Carolinas Beach Vitex Task Force Archived Announcements
JANUARY TO JUNE 2009

January 2009

NORTH CAROLINA UPDATE
January 22, 2009 The North Carolina Department of Agriculture officially listed beach vitex Vitex rotundifolia as a Class B State Noxious Weed.

WilmingtonStarNews1-23-09, StatePortPilot01-28-09

February 2009

SOUTH CAROLINA UPDATE
BASF Corporation’s magazine, Latitude, ran a feature article in its winter edition about Dr. Randy Westbrooks, Invasive Prevention Specialist, U.S. Geological Survey and his 30 year career devoted to invasive species. Westbrooks has been a valuable partner of the Carolinas Beach Vitex Task Force (CBTF) since its inception in November 2003. The article focuses on Westbrooks’s Early Detection Rapid Response Program (EDDR) and the success of the CBTF as a model EDRR program.

Latitude Winter 2009 article

February 6, 2009 Carolinas Beach Vitex Task Force partners gathered at the new Clemson Baruch Institute Lab at Hobcaw Barony, Georgetown County to plan for the 2009 season and annual symposium. The symposium will be held on Friday, March 13 at Fort Fisher Aquarium, Kure Beach, NC. A link to the agenda and directions to the aquarium are on the home page of the website.

 Clemson Update
The Clemson eradication crew in South Carolina continued to follow the restoration practices. Some C List sites were treated for the first time. A and B List sites that had been retreated were cleared and replanted with some cool season plants. Some C List sites will require treatment in an unconventional manner since they are within landscape situations under live oaks and in planters. The crew has adapted its methods of removal and restoration in these sites with different herbicides (depending on the site) and follow up.

A lecture on beach vitex and other invasive species was presented to a combined Horry-Georgetown Tech and Waccamaw High School class. The teacher will allow students that volunteer to work in monitoring, removal and replanting to receive extra credit. Hopefully, the result will be some new volunteer labor. The two summer intern positions have been approved and advertised through Clemson and closing date is March 31. These new crew members will start working in May.
March 2009

**March 13, 2009** The 2009 Beach Vitex Symposium was held at the North Carolina Aquarium at Fort Fisher, Kure, NC. Approximately 40 people attended from NC, SC and VA from Federal/State agencies, municipalities, academia, landscape companies, environmental organizations and sea turtle network volunteers. There was a morning agenda of speakers followed by lunch. Next, attendees went on a field trip to nearby Carolina Beach where they observed a large colony of beach vitex that was encroaching on a public park. Lee Rosenberg, with the City of Norfolk, was presented with a Carolinas Beach Vitex Task Force hat and t-shirt. This made it official that Virginia is now a part of the task force effort.

An article in the Wilmington Star Newspaper recapping the symposium was picked up by the Associated Press and ran in newspapers across the country.

2009 Beach Vitex Symposium Summary, 2008 Significant Accomplishments, Wilmington Star 3-13-09 article

---

**SOUTH CAROLINA UPDATE**

The Charleston Field Office of the U.S. Fish and Wildlife Service featured the beach vitex project in its Fall 2008 newsletter. The article entitled Beach Vitex Eradication Moving Forward highlighted efforts along the South Carolina coast, funding and recent Carolinas Beach Vitex Task Force awards.

USFWS Newsletter-Fall08

**CLEMSON UPDATE**

Clemson crews continued to remove beach vitex from areas on DeBordieu, Pawleys Island, Litchfield and Myrtle Beach and plant cool season grasses. Announcements for two temporary summer technicians to work on the eradication project were released with a closing date of March 31. Interviews will follow in April so that the technicians can begin work as soon as possible after their school ends in May. Sea oats have been ordered and planted in the greenhouse for delivery after the threat of frost and freeze passes. Waccamaw High School (Pawleys Island) students in Mr. Beau Gee’s PACE Biology class in dual enrollment at Horry Georgetown Tech will be conducting volunteer work with beach vitex starting the first weekend in April.

**NORTH CAROLINA UPDATE**

**March 26, 2009** An article appeared in Wrightsville Beach’s Lumina News about the success Parks and Recreation parks maintenance supervisor Billy Beasley has had in treating beach vitex sites.

