

# Ornamental Invasive Plants in Florida with Research-founded Alternatives

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**ABSTRACT.** The ornamental horticulture industry has long been significant in its vast economic contributions to the US agricultural sector, with Florida ranking second in nursery and greenhouse plant sales. A small proportion of introduced plants eventually escape cultivation and become invasive, leaving fragile ecosystems at risk. In response, a series of propagation and production research studies have been conducted over the years to 1) evaluate the female sterility and landscape performance of cultivars and/or hybrids of ornamental invasives, and 2) develop reliable propagation systems of novel or underused natives having ornamental and ecological value. Attractive, fruitless selections of popular species such as butterfly bush (*Buddleja* sp.), heavenly bamboo (*Nandina domestica*), Mexican petunia (*Ruellia simplex*), lantana (*Lantana strigocamara*), trailing lantana (*Lantana montevidensis*), privet (*Ligustrum* sp.), maiden silvergrass (*Miscanthus* sp.), and fountain grass (*Pennisetum* sp.) have been identified as suitable non-native alternatives to the invasive or potentially invasive resident species (wild type). Simultaneously, researchers have taken a closer look at native plant alternatives that may offer similar aesthetic traits as invasive plants, while bringing added biodiversity and function for more ecologically friendly landscapes and gardens. As such, successful multisite trialing and/or propagation systems have been developed for a number of species native to Florida, such as squareflower (*Paronychia erecta*), coastalplain honeycombhead (*Balduina angustifolia*), wireweeds (*Polygonella* sp.), blue porterweed (*Stachytarpheta jamaicensis*), wild coffees (*Psychotria* sp.), sweet acacia (*Vachellia farnesiana*), and wild lime (*Zanthoxylum fagara*). With pronounced marketing and consumer education, it is hopeful that together sterile cultivars and native species will ultimately replace wild-type forms of commercially available ornamental invasives. This paper summarizes the current status of ornamental invasives in Florida and the role of native species and sterile non-native cultivars.

Non-native species are thought to comprise as much as 80% of the plant inventory held by nurseries in the United States (Hulme et al. 2018). Although most introduced

ornamental plants do not escape cultivation, some plants spread into natural areas, develop self-sustaining populations, and subsequently disrupt the function and form of natural ecosystems (van Kleunen et al. 2018). Traits that might be economically beneficial to a nursery professional, such as disease/pest resistance, uniform germination and plant growth, and high fertility are traits that could also increase invasive potential (Anderson et al. 2006). The probability of plants becoming naturalized increases significantly with the number of years the plants were marketed and their monetary value (Pemberton and Liu 2009). Hence, unintentionally but indisputably, the ornamental horticulture industry has long been the primary

source for invasive plants and is a targeted issue of many countries (Hulme et al. 2018; Pyšek et al. 2011; van Kleunen et al. 2018).

In the past decade, significant progress has been made by the ornamental plant industry to minimize the risk of invasive plant introductions. Voluntary codes of conduct have been adopted nationally by botanic gardens and the horticulture trade to help reduce the pathway of invasive plants (Heywood 2014). Simultaneously, plant breeders have been developing new cultivars with much reduced or eliminated invasive potential that can replace invasive ones (Li et al. 2004; Vining et al. 2012; Wilson et al. 2012). Yet, confusion exists among private and public sectors of the plant industry due to different invasive plant lists that are largely nonregulated, and the role cultivars and geographic regions within states play for the invasive status of any given species. For example, when a species is deemed invasive, cultivars fall under this domain unless proven noninvasive. Likewise, species may be deemed invasive for an entire state, despite clear differences in seed production among northern, central, or southern parts of a state. The US Department of Agriculture (USDA) provides federal and state noxious weed lists set to regulate and prevent the sale and distribution of invasive plants (USDA, Natural Resources Conservation Service 2023). Some individual US states (i.e., Florida, California, Tennessee, Georgia, and others) or groups of states (i.e., Mid-Atlantic, Midwest, Pacific Northwest regions) have Invasive Plant Councils that formulate invasive plant lists as a resource for prioritization and implementation of management efforts by natural resource managers, in environmental education programs, and in voluntary removal programs (National Association of Invasive Plant Councils 2023). Florida is unique in that it also has an invasive plant resource called the University of Florida/Institute of Food and Agricultural Sciences' (UF/IFAS) Status Assessment (AS) of Non-native Plants in

