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Invasion Alert

Beach Vitex (*Vitex rotundifolia*): An Invasive Coastal Species

Matthew M. Cousins, Jeanne Briggs, Chuck Gresham, Jack Whetstone, and Ted Whitwell*

Beach vitex is a salt-tolerant, perennial, invasive shrub that has naturalized in coastal areas of the southeastern United States. Since its introduction in the 1980s, this Pacific Rim native has invaded many fragile beach-dune ecosystems along the Mid-Atlantic, Southern Atlantic, and Gulf of Mexico. Large-scale monocultures of beach vitex supplant native species through rapid vegetative reproduction and seed production. Fruits are capable of water-based dispersal, allowing for potential rapid range expansion in coastal areas. Ecosystem damage resulting from exclusion of native plant species by beach vitex and fears associated with potential negative effects on sea turtle nesting have served to promote the control and survey efforts presently underway in coastal areas of the Carolinas, Virginia, and Maryland.

Nomenclature: Beach vitex, *Vitex rotundifolia* L. f.

Key words: Beach dune community, seashore, landscape plant, medicinal plant, exotic.

Beach vitex (*Vitex rotundifolia* L. f.) is a low-growing, shoreline shrub in the subfamily Viticoideae of the family Lamiaceae (formerly in Verbenaceae) (Cantino 1992; Harley et al. 2004) that has colonized broad stretches of the continental Pacific Rim and the Pacific islands. Because of its remarkably outsized natural range stretching from Japan to Australia and from Hawaii to India, this plant has acquired a host of common names, including round-leaved chaste tree (English), dan ye man jing (Chinese) (FOCEC 1994), man hyung ja (Korean) (Shin et al. 2000), and pohinahina (Hawaiian) (Neal 1965).

Beach vitex was first introduced into the United States as early as 1955, with at least five subsequent introductions (Olsen and Bell 2005). The United States National Arboretum evaluated beach vitex in the 1960s and 1970s, but the plant was not grown in a coastal beach environment. Promotion of beach vitex as a landscape plant by the North Carolina State University Arboretum is credited with the introduction of this species into the nursery trade (Olsen and Bell 2005). Before 1985, the plant was typically unavailable in the landscape trade (Olsen and Bell 2005).

The landfall of Hurricane Hugo just north of Charleston, SC, on September 22, 1989, served as the primary driving force for the planting of beach vitex in the Carolinas. The hurricane's 217 km h^{-1} (135 mi h^{-1}) winds and large storm surge caused severe beach erosion in the form of lost or damaged frontal dunes. These dunes were rebuilt, but there was a shortage of planting stock for native dune species. It was believed that beach vitex would serve to maintain dune integrity while showcasing its attractive foliage and floral characteristics in the landscape (Raulston 1993). Unfortunately, beach vitex has proved to be highly invasive and now constitutes a major threat to the fragile coastal dune ecosystems of the southeastern United States.

In spite of the unintended consequences associated with the introduction of beach vitex, this introduction does teach the horticultural community an important lesson. New plant evaluations *must* be conducted in the proper context. Plants adapted to specific niches, such as beach vitex, should be evaluated in the niche that the plant is best adapted to fill. This niche will likely correspond to the habitats most similar to those from which the collections were made.

Description

Beach vitex is a deciduous, sprawling shrub that typically grows to be 0.5 to 1 m (1.5 to 3 ft) tall (potentially as tall as 1.5 m); its characteristic nodal rooting allows the plant to