Lumina News 3-26-09

**VIRGINIA UPDATE**

With springtime underway, City of Norfolk staff are monitoring the treated beach vitex sites on Willoughby Spit to see if any new growth appears. Follow-up treatment will be initiated as needed as well as we will continue to keep a look-out for any new colonies. We will also be following up with neighboring jurisdictions to spread awareness of the potential for beach vitex colonization along their waterways and dunes.

Since at least one nursery in Virginia has been identified as carrying beach vitex for sale, efforts have been...
initiated by the Virginia Department of Agriculture and Consumer Services’ Office of Plant and Pest Services to conduct a formal beach vitex retail survey. This effort will be a first step to determine if and where beach vitex is carried by nurseries and garden centers throughout the Commonwealth. Only after this effort is completed, will the State make a determination if the plant should be evaluated for listing as a State noxious weed. The results of the retail survey will be reported once that effort is completed.

Following the discovery of beach vitex in Virginia last year, a number of State agencies and municipalities have been educated on the significant threat this plant is to our State’s coastal environment. Clearly, Virginia will benefit from the excellent research, public awareness and testing of eradication techniques that have been spearheaded by the Carolinas Beach Vitex Task Force. This month’s Beach Vitex Symposium provided invaluable, current information for Virginia to use.

April 2009

**SOUTH CAROLINA UPDATE**

Beach vitex was featured in the Winter 2009 edition of Estuaries Illustrated, a quarterly publication of the North Inlet – Winyah Bay National Estuarine Research Reserve (NI-WB NERR). There was a general article about beach vitex and the task force efforts and another article recapping the recent 2009 Beach Vitex Symposium.

Estuaries Illustrated Winter 2009

**CLEMSON UPDATE**

Clemson University scientists recently published an article about the hydrophobicity of soil underneath Beach Vitex.

Clemson Article

**April 16, 2009** An article with photographs appeared in the Coastal Observer (Pawleys Island) about 11 seniors from Mr. Beau Gee’s Waccamaw High School – Horry Georgetown Tech class who over two days helped eradicate beach vitex from oceanfront property and replant the dunes with native species.

Coastal Observer 4-16-09

The pile of cut dead beach vitex continues to grow at the disposal site. The enormous first pile has been burned. Clemson has hired two summer interns to work with the crew on eradication and restoration.

**NORTH CAROLINA UPDATE**

North Carolina sites treated last fall (Sept-Nov ’08) have been checked for new growth and very little has been found. We estimate that between 95-99% of the plants on each treated site are dead and dying. The few stems that are re-sprouting are being treated now. This is extremely encouraging and we are very confident about future treatments.

We are modifying the spring protocol for fall-treated plants. Instead of cutting back all above-ground stems we
will leave them until the fall, if they need to be removed at all. This ought to increase the effectiveness of the herbicide and prevent new growth from a cut stump. If the existing stems are low and sparse enough, replanting of native vegetation (Sea oats) can be done right in among the dead Vitex stems.

May 2009

South Carolina Update

May 5, 2009 Dr. Chuck Gresham, retired from Clemson’s Baruch Institute, is now teaching environmental science at Lowcountry Day School in Pawleys Island. He invited Betsy Brabson, SC Task Force coordinator, to speak to his AP environmental science class about her experience with the Carolinas Beach Vitex Task Force. Brabson stressed the importance of reporting plants with invasive characteristics. In the case of beach vitex, early detection and rapid response has made it possible for the eradication of this species from the Carolinas/Virginia coastline.

May 13-15, 2009 The Southeast Exotic Pest Plant Council (SE-EPPC) held its 11th Annual Conference at the Quality Inn in Georgetown. The organization’s mission is “Creating Sustainable Landscapes for the Future” and the Georgetown area provided a great example of how invasive plants can overtake ecosystems and measures being taken to control them. The conference featured a variety of speakers who addressed invasive species and control efforts including Clemson’s Jack Whetstone who coordinates the beach vitex eradication effort. Whetstone gave an update on the progress of eradication/restoration of the plant and spoke of other invasives he works with including phragmites, alligator weed, Chinese tallow and water hyacinth. Task Force coordinator Betsy Brabson and North Inlet-Winyah Bay NERR’s Jen Spicer Plunket participated in a panel discussion “How can we stop the Sale of Non-Regulated Non-Native Invasive Plant Species?”