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## Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
3.7854	gal	L	0.2642
0.001	ppm	g·L <sup>-1</sup>	1000
1	ppm	mg·L <sup>-1</sup>	1
(°F – 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32

Florida's Natural Areas. Three components of this UF/IFAS AS are the 1) status assessment, 2) predictive tool, and 3) infra-specific taxon protocol (ITP) (Lieurance and Flory 2020).

The status assessment evaluates the invasiveness of non-native species that currently occur in Florida's natural areas. The predictive tool is a risk assessment model that evaluates species that are not currently found in Florida's natural areas but are invasive in other places with similar climate and growing conditions. The ITP evaluates the invasive potential of horticultural and agricultural selections, hybrids, and cultivars. This tool was developed to determine if the invasive potential of the introduction differs from that of the invasive parent species found in Florida ("resident species" or wild-type form). Since the UF/IFAS AS was first implemented in 1999, nearly 920 plant species have been evaluated with one or more of these tools (UF/IFAS 2023). Of the 540 species evaluated by the status assessment, 90.6% are available for horticulture sale (Lieurance D, personal communication). Thus, there is an urgent need to identify species and/or cultivars to replace nonregulated invasive ornamentals. The purpose of this paper is to survey the invasive ornamental plant situation in Florida and provide an overview of research-founded native and/or sterile cultivar alternatives suitable for ecologically friendly landscapes and gardens.

## Evaluation of nonfruiting ornamental cultivars as alternatives to invasive plants

Over the past 2 decades in Florida, the invasive potential of nearly 20 ornamental species and their hybrids or cultivars have been evaluated that include nationally popular landscape plants such as trailing lantana [*Lantana montevidensis* (Wilson et al. 2020)], porterweed [*Stachytarpheta cayennensis* (Qian et al. 2021; Wilson et al. 2009)], butterfly bush [*Buddleja davidii* (Wilson et al. 2004)], Chinese privet [*Ligustrum sinense* (Fetouh et al. 2020)], fountain grass [*Pennisetum setaceum* (Wilson and Knox 2009)], maiden silver grass [*Miscanthus sinensis* (Wilson and Knox 2006)], and heavenly bamboo [*Nandina domestica* (Wilson et al. 2021)]. In addition, as part of planned breeding programs, UF researchers have developed genetic techniques to reduce

the fecundity of plants, leading to sterile cultivars of Mexican petunia [*Ruellia simplex* (Freyre et al. 2012a)] and lantana [*Lantana strigocamara* (Czarnecki et al. 2012; Deng et al. 2017, 2020)]. Methodology of these studies included trialing of selections at two to three locations in Florida representing different soil types, rainfall patterns, and temperatures [USDA cold hardiness zones 8b, 9a, and 9b (USDA, Agricultural Research Service 2012)]. Typically, 1- to 3-gal container plants were transplanted into respective field sites in slightly raised linear beds covered with polyethylene mulch. Plants were irrigated and fertilized similarly among sites and evaluated monthly for the presence or absence of flowers and fruit for 4 months (herbaceous species) to 3 years (woody species). Plant performance was assessed every 1 to 3 months by rating plants on a visual quality scale (1 to 5, where 1 = poor and 5 = excellent quality), flowering scale (1 to 5, where 1 = no flowers and 5 = peak flowering), and measuring plant size (length + perpendicular widths/2). As described by Wilson et al. (2009), fruit were collected, counted, cleaned, and subjected to pregermination tetrazolium (TZ) tests to determine initial seed viability, then subjected to germination tests for 4 to 24 weeks (depending on species), with nongerminated seeds TZ stained to determine total viability. In addition to determining plant performance and seed germination, ploidy levels were inferred using flow cytometry to determine nuclear DNA content as described by Deng et al. (2017). When possible, female fertility indices were determined by randomly collecting 20 peduncles from each experimental unit (plant) and counting the number of fruit on each peduncle as described by Czarnecki and Deng (2020). Also, when pertinent, morphological, and cytological studies were conducted to distinguish leaves and flowers of selections from wild-type forms and to determine pollen production and stainability (viability) (Qian et al. 2021; Steppe et al. 2019).