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Interpretive Summary

Beach vitex is a relatively new threat to the fragile dune ecosystems of the southeast. This fast-growing Pacific native was imported in the aftermath of Hurricane Hugo to enhance the beauty of shore areas while preventing erosion. Unfortunately, beach vitex began demonstrating invasive characteristics, including rampant growth, dispersal off site, and exclusion of native species. The natural resource managers must understand beach vitex biology as it relates to negative environmental impacts, range expansion, and control/recovery methods so that successful management programs may be employed. Beach vitex creates near-monocultures by reducing the prevalence of native species. Additionally, it damages the environment by causing intense substrate hydrophobicity that persists for several years following beach vitex removal. Sea turtle enthusiasts have raised concerns that thick stands of beach vitex might impede sea turtle nesting efforts. Beach vitex is present throughout much of the Pacific and has substantial range potential with regard to climate (latitude), although it is an obligate beach dune plant. This extensive presence stretching from the equator to Korea alludes to the potential for range expansion in North America from Florida to Connecticut. Useful control methods have been developed and are being applied. A method employing repeated applications of imazapyr over multiple seasons has been effective, but this method is costly and labor intensive. Methods that are more efficient need to be developed for integration into future dune-restoration programs. In addition to dealing with these concerns specific to beach vitex, future introductions should consider a single important lesson: new plant evaluations must be conducted in the proper context. For species relegated to specialized niches, such as beach vitex, this means that the plant to be introduced must be evaluated within the niche that it is best adapted to fill.

form dense mats that spread from mother plants to distances of more than 10 m (Munir 1987). Young stems are square, green or purple, and fleshy at the tips; stems become round, brown, and woody with age. Branches from running stems are erect. Leaves possess a strong aromatic scent that intensifies when crushed (Wagner et al. 1999). Leaves are typically simple but can sometimes be palmately trifoliate (Munir 1987). Leaf blades measure 2 to 6.5 cm (0.8 to 2.6 in) in length and 1 to 4.5 cm in width (Figure 1) (Wagner et al. 1999). Margins are entire, and the leaf shape varies slightly from ovate to obovate. Bases are acute, whereas apexes are generally obtuse. Surfaces are tomentose at both top and bottom, with the upper surface being dark green and lower surface ranging from light green to silver or white (Neal 1965). Petiole bases are often tinged with purple.

Panicles can be terminal or axillary and are indeterminate (3 to 7 cm in length). The calyx (4 to 4.5 mm [0.16 to 0.18 in] in length) subtends a corolla, which is zygomorphic, purple to blue–purple, and funnel-form (8 mm in length)(Figure 1). Stamens ($n = 4$) extend beyond the corolla tube (9 to 10 mm), and styles extend beyond the stamens (12 mm)(Wagner et al. 1999). Ovaries

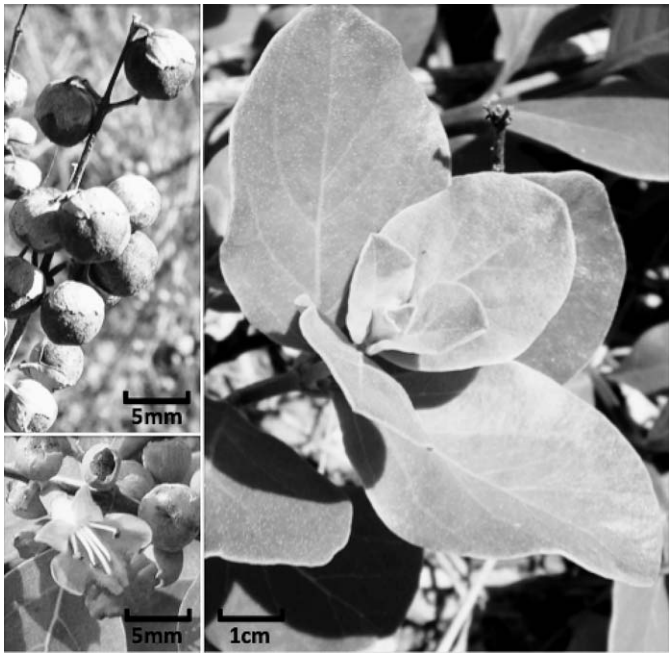


Figure 1. Beach vitex (*Vitex rotundifolia* L.) fruits (top left) leaves (right), and flowers (bottom left).

consist of two carpels, each containing two single-seeded locules. Fruits are globose drupes that are green (during expansion), yellow to red (during maturation), or charcoal black (after maturation and drying). Mature, hard, nonfleshy drupes (FOCEC 1994) are partially capped by persistent, pubescent calices (Figure 1). Drupes contain four seeds (or fewer by abortion) in separate compartments (de Kok 2007). Endosperm is absent (Corner 1939; Moldenke 1958). Seeds germinate into tender seedlings that bear two cotyledons and quickly develop two true leaves.