In addition to an agenda of speakers, attendees went on field trips in the area and enjoyed a Low Country Boil at Hobcaw House on Winyah Bay at Hobcaw Barony.

Clemson Update

The 2009 Eradication crew is hard at work. Byron McDaniel, Jacob Mears and Neil Wilson, headed up by Hal Drotor, are in the field. Sites in the city of Edisto Beach, Charleston and Sullivans Island with small regrowth were retreated. Several new sites that had been previously treated had beach vitex removed and the dunes were planted with native plants. Four new off beach sites have been discovered and one new beachfront landowner has agreed to enter the program. The systematic re-search, retreat and replant program of Georgetown County sites was initiated for the summer.

North Carolina Update

A thorough survey of the Outer Banks towns of Kitty Hawk, Kill Devil Hills and Nags Head, as well as beach surveys of those towns plus Corolla, Duck and Southern Shores was conducted from June 12th to the 14th. Thankfully, very little new beach vitex was found and the remaining dune systems (north of Kitty Hawk) look to be very healthy. A huge “Thank you!” goes out to Kathy Mitchell (Conservation Horticulturist at the NC Aquarium at Roanoke Island) for coordinating all the beach surveys with town personnel and recruiting some volunteer spotters. Thanks also go to: Sandy Cady (Duck), Merrie Smith (Southern Shores), Willie Midgett (Kitty Hawk), Doug
Huff (Nags Head), Ross Cipriano (KDH) and Jason Litteral (Corolla). Surveyors included Kathy Mitchell, Dale Suiter (USFWS), Melanie Doyle, Susan Ruiz-Evens and Debbie Kelso (Dare County Cooperative Extension), Bo Dame (NCCR), Rachelle Pinault and Britt Purtee (NC Aquarium Roanoke Island).

Sites treated last year in Wrightsville Beach, Topsail Island, and Bogue Banks continued to be monitored for regrowth. Some spot treatments are being done as needed.

June 2009

**SOUTH CAROLINA UPDATE**

The beach vitex website is hosted by North Inlet-Winyah Bay National Estuarine Research Reserve, www.north-inlet.sc.edu, a Beach Vitex Task Force partner. This website was recently redesigned thus www.beachvitex.org received a fresh new look. Many thanks to Jen Spicer Plunket for her web master expertise and creativity.

**CLEMSON UPDATE**

Dr. Ted Whitwell, Chairman of Horticulture at Clemson University, has been working with some of his students on the unique properties of beach vitex, selective herbicides for retreatment and seedling control and the germination of beach vitex seeds to see how many years beach vitex seeds remain viable. Beach vitex seeds are no longer viable after 4 years.

Dr. Lissa Riley, Clemson, has been conducting research on the hydrophobic properties on beach vitex and extraction methods.

The Clemson crew has treated all new known sites north of Hobcaw Beach in Georgetown County and retreated, removed and replanted all A, B and C sites between Myrtle Beach and Hobcaw Beach.

July will be spent searching all uninhabited beachfront sites from Santee River south to Edisto Beach.

**NORTH CAROLINA UPDATE**

On June 11th most of the known beach vitex plants growing on Masonboro Island were treated. This was the first growing-season application of herbicide and it was done largely as an experiment in expanding the treatment season. Some plants were treated by both the hack-and-paint and foliar spray method, others the hack-and-paint method only. A few colonies were left untreated (until the coming fall) to serve as controls. Also, six new plants have been found so far this summer, bringing the known total to 22 on the undeveloped island. Early effects on the sprayed plants are visible, but the final results won’t be known until the spring of next year. Those participating in this work were Hope Sutton, Stewardship Coordinator & Southern Sites Manager (NC Coastal Reserve & National Estuarine Research Reserve), Kai Curry-Lindahl (seasonal field biologist, NCCR), and Melanie Doyle. Thanks also to Mr. Byron Toothman of the NCCR for expertly ferrying the group to and from the island.

**VIRGINIA UPDATE**

There is some good and bad news from Virginia regarding beach vitex eradication effort. The good news is it appears that treatment with Habitat last year was 99% effective. For the main colony treated in Willoughby Spit in Norfolk, no new buds were found coming out this spring. However, there was one adjacent plant that did show some life. Apparently, this small plant just got a foliar spray treatment and was not hacked to provide for good uptake of the herbicide. The more disheartening news is a new plant was found on the crest of the dune that appears to be a newly germinated seed or growth from a section of plant that had broken off and been transported prior to treatment. It seems beach vitex is very well adapted to growing in Virginia’s coastal dunes and should it gain a foothold in multiple locations, it will be extremely difficult to eradicate or control.