Finally, for selections with significantly reduced fertility (98% or greater sterility), and suitable landscape performance, data were summarized and formally submitted to the UF/IFAS Assessment of Non-native Plants for ITP evaluation for internal approval. This protocol consists of 12 questions to determine 1) if the selection displays

invasive traits that cause greater ecological impact than the wild-type or resident species and if it can be readily distinguished; and 2) the fecundity of the selection and its chances of regression to characteristics of the wild-type (or naturalized resident species) (Lieurance and Flory 2020). Based on the yes or no responses to the ITP questions, there may be three possible conclusions: 1) not a problem species (may recommend for use), 2) use with caution (may recommend but manage to prevent escape), and 3) invasive (do not recommend for use). To date, more than 26 ITP assessments have been reported for cultivars of flooded gum (*Eucalyptus grandis*), golden pothos (*Epepremmum aureum*), lantana, heavenly bamboo, and Mexican petunia; and approximately two-thirds of these selections were concluded as noninvasive (UF/IFAS 2023).

As a result of these efforts, progress has been made within the nursery industry in gradually replacing wild-type forms of invasive species with approved noninvasive cultivars that are superior in flowering, form, and performance. Also, even without intentionally inducing triploid plants that lack fruiting, sterility has been inherently found among cultivars of a number of ornamental species. To illustrate, Wilson et al. (2021) reported nearly three-fourths of the 25 heavenly bamboo cultivars evaluated were low- to nonfruiting diploids, meriting consideration for use as an alternative to the invasive wild-type form. In another study, porterweed selections were found to vary considerably in their chromosome number, pollen stainability, and nuclear DNA content (Qian et al. 2021), with half of the selections evaluated having high female sterility (Wilson et al. 2009). To summarize these findings and others, Table 1 provides an overview of ornamental species that have been evaluated in Florida, their current invasive ranking, and cultivars that have either already been approved using the ITP assessment or merit future consideration.

## Evaluation of native ornamentals as alternatives to invasive plants

Florida boasts abundant flora with more than 3300 native plant species, yet less than a quarter of these are in cultivation. When incorporated into

**Table 1. List of popular ornamental species evaluated in Florida along with their current ranking by the Florida Department of Agriculture and Consumer Services (FDACS 2023), Florida Invasive Species Council (FISC 2023) and University of Florida (UF) Institute of Food and Agricultural Sciences (IFAS) Assessment (AS) of Non-native Plants for north (N), central (C), or south (S) Florida (UF/IFAS 2023). Cultivars that were determined to have little or no fruiting during research trials are listed, and marked with an asterisk (\*) if additionally subjected to the IFAS/AS Intraspecific Taxon Protocol for noninvasive approval.**

