



Magnitude of the Cultivated Flora of Florida

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ADDITIONAL INDEX WORDS. botanical, garden, herbarium, iNaturalist, native, naturalized, species

Florida is an estimated 37 million acres in size, of which approximately 12% is composed of loblolly and slash pine plantations, 6% bahiagrass pasture, 1% orange groves, 1% sugarcane plantings, and 0.4% bermudagrass golf courses. Here we set out to estimate the diversity of the cultivated flora. Compiling information from herbaria, botanic gardens, and iNaturalist, we estimate 7468 species of land plants are known only from cultivation (not native and not naturalized) in Florida, but perhaps only around 500 of these cultivated-only species are relatively common in cultivation. An estimated 200 native and 300 naturalized species are relatively common in cultivation. Summing the native (~3200 species), naturalized (1500), and cultivated (7500) flora gives an estimate of 12,200 species of land plants occurring in Florida in recent time.

The study of the flora of an area usually makes the distinction between wild and cultivated plants. Wild plants occur primarily in natural areas and include the indigenous (native) species and the non-native naturalized species that reproduce and spread in the region. Cultivated plants generally occur in heavily altered areas and rely on more intensive human management for establishment and persistence.

The wild plants of Florida consist of about 4700 species of native or naturalized land plants (Embryophyta) (Wunderlin et al., 2019). About 10 million acres of conservation land (excluding perennial open water; FNAI 2019) help to preserve natural areas that support these wild plant species (see also Pearlstine et al., 2002), but these wild plants also occur in privately owned timberland, rangeland, perennial open water, natural areas fragments, ruderal areas, and in cultivated areas as weeds. Here we focus on the cultivated flora of Florida, especially pine plantations, pasture, crops, lawns, urban trees, and ornamentals (Fig. 1).

There are an estimated 11 million acres of private timberland in Florida (Hodges et al. 2017), of which about 4.4 million acres are cultivated pine plantations (Guldin and Wigley 1998; Zhang and Polyakov 2010), the vast majority consisting of *Pinus elliotii* and *P. taeda* (Landers et al., 1995). Planted pasture covers approximately 4 million acres (NRI 2015; USDA 2019) and, of this, over 2 million acres consist of *Paspalum notatum* pasture (Chambliss and Sollenberger 1991; Vendramini 2016). In the past few decades, pasture had covered as much as 5 million acres (NRI 2015).

Approximately 2.8 million acres are devoted to cropland in Florida (USDA 2019). In 2017, the 15 largest crops, by acreage, were *Citrus ×aurantium* (oranges; 422,421 acres), *Saccharum officinarum* (sugarcane; 386,428), *Arachis hypogaea* (peanuts; 186,803), *Gossypium hirsutum* (cotton; 98,569), *Zea mays* (corn for grain, silage, or greenchop; 62,717), *Citrus ×aurantium* (grapefruit; 40,248), *Solanum tuberosum* (potatoes; 30,378), *Solanum lycopersicum* (open-grown tomatoes; 29,136), *Zea mays* (sweet corn; 28,403), *Phaseolus vulgaris* (green beans; 27,823), *Cucumis sativus* (cucumbers; 26,222), *Citrullus lanatus* (watermelons;

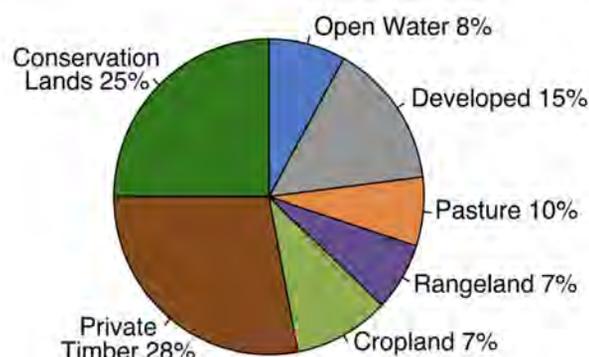


Fig. 1. Estimates of land use in Florida. Conservation lands here represent only the government-owned portion (9.5 million acres) and not the 0.85 million acres of privately owned conservation land. Land use totals add up to 38.1 million acres, exceeding the 37.5 million acres of surface area in Florida. This is due to the heterogeneity of sources (NRI 2015; Hodges et al. 2017; FNAI 2019) which have probably caused double-counting for some acres. Since forest land is 13.2 million acres in NRI (2015) and 17.2 million acres in Hodges et al. (2017) of which 66% is privately owned, land acreage coverage of 0.6 acres was subtracted from private timber to bring land use total to 37.5 million acres. An additional discrepancy is the pasture and rangeland in the NRI (2015) data is much higher than the USDA (2019) data.