As noted in the March update, the Virginia Department of Agriculture and Consumer Services’ (VDACS) Of-
The office of Plant and Pest Services completed a formal beach vitex retail survey. The survey prompted a letter from VDACS’s Commissioner, Todd Haymore, to all Virginia nursery growers and dealers to request their assistance in “voluntarily refraining from selling or distributing beach vitex”. “Further, the VDACS is actively monitoring the issue and, if necessary, will take regulatory action to list and treat beach vitex as a noxious weed (emphasis added)”.

In tandem with this effort, the City of Norfolk’s Environmental Services Division is seeking voluntary eradication of three separate specimens of beach vitex that have been growing at the Norfolk Botanical Gardens for a number of years. Their eradication protocol requires that for a plant to be removed, it must be listed by the Virginia Department of Conservation and Recreation as “highly invasive”. Unfortunately, beach vitex is so new to the Commonwealth that it does not even appear on the list. The city’s Environmental Services Division is working to correct that oversight.

And, as a final note, Lee Rosenberg, manager of the City of Norfolk’s Environmental Services Division, has been nominated to serve as the region’s representative on the Virginia Invasive Species Advisory Committee. This will provide a good opportunity to make sure beach vitex is addressed since many in the state are unfamiliar with this plant and the dangers it poses to our coastal environment.
State officially bans vitex, ‘kudzu of the coast

By Gareth McGrath
Staff Writer

Published: Thursday, January 22, 2009 at 5:33 p.m.
Last Modified: Thursday, January 22, 2009 at 5:43 p.m.

A plant that was first promoted by North Carolina has now been outlawed by state officials.

Related Links:

- Wrightsville might stand against beach vitex
- State hopes to wipe out pretty but invasive plant
- Know plants’ growing habits to avoid unwanted annual spreading
- Invasive plant crowds out dune stabilizers
- Kudzu of the coast

External Links:

- For more information about the invasive plant or to report an infestation, click here:

Rules to ban the sale, transport and possession of beach vitex by nurseries, garden shops and private property owners passed their final regulatory hurdle on Thursday.

The plant will be officially added to the state’s “noxious weed” list on Feb. 1.

Fast-growing, salt-tolerant, disliked by animals and sporting a beautiful purple flower during the summer, vitex was marketed as a coastal landscaping plant by N.C. State University in the 1980s.

But vitex started worrying researchers earlier this decade when it began overtaking dunes, crowding out the native sea oats and sea grasses.

The shrub that’s native to the Pacific Rim also lacks the dune-building benefits of the native vegetation and is a hazard to nesting sea turtles and shorebirds.

Beach vitex, beside being a prolific seed producer, also can grow up to 15 feet a year – a characteristic that has earned the plant the moniker of “kudzu of the coast.”

Melanie Doyle, the state’s beach vitex task force coordinator, said Thursday’s approval by the N.C. Rules Review Commission will allow officials to build upon last year’s strong momentum as worries about the invasive weed saw town after town along the coast pass ordinances outlawing the plant.
“This is just one more tool we get to use,” she said of the state ban. “It’s going to make the task at hand that much easier.”

Doyle, who also is the horticulturist at the N.C. Aquarium at Fort Fisher, said officials intend to step up their surveying, education and eradication efforts in 2009.

Beach vitex has been found all along the North Carolina and South Carolina coasts, including on most barrier islands in Southeastern North Carolina.

It also has been reported in Virginia, Georgia and along the Gulf Coast.

For more information about the invasive plant or to report an infestation, go to www.beachvitex.org.

Gareth McGrath: 343-2384

gareth.mcgrath@starnewsonline.com

All rights reserved. This copyrighted material may not be re-published without permission. Links are encouraged.
Vitex finally on state noxious weeds list
1.29.09 edition

By Ben Brown
Staff Writer

Planting or selling beach vitex will finally be an act on the state’s no-no list.