Species	Invasive ranking in Florida	Low to no fruiting cultivars	Additional comments
Lantana ( <i>Lantana strigocamara</i> )	FISC- Category I IFAS/AS- invasive N, C, S	*UF-T2, UF-T3, and UF-T4 (Czarnecki et al. 2012); UF-T9; Bloomify™ Rose and Bloomify™ Red (Deng et al. 2017); Lucious® Royal Red Zone™ (Deng et al. 2020).	Czarnecki and Deng (2020) report ploidy level and an unreduced female gamete (UFG) producing trait played a significant role in determining the fruit production capacity of this species. Triploids without the UFG-production trait were most sterile.
Trailing lantana ( <i>Lantana montevidensis</i> )	FISC- not listed IFAS/AS- high invasion risk N, C, S	Purple or white US selections (Wilson et al. 2020).	Purple and white selections obtained in the United States were morphologically and cytologically distinct (Steppe et al. 2019) and highly sterile from the purple accession obtained in Australia that was a tetraploid.
Japanese privet ( <i>Ligustrum japonicum</i> )	FISC- not listed IFAS/AS- high invasive risk N, C, S	Howard, Jack Frost, Lake Tresca, Rotundifolium, Texanum, and Davidson had little to no fruiting in south Florida (Wilson et al. 2014b).	Tetraploids have been successfully induced that are morphologically distinct with novel ornamental traits useful for producing future new cultivars with reduced invasive potential (Fetouh et al. 2016).
Chinese privet ( <i>Ligustrum sinense</i> )	FLDACS- noxious weed FISC- Category I IFAS/AS- invasive N, C, S	Sunshine (Wilson SB, unpublished data); Swift Creek (Wilson et al. 2014b).	Tetraploids have been induced for triploid development (Fetouh et al. 2020).
Heavenly bamboo ( <i>Nandina domestica</i> )	FISC- Category I IFAS/AS- invasive N, C	*Firepower, Gulf Stream, Harbour Dwarf, Firestorm, AKA Blush Pink, Firehouse, Lemon-Lime, Murasaki Flirt, SEIKA Obsession (Wilson et al. 2021).	All cultivars evaluated were diploid and produced less fruit in south Florida compared with north Florida (Knox and Wilson 2006; Wilson et al. 2014a). Tetraploids have been induced for triploid production (Deng Z, unpublished).
Mexican petunia ( <i>Ruellia simplex</i> )	FISC- Category I IFAS/AS- invasive N, C, S	*Mayan™ White and Mayan™ Purple (Freyre et al. 2012b), Mayan™ Pink (Freyre and Wilson 2014); Mayan™ Compact Purple (Freyre et al. 2016); Aztec Series (pink/white, pink, purple).	Listed cultivars were approved for use with caution to prevent vegetative spread (UF/IFAS 2023).
Nettleleaf porterweed ( <i>Stachytarpheta cayennensis</i> )	FISC- Category II IFAS/AS- use with caution N, C, S	Mario Pollsa, Naples Lilac, and Violaacea (Wilson et al. 2009).	Nuclear DNA content and chromosome number was confirmed for five species within the porterweed complex (Qian et al. 2021). Additional nonfruiting hybrid porterweed bred with improved form and flowering are currently being evaluated (Parrish SB and Deng Z, unpublished).

appropriate spaces, native plants can offer desired aesthetic attributes such as color and form, while contributing biodiversity and function for ecologically friendly landscaping (Kalaman et al. 2022a, 2022b). In the past 2 decades,

significant progress has been made in the propagation, production, and landscape trialing of more than 15 native species that are either 1) attractive in their natural areas and have potential for the ornamental industry (Campbell et al. 2021,

2022); or 2) are already in limited cultivation, but merit widened use for landscapes and gardens (Smith et al. 2022; Young et al. 2022). This includes species such as squareflower (*Paronychia erecta*), coastalplain honeycombhead

**Table 2. Select list of ornamental native species evaluated in Florida. Propagation systems were evaluated using seed, cuttings, or micropropagation with key findings briefly described for each species. Ornamental traits useful when selecting alternatives to invasive ornamentals are listed.**