We are grateful to Kent Perkins (FLAS), Brett Jestrow (FTG), Bruce Holst (MSBG), and Shawn McCourt (MSBG) for their kind assistance. Many thanks to Javier Francisco-Ortega (FIU) for his review of the manuscript.

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22,071), *Oryza sativa* (rice; 18,422), *Glycine max* (soybeans; 14,376), and *Capsicum annuum* (peppers; 11,739). Acreages of oranges and grapefruits were approximately 666,000 and 118,000 (Hodges et al. 2001), respectively, in 2000, and have continually declined since (Court et al., 2017).

Stenotaphrum secundatum is a dominant lawn grass in Florida, comprising over half of the sod grass, followed by *Paspalum notatum* (Satterthwaite et al., 2009). In 2000, golf courses had about 147,000 acres of turf, primarily (93%) composed of *Cynodon dactylon* (Haydu and Hodges 2002).

A comprehensive view of the plant species cultivated in Florida is lacking, especially concerning the ornamental species and urban trees which are important floristic components of the 5.5 million acres of developed/urban areas in Florida (NRI 2015). Here we attempt to inventory the plant species cultivated in Florida using herbarium records, botanic garden lists, and iNaturalist (inaturalist.org). With some quantitative data, we roughly estimate their abundance in Florida.

Materials and Methods

Documented occurrences of cultivated plants were compiled into one list from herbaria, iNaturalist, and botanic gardens. Cultivated specimens of the FLAS (standard abbreviation for the University of Florida herbarium) and USF (University of South Florida) herbaria were downloaded 31 May 2019. Cultivated observations in iNaturalist were downloaded 15 June 2019. The species richness of select botanical gardens were consulted, Fairchild Tropical Botanic Garden (FTG 2016), Marie Selby Botanical Gardens (MSBG; B. Holst and S. McCourt, pers. comm.), and Montgomery Botanical Center (MBC 2016). The compiled list was reviewed to find and match synonyms to minimize duplicate listings.

Only records identified to species were analyzed (except for *Bougainvillea* spp.); infraspecific taxa were not considered. Species identifications of the cultivated bougainvilleas are erratic and inconsistent; therefore they were considered one species for convenience and any records identified to genus were included.

Review of the records of the cultivated bougainvilleas suggest they are primarily identifiable as *Bougainvillea xbuttiana* and less often as *B. glabra*; all cultivated bougainvilleas were called *B. cf. xbuttiana* in the dataset for convenience. The records given as *Lantana camara* appear more likely to be *L. strigocamara*, and were referred to as *L. cf. strigocamara*. The records of *Epipremnum pinnatum* appear to be *E. aureum* and were thusly named. The records given as *R. indicum* in iNaturalist appear to be *R. pulchrum* or *R. simsii*; they were all named as *R. cf. simsii* for convenience. The iNaturalist records of *Handroanthus chrysanthus* seem more likely to be *H. chrysotrichus* and were named thusly as *H. chrysotrichus*. The iNaturalist records of *Aristolochia littoralis* are more likely *A. elegans*, and were so named in the dataset.

Records in iNaturalist found to be plant products and not plants actively being cultivated were removed (e.g. *Abies fraseri* as a cut Christmas tree). Since cultivated observations in iNaturalist receive less scrutiny, all species with 1–3 observations (1389 species) were reviewed and identifications were added if there was disagreement. Of these, 249 species were determined either to be misidentifications or, less commonly, to be wild (not cultivated) observations, such as weeds in cultivated settings or wild plants clearly in natural settings; as a result, 313 observations and 249 species were removed from the initial iNaturalist dataset. The common name “sago palm” caused four observations of cycads to be misidentified as *Metroxylon sagu* (Arecaceae), which was also removed from the iNaturalist dataset.