The invasive weed, condemned by coastal naturalists for its damaging impacts to sand dunes and hindrance to sea turtle nesting, will make the N.C. Department of Agriculture’s class B noxious weeds list on February 1. That classification represents non-native invasive weeds present in fewer than 20 counties in the state and prohibits the planting or sale of the species in hopes of containing it and ultimately eradicating it.

Since the state’s announcement Thursday, botanists and coastal scientists have been in celebration mode.

“Thrilled,” said Melanie Doyle, N.C. Beach Vitex Task Force coordinator. “(Beach vitex) is a real threat to the ecosystem, but it’s one we have a real shot at controlling.”

Beach vitex (vitex rotundifolia) is a woody, leafy—and in the blooming season, flowery—shrub imported to the state from the Pacific Rim in the 1980s for use in stabilizing dunes.

What its bringers didn’t know at the time was the plant’s invasive qualities, which crowded out native dune plants like sea oats. Dunes suffered as vitex could not trap sand as efficiently as the native plants. Further, it grew thick down to the base of sand dunes, where loggerheads would nest. Several sea-turtle assistance groups have condemned the plant as a destructive nuisance disguised as a pretty shrub. It looked so good that property owners in the 1980s and early 1990s adopted it to beautify their yards.

Into the 1990s, however, the negative qualities of beach vitex were in discussion while it grew in thick colonies along the coast. Areas like Caswell Beach, Oak Island and Bald Head Island were infested, and eradication measures were put into play. Over the next decade, organizations like the Carolinas Beach Vitex Task Force (CBVTF) and several municipal initiatives experimented with ways to kill the weed, eventually finding success with herbicides glyphosate and imazapyr. The Brunswick County beaches are mostly rid of the plant and are
watching for new growth. Some towns, including Caswell Beach, had enacted ordinances against vitex.

But trying to get the Carolina states to outlaw beach vitex was the real challenge. North Carolina’s recent decision to place it on the noxious weeds list makes it the first state to take such action, according to Doyle.

“Kudos to North Carolina,” said Maureen Dewire, senior naturalist at the Bald Head Island Conservancy, following the announcement. Dewire headed the attack on Bald Head Island’s vitex infestation, working with N.C. State University to research the best kill methods. “It’s really a great step they’ve taken,” she said.

CBVTF leader Betsy Brabson credited N.C. Plant Industry Division weed specialist Rick Iverson with guiding vitex to official condemnation. “He’s to be commended,” Brabson said. “It was a long process.”

Iverson said Monday the process entailed the initial recognition of vitex’s threat, followed by a “weed risk assessment” that goes deep into the biology of the plant and its potential for spreading.

Its potential for containment is likely what got it on the state list, Doyle said, explaining that other invasive plants like kudzu and the “dreaded” Chinese privet run unregulated by the state because they’re everywhere. There’s no way to contain or regulate them.

As for vitex, blooming season will being in April or May, Doyle said. While Iverson said property owners with vitex currently running across their lawns won’t be in trouble despite the new regulation, Brabson said she’s working to eradicate it completely from the coast and is attempting to locate and contact vitex property owners to that end.

She said some have already come to her, “almost apologetically.”

Beach vitex is identified by its vine-like, woody stems, green, oval leaves and bright, purple flowers that bloom in the summer. Doyle said Brunswick County is currently in good shape, but northward at areas like Wrightsville Beach and Topsail Beach, it’s still a concern.

Scientists warn those who see vitex to not attempt removing it, and under no condition should it be cut. Doyle warned that cutting the plant could stimulate its growth.

Persons who find vitex are asked to call Doyle at 458-8257, extension 250. A CBVTF plant scientist would be dispatched to the site.
CBVTF’s website, which contains vitex pictures and news, is http://www.beachvitex.org.
INDUSTRY IMPACT

Celebrating the Career of a Pioneer

For more than 30 years, Randy Westbrooks, Ph.D., has been a pioneer in the fight against invasive weeds. As one of the first champions of early detection and rapid response, he has helped countless individuals and government entities implement vegetation management solutions across the United States. Now, as Randy readies himself for retirement, one of his greatest fans, Betsy Brabson, chairwoman of the Carolinas Beach Vitex Task Force, pays tribute.

Dr. Randy Westbrooks has impacted the lives of many people during his career. And his mission to restore natural areas and habitat has had a direct impact on the Carolina coast — the area that I call home.