Common name	Species	Propagation techniques <sup>1</sup>	Ornamental traits
Coastalplain honeycombhead	<i>Balduina angustifolia</i>	Seeds germinated under light or dark conditions, and germination was influenced by temperature and population (Campbell et al. 2021). Seeds are orthodox and retained high viability after a year of storage. Gibberellic acid (GA <sub>3</sub> ) improved germination of some populations. This species can be propagated by cuttings with an application of 5000 mg·L <sup>-1</sup> indole- 3-butyric acid (IBA) recommended for optimal rooting response. Use of substrates with sand improved container quality of plants (Smith et al. 2014).	Annual to biennial herbaceous wildflower with attractive yellow inflorescences produced in solitary or branches corymbs in the later summer and early fall. Tolerates full sun and sandy soils.
Florida scrub roseling	<i>Callisia ornata</i>	Propagation by seed is possible but vegetative propagation results in a fuller plant that performed well in the landscape trials. Plants grown in container media with a high proportion of vermiculite (low air-filled porosity) did not perform as well as other substrates tested (Smith et al. 2014).	Perennial wildflower with grass-like leaves bearing three-petaled purple flowers. Useful for mass plantings in full sun and well-drained soils.
Woody goldenrod	<i>Chrysoma pauciflosculosa</i>	Seeds prefer cooler temperatures (20/10 °C alternating day/night temperatures) to germinate best (Miller et al. 2018). Cutting propagation is possible from softwood or hardwood apical stem cuttings. Auxin is not necessary, but 5000 mg·L <sup>-1</sup> IBA will improve rooting quality. Plants can grow in a variety of substrates (Smith et al. 2014).	A branching evergreen sub-shrub with sessile leaves and abundant yellow flower heads produced in dense corymbs occurring late summer to fall. Tolerates drought, salt, well-drained soil and full sun.
Feay's prairie clover	<i>Dalea feayi</i>	Seed scarification was necessary to alleviate physical dormancy. This species had very good visual quality ratings when container grown in both peat and bark-based media.	A long-lived perennial boasting linear foliage and white to purple flower heads appearing as early as March with peak performance in September. Tolerant of acidic soils, full sun to part shade, and periods of drought.
Squareflower	<i>Paronychia erecta</i>	Seeds germinate readily to high percentages without pretreatments (Campbell et al. 2022). Germination is promoted by exposure to light although some germination occurs in the dark. Seeds prefer moderate to cooler temperatures compared with summer. This species has been successfully propagated by cuttings with or without auxin and also by micropropagation (Wilson SB, unpublished data).	An herbaceous perennial with unique white inflorescences in multibranching corymbs occurring from spring to fall. Tolerates full sun, sandy soils, salt and drought.
October flower	<i>Polygonum polygamum</i>	Seeds have nondeep physiological dormancy that can be overcome by after ripening, warm stratification, or application of GA <sub>3</sub> (Heather et al. 2010). This species can be easily propagated by softwood cuttings stuck in late May (Thetford et al. 2012).	Herbaceous perennial wildflower with linear leaves and cream to yellow flowers appearing in late fall on terminal racemes. Tolerant of sandy, dry soils and full-sun conditions.
Largeflower jointweed	<i>Polygonum nesomii</i>	Seeds have nondeep physiological dormancy (Heather et al. 2010). The population from where cuttings are collected may affect rooting percent and quality, with a combination of different 1-naphthaleneacetic acid (NAA) and IBA concentrations useful (Thetford et al. 2012).	Herbaceous perennial wildflower with linear leaves and pink to cream terminal racemes occurring sporadically throughout the year but predominately in fall. Tolerant of sandy, dry soils and full-sun conditions.

(Continued on next page)

Table 2. (Continued)