For the top five most abundant species in herbaria (based on specimen sheets), records were reviewed to remove extra counts resulting from multi-sheet collections or duplicate specimens. The remainder of the records in each herbarium was not corrected for multi-sheet collections or duplicates.

To roughly estimate abundances of urban tree species, published analyses of urban tree studies from across the state were evaluated to identify the trees most abundant in each study and across the studies. The seven studies consulted were north Florida (Duryea 2007a), south Florida (Duryea 2007b), the panhandle (Escobedo et al., 2009a), Gainesville (Escobedo et al., 2009b),

Table 1. Top five most abundant cultivated plant species observations in Florida, as seen in iNaturalist in seven categories, with the number of observations in parentheses, as of 15 June 2019. FLEPPC = Florida Exotic Pest Plant Council. Cultivated-only refers to species known only from cultivation in Florida, neither native nor naturalized. Although *Hamelia patens* had 61 observations, nine of them were of the non-native *H. patens* var. *glabra*.

Top five most abundant cultivated plant species observations in Florida, as seen in iNaturalist Plant category in seven categories, with the number of observations in parentheses, as of 15 June 2019.					
Native	<i>Magnolia grandiflora</i> (191)	<i>Zamia integrifolia</i> (143)	<i>Sabal palmetto</i> (68)	<i>Quercus virginiana</i> (65)	<i>Roystonea regia</i> (60)
Naturalized	<i>Hibiscus rosa-sinensis</i> (291)	<i>Schefflera arboricola</i> (174)	<i>Codiaeum variegatum</i> (163)	<i>Plumbago auriculata</i> (147)	<i>Ixora coccinea</i> (140)
FLEPPC Cat. I	<i>Ruellia simplex</i> (79)	<i>Eugenia uniflora</i> (65)	<i>Bauhinia variegata</i> (44)	<i>Nephrolepis cordifolia</i> (39)	<i>Tradescantia spathacea</i> (38)
FLEPPC Cat. II	<i>Cocos nucifera</i> (57)	<i>Epipremnum aureum</i> (56)	<i>Begonia cucullata</i> (38)	<i>Platynerium bifurcatum</i> (31)	<i>Aristolochia elegans</i> (31)
Cultivated-only eudicots	<i>Bougainvillea cf. xbuttiana</i> (412)	<i>Rhododendron cf. simsii</i> (59)	<i>Adenium obesum</i> (57)	<i>Ceiba speciosa</i> (47)	<i>Gardenia jasminoides</i> (45)
Cultivated-only monocots	<i>Cordylone fruticosa</i> (168)	<i>Philodendron bipinnatifidum</i> (82)	<i>Strelitzia reginae</i> (78)	<i>Ananas comosus</i> (62)	<i>Dietes bicolor</i> (52)
Cultivated-only palms	<i>Bismarckia nobilis</i> (41)	<i>Phoenix canariensis</i> (35)	<i>Phoenix roebelenii</i> (32)	<i>Adonidia merrillii</i> (19)	<i>Phoenix dactylifera</i> (16)

Orlando (Ekpe et al., 2012), Tampa (Landry et al., 2018), and Miami (Escobedo et al., 2011). Urban trees are often planted or, if from wild propagules, managed in cultivated settings; thus for convenience they are treated as part of the cultivated flora.

To compute the rate of taxa added to the flora of Florida per year, we compared totals from 2003–2019. From the first comprehensive state-focused flora (Wunderlin 1998) to the second edition (Wunderlin and Hansen 2003), there was the largest increase in both native and non-native taxa, probably partly due to records that had been overlooked. From 2003–2019, rates were fairly constant, increasing from 2827 native and 1318 naturalized taxa (Wunderlin and Hansen 2003) to 2,895 native and 1,512 non-native taxa (Wunderlin et al. 2019). Taxa here are comprised of about 98% as species and 2% as a second or third infraspecific taxon of a species in the flora.