Randy has been a major force in protecting the habitat that is so vital to the survival of the sea turtle hatchlings that make their way from the beach to the ocean near my home each year. His guidance and collaboration helped my volunteer group control invasive beach vitex, a weed that crowds the turtles' habitat and ensnares tiny hatchlings as they struggle toward the safety of open water.

Randy began his career as a high school science teacher in South Carolina, and then worked as a plant quarantine officer with the U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS) in Charleston. He became the national weed coordinator for APHIS in 1996, and then the national invasive plant coordinator for the U.S. Geological Survey in 2000. He has been instrumental in international efforts to control the spread of invasive weeds and a cornerstone of interagency cooperation for weed control.

But his resume tells only part of the story. It doesn't describe his ability to energize people. It doesn't reveal the creativity he brings to halting weed infestations, nor his uncanny ability to instantly identify new threats to the American landscape.

Randy's passion for protecting ecosystems has made him a chief asset in the war on invasive weeds. He can explain the threat of invasive weeds to congressmen, scientists, economists and regular citizens like me. He assembles the right elements to get things done quickly, using integrated vegetation management tools to repair the damage weeds have already caused.

Before our task force to fight beach vitex was formed, Randy helped us find the resources and key partners to study the plant and determine the best control methods. He also helped us educate the public about the serious threat the weed posed to our shoreline.

Our sea turtles aren't the only species to benefit from Randy's legacy. Early detection and rapid response is helping save habitat all over the United States.

Westbrooks has served the invasive plant control community via positions with the U.S. Department of Agriculture and the U.S. Geological Survey.

Betsy Brabson is a key leader in the Carolinas Beach Vitex Task Force.
Anyone who has heard Randy speak knows his depth of dedication to eradicating invasive weeds. Whether in his role as a leading weed scientist or as a facilitator of agency partnerships, Randy's dogged determination and creativity have been invaluable to groups across the country.

I hope you'll join me in wishing Randy all the best as he retires from his distinguished career in public service, with the hope that he will continue to be a driving influence in the war on weeds for many years to come.

For the full story about Westbrook and his involvement in the sea turtle project, see the winter 2008 issue of Latitude at vmanswers.com/latitude.

Clearcast® herbicide offers a new solution to selectively target the troublesome Chinese tallowtree while leaving more desirable hardwoods unharmed.

Hardwood selectivity studies in several states, including South Carolina, Louisiana and Texas, have shown control of Chinese tallowtree with little activity on a mix of hardwood species including water oak, live oak, southern red cedar, bald cypress, wax myrtle and elm.

Willow, black cherry, hawthorn, sweetgum and sumac have shown some sensitivity to the herbicide, so lower rates should be considered in areas with these species.

Chinese tallowtree (Triadica sebifera), also called popcorn tree, is an aggressive invader. Reproducing quickly, the nonnative tree crowds out native plants and threatens wildlife habitat.

For more information, download a recent LiveMeeting presentation with Dan Beran, BASF market development specialist, at www.vmanswers.com/research.

Controlling Chinese Tallowtree Among Desirable Hardwoods
No Place to Hide
Ranchers Rally Against Carrizo Cane

Merging Management Programs
Finding Common Ground in North Carolina

Can-do in Kansas
Native Wildflowers and Grasses Prevail

Shoring Up Resources to Fight Phragmites
Wisconsin's Scenic Door County Strikes Back
North Carolina Update – Melanie Doyle, NC Task Force Coordinator
Dale Suiter, US Fish & Wildlife Service

The NC Dept. of Agriculture has listed beach vitex as a Class B Noxious Weed. The plant has been found in 7 of 9 coastal counties. There are 409 known sites which is an ever-changing number. 156 beach vitex sites were treated in 2008 with some spring treatments planned for this season. The NC Task Force has surveyed most of the southern coast and will concentrate efforts this season on the northern coast and undeveloped barrier islands. Fourteen beach vitex plants were found on undeveloped Masonboro Island indicating the plant can spread by water. A landscaper training workshop was held at Wrightsville Beach in 2008 with several more workshops are planned for 2009. Partnering has been very effective in the beach vitex effort in NC.