Voucher Specimen. United States, South Carolina, Georgetown County: Site along coast within DeBordieu Colony. Patrick McMillan, 33°21′30.81″N, 79°09′08.16″W. Datum: WGS84, September 8, 2001 (CLEMS 76836).

Taxonomy

Beach vitex has been the subject of frequent taxonomic revision over the years. In fact, the most recent genus level revision has placed *V. rotundifolia* in synonymy with *Vitex trifolia* L. ssp. *littoralis* Steenis (de Kok 2007, 2008), whereas an earlier generic revision held that *V. rotundifolia* was distinct (Munir 1987). This is not the first time that beach vitex has been placed within *V. trifolia*. Moldenke (1958) placed *V. rotundifolia* in synonymy with *V. trifolia* var. *simplicifolia* Cham. This placement was in disagreement with an earlier placement by Corner (1939) that was supported by Fosberg (1962) and Wagner et al. (1999).

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Significance of *V. rotundifolia* Presence

Detrimental Effects. Rapid growth, vegetative reproduction, and massive fruit production (up to 5,581 fruits m^{-2}) allow beach vitex to dominate dune ecosystems (Gresham and Neal 2004; personal observation) and reduce the prevalence of native species. Beach vitex plants accounted for 86% of spatial cover on infested sites with a density of 59 stems m^{-2}, whereas native species, such as sea oats (*Uniola paniculata* L.), covered 3.8% of the sites with 11 stems m^{-2} (Gresham and Neal 2004). On nearby control sites, without beach vitex, native species covered 49% of the site area with 56 stems m^{-2}. Thus, beach vitex–dominated sites had lower native species representation (fewer total plants; biodiversity effects have not been assayed to date) and less open space, resulting in a greatly altered ecosystem. Experimentally, beach vitex's root competition negatively affected native species in a greenhouse study in which native species were co-potted with beach vitex (unpublished data).

Beach vitex produces a thick, waxy cuticle containing large quantities of diverse *n*-alkanes. These compounds are transferred to the surface of sand particles, where they cause intense substrate hydrophobicity (Cousins et al. 2009). This activity could assist in the maintenance of monocultures by preventing establishment of native species underneath established, deep-rooted sands of beach vitex. Sand hydrophobicity also constitutes an ecological concern because these compounds persist in the soil for many years following the removal of beach vitex (Cousins et al. 2009).

Sea turtle conservation groups suspect that dense beach vitex growth may form a physical barrier that bars sea turtles from reaching acceptable nesting locations and prevents baby turtles from reaching the ocean. These fears were publicized as part of a recent *USA Today* article designed to raise awareness about beach vitex (Dorell 2009). To date, this supposition has not been confirmed scientifically. If proven true, this would be an important concern because the Carolinas are home to three endangered sea turtle species: loggerhead turtle (*Caretta caretta* L., endangered), green turtle (*Chelonia mydas* L., endangered), and Kemp's Ridley turtle (*Lepidochelys kempii* Garman, critically endangered).

Benefits

There are no known positive ecological effects of beach vitex; however, modern scientific efforts have resulted in the discovery of many medicinally active compounds in this plant. Studies have demonstrated the potential of beach vitex for use in the treatment of cancer (Haïdara et al. 2006), female hormone-related health issues (Hu et al. 2007), allergies (Shin et al. 2000), and pain (Hu et al. 2007). Beach vitex is produced for traditional medicinal uses in Korea and China (SPCC 2000), and as a result, it is of great economic importance in those countries.

Legislation

Beach vitex was added to the North Carolina Noxious Weed List (effective February 1, 2009); this classification makes possession, sale, and transport of beach vitex illegal in North Carolina (NCDACS 2009). In Virginia, a beach vitex quarantine has been enacted; this ruling (effective October 26, 2009) is designed to prevent further distribution and spread in coastal counties of Virginia (VADACS 2009). In North and South Carolina, ordinances have passed in 12 coastal municipalities that ban planting of beach vitex and require its removal (CBVTF 2009).