Common name	Species	Propagation techniques <sup>1</sup>	Ornamental traits
Wild coffee	<i>Psychotria nervosa</i>	In environmentally controlled studies, spring and summer were ideal for seed germination, but seeds had sporadic emergence over time. Cutting propagation proved to be a reliable and efficient method of production with or without auxin. Provision of 8000 or 16,000 mg·L <sup>-1</sup> IBA produced higher-quality root systems than untreated cuttings (Young et al. 2022). A cultivar of this species is in commercial micropropagation production.	Evergreen shrub having glossy, simple leaves with pronounced venation, white fragrant flowers, and attractive red drupes; shade tolerant and withstands pruning.
Softleaf wild coffee	<i>Psychotria tenuifolia</i>	A high proportion of cuttings can root fairly quickly with or without IBA, but IBA increases rooting response (Young et al. 2022).	Evergreen shrub having blue-green simple leaves, white fragrant flowers, and attractive red to yellow drupes. Shade tolerant and withstands pruning.
Blue porterweed	<i>Stachytarpheta jamaicensis</i>	Seeds can be easily collected and lack physical or physiological dormancy (Wilson et al. 2009). High germination (84% to 86%) was achieved by alternating temperatures at 25/15 or 30/20 °C. The average time to 50% germination at these temperatures was 7.5 d. Germination was reduced by half when placed at lower (20/10 °C) or higher temperatures (35/25 °C). Can be easily propagated by cuttings any time of the year except winter.	A short-lived perennial with showy lavender flowers appearing in indeterminate spikes extending well above the foliage throughout the year. Versatile in the landscape and can be used in masses as a tall groundcover.
Sweet acacia	<i>Vachellia farnesiana</i>	Seed scarification is needed before germination to alleviate physical dormancy (Smith et al. 2022). Cutting propagation is possible but with low rooting responses. This species can be easily micropropagated using multiplication medium with 6-benzylaminopurine (BA) and rooting media with IBA and NAA resulting in a 150-d production cycle (Xu et al. 2023).	A small tree having compound leaves and fragrant yellow flowers. Versatile in the landscape and extremely drought tolerant.
Wild lime	<i>Zanthoxylum fagara</i>	A portion of the seeds have physiological dormancy that must be overcome before germination (Mikell et al. 2023). With proper stock management, semihardwood/softwood cuttings root best when using moderate levels of IBA. Micropropagation has been a challenge due to stage I pathogen deterioration of seeds, nodal explants, and leaf tissue.	A small tree with glossy evergreen compound leaves and fragrant, yellow-green axillary flowers. Versatile in the landscape with high drought and moderate salt tolerance.

<sup>1</sup> 1 mg·L<sup>-1</sup> = 1 ppm, (1.8 × °C) + 32 = °F.

(*Balduina angustifolia*), wireweeds (*Polygonum* sp.), goldenasters (*Chrysopsis* sp.), woody goldenrod (*Chrysoma pauciflosculosa*), wild coffees (*Psychotria* sp.), sweet acacia (*Vachellia farnesiana*), and gopher apple (*Geobalanus oblongifolius*) as examples. Propagation practices of these species have been explored to optimize production of natives by seed (Heather et al. 2010), cuttings (Thetford et al. 2012), and tissue culture (Xu et al. 2023). Likewise, studies have been used to evaluate natives for their optimal container media (Smith et al. 2014) and landscape performance in multiple trial

locations (Thetford et al. 2018). Methodology of these studies typically began with determining initial seed viability using TZ testing, followed by germination tests conducted at four different temperatures that mimic seasons in Florida [winter (22/11 °C), early spring or late autumn (27/15 °C), early autumn or late spring (29/19 °C), and summer (33/24 °C)] as described by Campbell et al. (2022). Depending on the species, additional studies have been conducted to explore the effects of photoperiod, population, seed pretreatment, and seed storage on germination (Campbell et al. 2021).

For recalcitrant species with complex dormancy, intolerance of storage, or narrow collection times, cutting propagation has been explored as an alternative to seed propagation. Cutting propagation methodology began with sticking cuttings in a combination of auxin formulations [talc indole-3-butyric acid (IBA) or liquid IBA and/or 1-naphthaleneacetic acid (NAA)] at varying concentrations [0 to 16,000 mg·L<sup>-1</sup> IBA or a combination of potassium salt IBA (K-IBA) and NAA (K-NAA)] to achieve optimal rooting responses as described by Thetford et al. (2012)

and Young et al. (2022). If rooting response did not achieve greater than 70% rooting, alternative treatments were explored such as cutting maturity (softwood vs. semihardwood), stock plant management (natural populations vs. container grown, well-maintained stock plants), cutting length (three to six nodes), and seasonality (sticking in spring, summer, or fall). After 6 to 12 weeks (depending on if the species was herbaceous or woody), root quality was evaluated using a scale from 0 to 4, with 0 = dead cuttings, 1 = alive cuttings with no roots, 2 = roots forming but do not hold medium, 3 = root ball partially holds plug medium, and 4 = fully formed root ball entirely holding the medium. In addition, roots were counted, and the two longest roots were measured to determine overall rooting performance.