North Carolina is funded by a $128,000 Keystone Grant from the National Fish & Wildlife Foundation (NFWF). Funds which were frozen in the fall are finally coming in and grant agreements have been sent out to the coastal towns. Beach vitex which is heavily concentrated on the southern coast has been found in on the northern coast in Duck, Corolla, Southern Shores and Nags Head. $71,750 of the $128,000 grant has been allotted for treatment and removal but no replanting.

Wrightsville Beach is a beach vitex success story. The Task Force and Wrightsville Beach Parks and Recreation Dept. were first met with opposition from property owners who did not want to have their beach vitex removed. Through persistence by the CBVTF and PRT and with help from the media in educating the public about the problems with beach vitex, there was 100% participation. There were 52 sites found which were all treated in 2008.

South Carolina Update – Jack Whetstone, Clemson University Baruch Institute

Clemson’s efforts to control beach vitex began in fall 2004. Aquatic herbicides were used due to the sensitive beachfront environment. An oceanfront plot with four herbicides was set up. The herbicide Imazapyr (Habitat) and the hack/squirt method was found to be the most effective at killing beach vitex. In 2008, Clemson was awarded grants totaling $87,000 from US Fish & Wildlife Service, Natural Resources Conservation Service, 2 501 (c) 3 foundations and the Town of Pawleys Island. South Carolina needs another year of funding. In 2008, 178 sites were treated and replanted with native dune vegetation. Some retreatment of beach vitex was necessary. Beach vitex seeds are a problem. They are thought to be viable 3-5 years. There are 31 sites remaining to be treated but most all
known SC sites have been treated. Survey of the southern coast and undeveloped barrier islands will be the focus for 2009. Partnering has worked very well in SC with Clemson and USC working together. Local high schools and Horry Georgetown Technical College are involved in the beach vitex project.

Whetstone spoke about a NOAA grant opportunity that is part of the government’s stimulus package to help create jobs. These ‘shovel ready’ grants are $500,000 to be used in 18 months and are for coastal and marine habitat restoration projects. South Carolina needs one more year of funding of about $100,000 and would not qualify. North Carolina would be a more likely candidate. The application deadline is April 6, 2009.

**Virginia Update** – Lee Rosenberg, City of Norfolk Dept. of Planning & Community Development

A large site of beach vitex was first found in 2008 near Willoughby Spit at Virginia Beach. Rosenberg identified the plant via the Task Force website [www.beachvitex.org](http://www.beachvitex.org) and surmised that it had probably been planted. Rosenberg consulted with Clemson on control methods and treated sites using Habitat and the hack/squirt method in October. Some foliar spraying with dye was also used. Beach vitex now tops Japanese sedge in invasiveness along the VA coast. Although there is no sea turtle nesting in VA, Rosenberg contends that if beach vitex is allowed to grow and spread, it could limit beach access by the public.

There have been several local newspaper articles about beach vitex which serve to educate the public. Rosenberg spoke about the plant on a local radio talk show. His next focus will be to try to have beach vitex listed as a State Noxious Weed. He feels confident that VA will want to be pro-active with the state’s few sites after seeing what has occurred in North and South Carolina. His department is providing property owners with a list of native dune plants.

**Beach Vitex Listing as a North Carolina State Noxious Weed** – David Pearce, NC Dept. of Agriculture

This listing prevents beach vitex from being in the trade industry in NC. Letters have been sent to those in the nursery trade. There has been some resistance by the nurseries which is expected when they are asked to stop selling a species. NCDA inspections by plant pest specialists will begin in April. Coastal counties have been quarantined.

**Beach Vitex Listing Update in South Carolina** – John Brubaker, South Carolina Exotic Pest Plant Council (SC-EPPC)

Dialogue has begun between the CBVTF and the South Carolina Dept. of Agriculture. A letter will be submitted asking the SCDA Commissioner to request the legislature to list beach vitex as a State Noxious Weed. Clemson Dept. of Plant Industry will be involved in the decision.
Beach Vitex Control with Selected Herbicides – Sarah True, NC State University, graduate student