Geographical Distribution

The natural range of beach vitex includes much of the Pacific Rim and many of the Pacific islands, including the Andaman Islands, Australia, Bangladesh, Borneo, China, Hawaii, Hong Kong, India, Indochina, Indonesia, Japan, Korea, Malaya, Mauritius, New Caledonia, New Guinea, the Philippines, Polynesia, Reunion, the Ryukyu Islands, Sarawak, Sri Lanka, Taiwan, and Thailand (Munir 1987). Cultivation of beach vitex has been reported in England, Florida, Germany, the Hawaiian Islands, Hong Kong, Java, Johnston Island, Maryland, and New York (Munir 1987). In the United States, beach vitex has naturalized in coastal regions of the Mid-Atlantic and Southeastern states along the eastern (Georgia, Maryland, North Carolina, South Carolina, and Virginia) and gulf (Alabama) coasts (Figure 2). Unconfirmed sightings have been reported in Florida. In North Carolina, 621 beach vitex-infested sites were discovered (M. Doyle, personal communication), and 246 sites were found in South Carolina (J. Whetstone, personal observation). The true extent of the problem will only be known after thorough survey efforts are complete.

A long-distance dispersal mechanism or combination of mechanisms must be responsible for the distribution of beach vitex over such a broad range. It is likely that fruits travel to new locations via a water-based dispersal mechanism. Fruits are covered with thick coatings of hydrophobic, cuticular alkanes that allow them to resist water penetration (Cousins et al. 2009). Fruits readily float on the water's surface for weeks (M. M. Cousins, personal observations), and fruits were noted to be floating in the ocean and in beach drift (Munir 1987).

Habitat

Climatic Requirements. Beach vitex grows naturally along rocky and sandy coasts 0 to 15 m above sea level (Wagner

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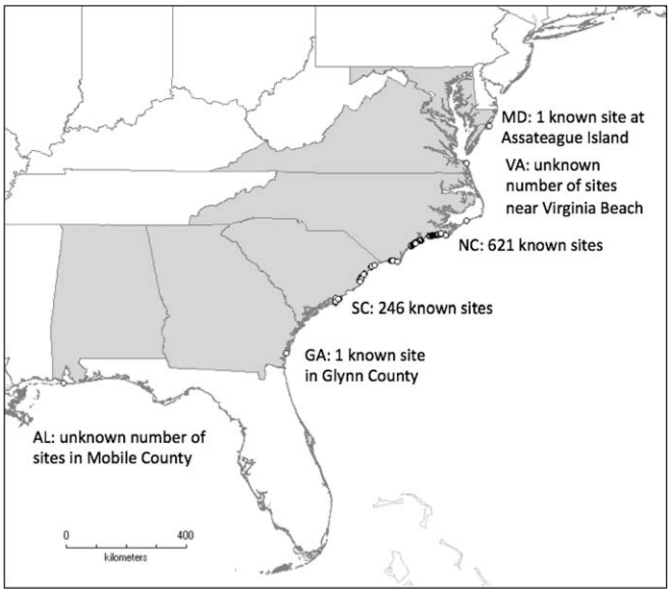


Figure 2. Known distribution of beach vitex (*Vitex rotundifolia* L.) in the southeastern United States.



Figure 3. A beach vitex (*Vitex rotundifolia* L.)–infested site (right) adjacent to an uninfested site (left) in fall. The delineation between the deciduous beach vitex (dark gray) and the sea oats (*Uniola paniculata* L.) (light gray) is clearly visible.

et al. 1999). Globally, according to the Köppen-Geiger climate classification (Peel et al. 2007), beach vitex is known to exist in a host of climatic regions, including three of the six major groups: tropical (specifically, Af, Am, and Aw), temperate (Cfa and Csa), and continental (Dfa and Dwa). It is evergreen in tropical areas, such as Hawaii and deciduous in temperate areas along the coasts of Korea and North America.