Results

A total of 12,355 observations from iNaturalist, 9938 specimens from FLAS, and 4683 specimens from USF were included. Combined from iNaturalist, FLAS, USF, and FTG, there were 684 cultivated native species, 786 cultivated naturalized non-native species, and 4886 species known only from cultivation in Florida. Of the species known only from cultivation, iNaturalist recorded 896 species, FLAS recorded 2444, FTG recorded 1966, and USF recorded 1156. Of these species known only from cultivation, 382 were unique to iNaturalist, 1443 to FLAS, 1270 to FTG, and 623 to USF, meaning only 1168 species known only from cultivation were in at least two of these datasets.

The most commonly observed cultivated species in iNaturalist are given in Table 1. The most commonly observed cultivated species endemic to Florida in iNaturalist was *Illicium parviflorum* (10 observations). *Lagerstroemia indica*, one of the most commonly planted small trees and occasionally naturalized in Florida, had 134 iNaturalist observations. There were 391 palm species in the compiled dataset, almost all found at FTG. The most common cultivated specimens at FLAS were *Podocarpus macrophyllus* (27 collections), *Galphimia gracilis* (20), *Asystasia gangetica* (19), *Cnidioscolus aconitifolius* (24), *Loropetalum chinense* (17), and *Hibiscus rosa-sinensis* (17), and at USF were *Ruellia nudiflora* (107), *Ruellia caroliniensis* (43), *Calliandra haematocephala* (35), *Allamanda cathartica* (33), *Hibiscus rosa-sinensis* (29), and *Parkinsonia aculeata* (29). Also reported in 2018 were the eradication of 3409 plants of *Cannabis sativa* grown outdoors and 692 plants grown indoors (FDMEP 2019).

The total number of plant species in the Araceae (405 species), Bromeliaceae (1215), Gesneriaceae (157), Orchidaceae (1456), and fern group (320) cultivated at MSBG all exceeded that in the compiled dataset from iNaturalist, FLAS, FTG, and USF [Araceae (207); Bromeliaceae (154); Gesneriaceae (62); Orchidaceae (323); ferns (144)]. The total number of plant species in the cycad group (228) cultivated at MBC exceeded the number of species in the compiled dataset [Cycadaceae (13) and Zamiaceae (54)]. Considering these specialized collections at MSBG and MBC, then at least 2824 more species of plants are cultivated in Florida (i.e. 957 species in these groups from the compiled dataset subtracted from 3781 species in these groups at MSBG and MBC), which would bring the total number of species cultivated in Florida to 9178 species (i.e. 682 cultivated native species, 786 cultivated naturalized non-native species, and 4886 cultivated-only species from the compiled dataset plus 2824 more

species from MSBG and MBC). From these groups there are 355 native and naturalized species (including named hybrids) in the Florida flora [Araceae (34); Bromeliaceae (22); Cycadaceae (1); ferns (178); Gesneriaceae (0); Orchidaceae (118); and Zamiaceae (2)] and 844 species from the compiled cultivated-only dataset [Araceae (192); Bromeliaceae (135); Cycadaceae (12); ferns (94); Gesneriaceae (62); Orchidaceae (297); and Zamiaceae (52)]. Allowing that MSBG and MBC could be cultivating all of Florida's 355 native and naturalized species in these groups and as well as all of the 844 species in the compiled cultivated-only dataset, then MSBG and MBC could have 2582 more species known only from cultivation in Florida (i.e. subtracting both the 355 native and naturalized species in these groups and 844 species in the compiled cultivated-only dataset from 3781 species from MSBG and MBC), bringing the total to 7468 species known only from cultivation in Florida (i.e. 2582 plus 4886).

Based on the urban tree literature in Florida, the most abundant urban trees are *Quercus virginiana* (occurring in all seven references, possibly including some *Q. geminata* which can be difficult to identify), *Pinus elliottii* (five references), and *Quercus laurifolia* s.lat. (four references, probably including *Q. hemisphaerica*; absent to rare generally in extreme southern Florida, such as Miami). A checklist of woody plants of relative horticultural or commercial importance that were cultivated in Florida included 1979 species, of which 239 were native species (Burch et al. 1988), but abundances were not given. This list (Burch et al. 1988) has not yet been transcribed and incorporated with the present dataset.

