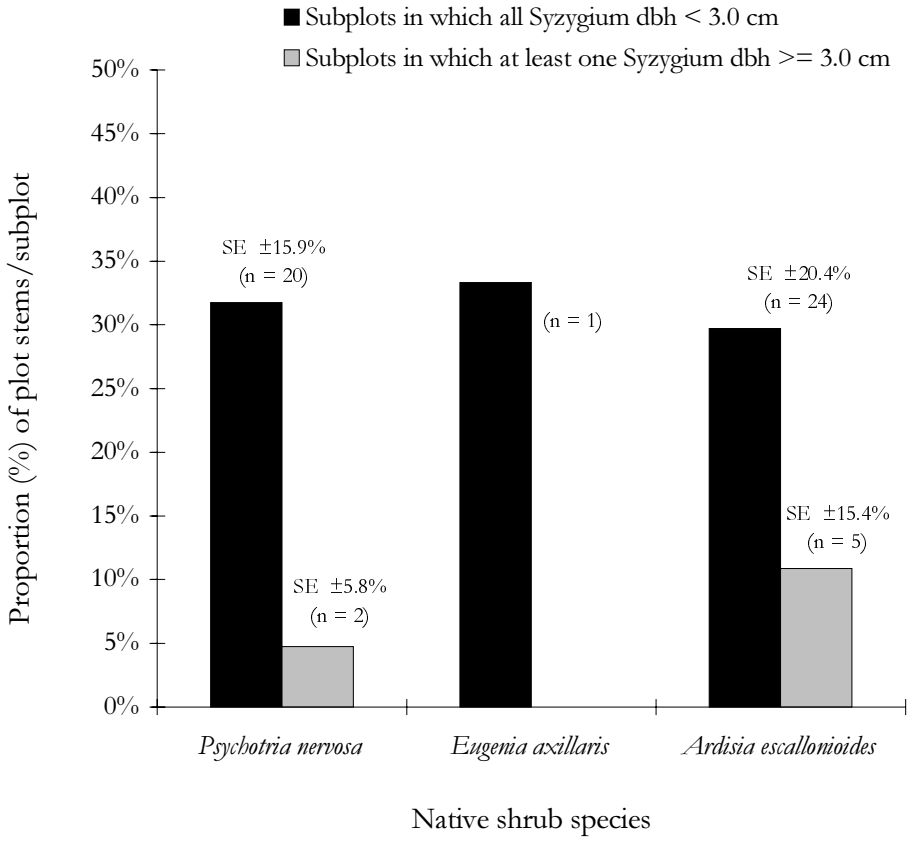

Figure 4. Mean proportion of native stems within a plot that occur within a subplot either lacking (n=9; black bars) or containing (n=3; gray bars) a large(dbh $\geq$ 3 cm) *Syzygium cumini*. Proportions were computed within each transect, then averaged. Means are shown with the total number of stems in that type of subplot. An even distribution would have a proportion of 25%

viduals contained seven native shrub species, while neighboring subplots containing large *S. cumini* individuals contained only three native shrub species.

Larger *S. cumini* individuals growing in this forest had a narrow, dense, cone-shaped crown that began within 1-2 m of the ground. The density and low extension of the crown may have physically inhibited dispersal of seeds into the area around the tree. Additionally, the shade cast by a large tree appeared deeper than the shade beneath any native tree or shrub (pers. obs.). This condition may have inhibited germination and/or subsequent growth of any seeds dispersed into the area around the tree. The apparent rapid growth of *S. cumini,* and the resulting

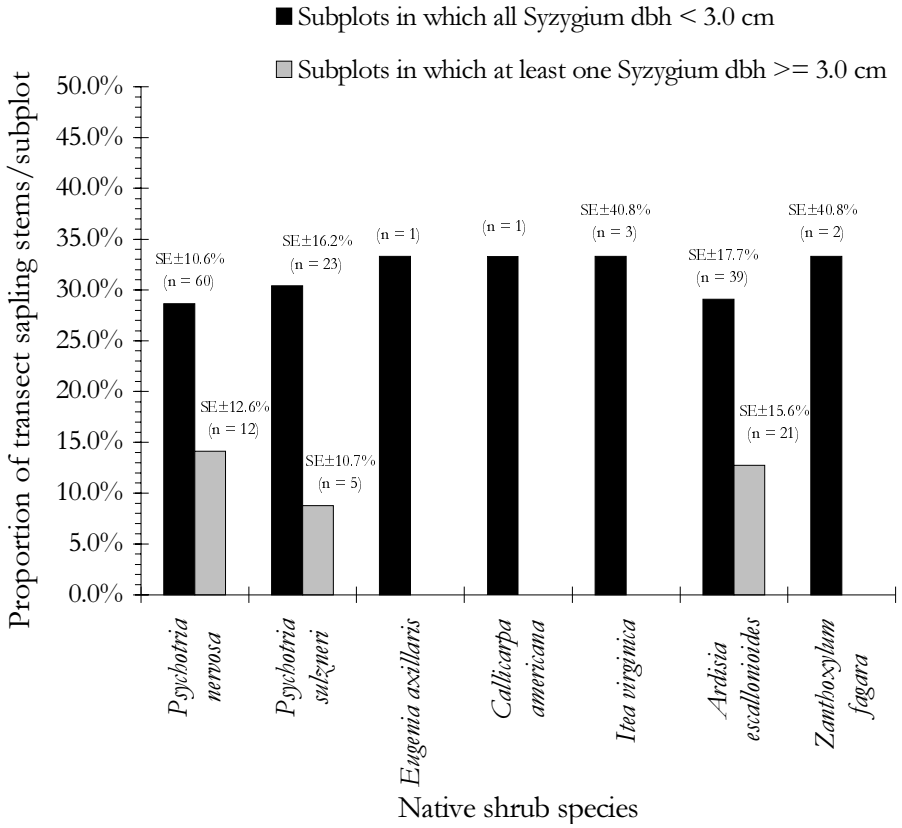

Figure 5. Mean proportion of native saplings within a transect that occur within a subplot either lacking (n=9; black bars) or containing (n=3; gray bars) a large (dbh ≥ 3 cm) *Syzygium cumini*. Proportions were computed within each transect, then averaged. Means are shown with the total number of saplings in that type of subplot. An even distribution would have a proportion of 25%.

deep shade below it, may have suppressed growth of shrubs and saplings already found in the area. These characteristics are consistent with the classification of *S. cumini* as a "seedling layer 'oskar' winner" (Horvitz et al. 1998), a non-indigenous invasive plant that establishes in shade, dominates the 'oskar' (low persistent sapling) layer, and out competes shrubs and saplings in this environment.

Conclusion

Without control efforts, it seems likely that *Syzygium cumini* will soon reach the can-

opy of the study area and eventually dominate the forest. At available light, water, and nutrient levels, and in the absence of significant recent disturbance to the site, many individuals of this species have grown vigorously in the forest understory. A *S. cumini* sapling appears to have a better chance of growing larger than a sapling of any native tree species, and the tree it grows into will suppress potential competitors and further reduce native species diversity. It is disturbing that this can occur within an intact forest that appears healthy and not in need of management.

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