Beach vitex is native to latitudes ranging from 0° to 38° (and potentially further north) (Lee et al. 2007). The range of beach vitex is restricted in that it is an obligate seashore shrub but expansive with regard to climatic tolerance. According to all BIOCLIM (Beaumont et al. 2005) statistics, except those associated with the seasonality of precipitation, the climate at the highest latitude from which the authors have found plant samples (Korea) is similar in many ways to the climate associated with areas near the Connecticut–New York border. The Korean site and the Connecticut–New York border record annual mean temperatures of 11.7 and 11 C, (53 and 52 F), annual precipitation of 1,196 and 1,183 mm, maximum temperature in the warmest month of 27.6 and 28.7 C, and minimum temperatures in the coldest month of −5.9 and −6 C, respectively (WorldClim 2009). It is logical to assume that the maximal extent of beach vitex in the United States should be climatically equivalent to the extent of beach vitex in the Pacific. Under these assumptions, beach vitex is likely capable of growing in Connecticut, Delaware, New Jersey, and New York. Our predictions are limited by the published accounts of beach vitex sightings. Beach vitex may exist at higher latitudes than have been reported. Thus, additional range expansion beyond these states would be possible, although less likely with increasing latitude.

Native Species Found in Conjunction with Beach Vitex. In the United States, beach vitex is frequently found growing near American beach grass (*Ammophila breviligulata* L.), bitter panicum (*Panicum amarum* Elliot), blackberry (*Rubus* spp.), cord grass [*Spartina patens* (Ait.) Muhl.], greenbrier (*Smilax* spp.), seaside amaranth (*Amaranthus pumilus* Raf.), sea oats, seacoast marsh elder (*Iva imbricata* Walter), southern sandbur (*Cenchrus echinatus* L.), sweetgrass [*Hierochloe odorata* (L.) P. Beauv.], and southern waxmyrtle (*Myrica cerifera* L.) (Gresham and Neal 2004; personal observations).

Description of Infested Sites. As previously noted, beach vitex appears to successfully compete with native species leading to near-monocultures of beach vitex, which may be dotted with a few surviving native species (Figure 3) (Gresham and Neal 2004; personal observations). Thick beach vitex cover prevents approximately 90% of photosynthetically active radiation (PAR) from reaching the sand surface as opposed to exclusion of 20 to 40% of PAR by sea oats (unpublished data). Beach vitex is highly tolerant of the harsh beach-dune environment characterized by intense heat, high winds, coarse-textured soil, and elevated salinity (Dirr 1998). This tolerance allows beach vitex to persist while expanding mostly vegetatively at the margins of infested sites. Large numbers of fruits have also been noted in the substrate surrounding sites with large amounts of beach vitex growth (Cousins et al. 2010). Beach vitex naturalization is limited to beach-dune areas because it is an obligate beach-dune species (Kim 2005).

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Management

Mechanical Control. The removal of plant parts from the dune surface has been practiced despite the labor-intensive nature of such control methods. Mechanical control alone is ineffective because of the large numbers of underground roots and stems that are capable of rapid regeneration. Removal of all underground beach vitex plant parts would require extensive substrate excavation leading to the destruction of other dune-stabilizing plants and to increased beach erosion.

Biological Control. No biological control systems are known for beach vitex. Beach vitex produces insect-repelling chemicals (Watanabe et al. 1995), which may provide resistance to insect predation. The authors have not observed disease in populations in the field or in the greenhouse environment; however, aphids occasionally attack beach vitex in the greenhouse.

Chemical Control. The most effective control method employed to date was developed by the authors and incorporates both chemical and mechanical means. Initially, the aboveground beach vitex stems are wounded with a machete at several locations along each stem, and a 5.25% solution of imazapyr is painted into the wounds. Imazapyr was selected because it is one of the few herbicides that provided long-term control of beach vitex (Cousins et al. 2006; unpublished data). Plants are allowed to remain intact for 6 mo following treatment (to allow for herbicide translocation). Seedlings and small-caliper resprouts have been successfully treated with spray applications of triclopyr at labeled rates.

The process of treating and physical removal must be repeated until each site has zero regrowth. Massive regrowth has been observed following initial treatments, and beach vitex has many features, which allow it to reestablish itself following control attempts (Cousins et al. 2010). All of the authors' control studies of beach vitex have indicated that multiple seasons of retreatment are required for successful eradication of large, established beach vitex infestations (unpublished data). Additionally, care must be taken to avoid secondary infestations following beach vitex removal. The authors have observed significant growth of greenbriar (*Smilax* spp.) and other weedy species in areas recently cleared of beach vitex. These secondary invasions following beach vitex removal compete with replanted dune natives (personal observations).

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