Based on rates from 2003–19 (Wunderlin and Hansen 2003; Wunderlin et al. 2019), about 4.3 native and 12.1 naturalized taxa have been added to the flora per year.

Discussion

Based on these data (from iNaturalist, FLAS, FTG, MBC, MSBG, and USF), about 7468 species of land plants (Embryophyta) are known only from cultivation (neither native nor naturalized) in Florida. Only 1168 species known only from cultivation were found in at least two datasets (from iNaturalist, FLAS, FTG, and USF). Even if found in two datasets, some of these 1168 species might only be found in one place such as FTG (e.g. *Caloncoba echinata* is in the FTG list and the only FLAS specimen is from FTG, and thus it shows up in two datasets). Additionally, there are very likely some misidentifications as well as unmatched synonyms in the dataset which could reduce the number of species. There are also likely species cultivated in Florida not found in the dataset. A previous estimate suggested about 25,000 species of plants were cultivated but not naturalized in Florida (Frank and McCoy 1995).

For species with two or more cultivated observations in iNaturalist, there were 423 species known only from cultivation, 217 native species, and 307 naturalized species. Considering this, perhaps approximately 500 species of plants known only from cultivation, 200 native species, and 300 naturalized species are relatively common in cultivation in Florida. Following this, perhaps the other 7000 species known only from cultivation (many known only from botanic gardens), 500 native species, and 500 naturalized species are relatively rare in cultivation in Florida. Thus, together, roughly, ~1000 species of plants might be somewhat commonly cultivated or available in Florida.

While the iNaturalist website is quite useful for studying the cultivated flora, it is optimized for wild organisms and is of

limited utility for cultivated observations. By default the option “verifiable” is selected for searches in iNaturalist, which excludes cultivated plants in the results. Cultivated observations are considered not “verifiable” or ineligible for “research grade” (when more than 2/3rds of species-level identifications agree). By default uploaded observations are presumed wild unless the “captive” option is selected. The result is that cultivated observations receive less scrutiny from users and many cultivated observations are uploaded as wild organisms. Further, some species that can be locally common in cultivation, e.g. *Dimocarpus longan*, *Elaeagnus pungens*, or *Magnolia figo* are poorly represented in iNaturalist, each of these having only two cultivated observations. One of the top crops in Florida, *Saccharum officinarum*, had zero observations in iNaturalist for Florida. The user bias of iNaturalist favors more urban observations and more observations of attractive and conspicuous plants. For example, *Quercus virginiana* is the most common urban tree and very widely planted, yet it had only 65 cultivated observations in iNaturalist while *Magnolia grandiflora* (commonly planted but not as much as *Q. virginiana*) had 191.

There are similar biases towards urban locations and wild organisms in herbaria. Herbarium collections tend to favor representing the diversity of species over the abundance of a species. Cultivated occurrences of common native trees and common lawn grasses are relatively poorly represented in herbaria. For example, the native *Coccoloba uvifera* had a combined total of nine cultivated specimens in the FLAS and USF herbaria, while the non-native *Adenantha pavonina* had 25 cultivated specimens, even though *C. uvifera* is much more commonly planted. For this example, iNaturalist is a better representation of abundance as it recorded 28 cultivated observations of *C. uvifera* and zero cultivated observations of *Adenantha pavonina*.

The 7468 non-native, cultivated-only plant species in Florida serve ornamental, agricultural, research, educational, and ex-situ conservation purposes. While some of these are cultivated indoors (e.g. greenhouses), the majority are cultivated outside, thus having the increased potential for ecological interactions such as microbial associations, animal visitations, and propagule dispersal. The extent of these ecological interactions are relatively poorly known overall for the cultivated flora of Florida (e.g. Riddle and Mizell 2016). While local populations of native species are genetically unique and contribute some of the most vitally important ecosystem services (Pauchard et al. 2018), both the positive and negative impacts to ecosystems from the non-native cultivated flora bear consideration (Dale and Polasky 2007; Schlaepfer 2018a, 2018b; Pyšek et al. 2019). It is also interesting to consider the taxonomic diversity of propagule pressure from the cultivated-only flora, as the Florida flora on average adds about one non-native naturalized taxon per month, some being escapes from cultivation and others naturalizing without being cultivated.

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