In addition to seed and cutting propagation, for native species with high ornamental value (and potential demand) that may require year-round propagation, micropropagation has been explored to produce uniform plants in large quantities (Valero-Aracama et al. 2008; Xu et al. 2023). Following doner plant selection (stage 0), explant tissue, such as seeds, immature flower buds, nodal stem explants, and/or leaves, was tested for establishment (stage I) where explants were surface sterilized before placement on full- or half-strength MS media (Murashige and Skoog 1962) containing 0.1 g·L<sup>-1</sup> of inositol, 30 g·L<sup>-1</sup> sucrose, 7 g·L<sup>-1</sup> agar (and no hormones), with an adjusted pH of 5.6 to 5.8. Following the establishment stage, a combination of media types and growth regulators were tested to achieve maximum shoot multiplication (stage II) using different concentrations of 6-benzylaminopurine (BA) as described by Xu et al. (2023). After 30 d or more, representative samples of shoot clusters were destructively harvested, and data were collected to determine the best cytokinin treatment effects on shoot number and shoot length per explant. Excised shoots from stage II were then placed on a rooting medium (stage III) supplemented with different concentrations of IBA and NAA for 60 d, or rooted ex vitro, depending on the species. To determine the best auxin treatment effects, the percentage of explants rooting was recorded for each culture jar, and then primary root

number, root length, and root diameter were recorded for each explant. Plantlets were acclimatized in a mist house (stage IV) for 3 to 4 weeks and then transferred to an environmentally controlled greenhouse until maximum root quality was achieved. To determine the most optimal stage III treatment, stage IV rooted transplants were typically assessed after 60 d for root quality using the same rooting scale as previously described for cutting propagation. Plants were then soaked in water to remove soil from roots to determine the total number of primary roots, mean root length (from two longest roots), plant height, and primary leaf number.

Once propagation methods have been determined, native species were trialed in two to three locations in Florida, representing different soil types, rainfall patterns, and temperatures [USDA cold hardiness zones 8b, 9a, and 9b (USDA, Agricultural Research Service 2012)]. Typically, 1-gal container plants were transplanted into respective field sites in slightly raised linear beds covered with polyethylene mulch. Plants were irrigated and fertilized similarly among sites and evaluated monthly for flowering performance for 6 to 12 months, depending on species. Flower performance was assessed by rating plants on a flowering scale (1 = no flowers, 2 = flower buds, 3 = few open flowers, 4 = greater than 50% of foliage flowering, and 5 = peak flowering). Plant quality was assessed by rating plants on a visual quality scale (1 to 5) as described previously for sterile cultivar evaluation and measuring plant size (length + perpendicular widths/2). To summarize the previously mentioned sexual and asexual propagation findings by species, Table 2 provides an overview of native plants that have been evaluated in Florida's climates, and their attributes that can be considered when selecting alternatives to commonly used ornamental invasives.

## Conclusions

In summary, the substantial economic and ecological costs of invasive species management and removal warrant aggressive early detection and prevention programs. The ornamental industry plays an important role in this by making informed, research-driven decisions in sterile cultivar adoption (Bechtloff et al.

2019) and by phasing out invasive species, replacing them with species that can serve the same role (i.e., ease of propagation, aesthetic traits, and versatility in the landscape) while providing added ecological services. It is hoped that the research findings presented herein will bring clarity of the current status of cultivar evaluation using invasive assessment protocols. Moreover, efforts to identify and determine propagation systems for a suite of native plants that can serve as alternatives to invasive ornamentals are summarized herein. Opportunities remain for better consumer awareness, marketing, and promotion of environmentally friendly plants and extension programming directed toward distinguishing invasive plants from noninvasive alternatives. As an example, a three-ringed easy-to-use flip book guide called "Plant This Not That" (McIntyre et al. 2021) was developed to address these needs and initiate the conversation process. In this extension guide, 22 color entries and descriptions pair an ornamental invasive with a list of noninvasive alternatives and cultivars to use instead. Finally, efforts to use consistent, newly proposed, invasive species terminology (such as native, non-native, introduced, established, invasive, and nuisance) (Iannone et al. 2021) will ultimately increase stakeholder understanding and education.

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