Field and greenhouse studies were conducted from 2006 through 2008 to evaluate the efficacy of selected herbicides and mixtures on beach vitex. In one experiment, beach vitex control at 12 months after treatment was greatest with glyphosate and glyphosate plus imazapyr, with 90 and 94% control respectively. Control with triclopyr mixtures was less than 11% at 12 MAT. In a second experiment, at 8 MAT greatest control was observed with glyphosate and imazapyr (83 and 90%, respectively). Control levels with other treatments were significantly lower. The absorption and translocation of glyphosate in beach vitex was evaluated with cut stem and foliar applications. In beach vitex cut stems, time of harvest was not significant indicating that all absorption and translocation occurred within the first six hours after treatment. The greatest amount of herbicide recovered remained in the stump. A moderate amount translocated to the first root section and a minimal amount translocated to root segments greater distances from the stump. In foliar treatments, the greatest recovered herbicide remained in the treated leaf. Recovered 14C-glyphosate in other plant parts did not differ. Translocation of the applied herbicide was generally low with both application methods.

After a box lunch at the Aquarium, attendees visited nearby Carolina Beach. Here they observed a large oceanfront colony of beach vitex that was spreading onto public Freeman Park and scheduled for treatment this season. The park’s front dunes had been recently replanted with sea oats which are doing a good job of building the dunes. Melanie Doyle presented Lee Rosenberg with an official Carolinas BeachVitex Task Force t-shirt and hat making Virginia a part of the Task Force.
2008 SIGNIFICANT ACCOMPLISHMENTS

Support and Funding
- National Fish & Wildlife Foundation (NFWF) awarded a fifth Pulling Together Initiative Grant to the Carolinas Beach Vitex Task Force for $40,000.
- In SC, the Town of Pawleys Island appropriated $15,000 for beach vitex which was matched with a $45,000 grant from the Natural Resources Conservation Service (NRCS). Additional funding: Bunnelle Foundation ($12,000), US Fish & Wildlife Service ($15,000)
- The NC Task Force began work on their $128,500 NFWF Keystone Grant by surveying much of their coastline for beach vitex, working with beach communities to encourage the passage of ordinances and beginning eradication efforts.

Permits and Policy
- Ordinances banning beach vitex were passed in a number of NC beach communities: Kure Beach, Carolina Beach, Emerald Isle, Oak Island, Surf City, Wrightsville Beach, Southern Shore, the communities of Bogue Banks (Atlantic Beach, Pine Knoll Shores, Salter Path, Indian Beach, Emerald Isle).
- The NC Board of Agriculture listed beach vitex as a Class B State Noxious Weed which bans the sale, transport and possession of beach vitex by nurseries, garden shops and private property owners

Research and Monitoring
- Sea turtle volunteers on NC/SC beaches continued to survey and report locations of beach vitex. Reporting forms were submitted to www.beachvitex.org and added to a geographical data base maintained by North Inlet-Winyah Bay National Estuarine Research Reserve.
- NC Task Force members surveyed many beaches of the coast including: Kure, Carolina, Topsail, N. Topsail, Surf City, Holden, Ocean Isle, Dare County beaches and Cape Hatteras beaches. Many plants were discovered on undeveloped Masonboro Island which shows the need for surveying undeveloped sandy islands. Parts of the northern Outer Banks were surveyed but a thorough, systematic search will be done in 2009.
- Clemson University’s Baruch Institute and SC Task Force members completed surveying for beach vitex all beaches north of Winyah Bay in Georgetown County. Nineteen beach vitex plants were found on remote, undeveloped North Island in Georgetown County exhibiting how easily beach vitex spreads by water.
- Through the Task Force website, the first report of beach vitex in Virginia near Virginia Beach was documented. The site was reported by an official with the City of Norfolk who consulted with Clemson staff for methods of treatment.
- NC/SC Task Force members attended a BASF workshop on Clearcast, an herbicide which could prove effective in beach vitex eradication.

Beach Vitex Removal/Restoration
- Hundreds of seedlings were documented on NC/SC beaches by Task Force volunteers. The Clemson crew was notified to visit sites for treatment and follow up herbicide treatment was completed on those that were beach vitex.
- In NC, under the NFWF Keystone grant, 156 sites of beach vitex were treated. In SC, under grants from
NRCS, Town of Pawleys Island, Donnelley and USFWS, 178 sites on the A & B lists were treated and all sites were replanted with native vegetation.

- In addition to sea oats and bitter panicum, Clemson crews added American beachgrass to replant the dunes after eradication of beach vitex.
- A trial of sweetgrass as part of an NRCS Research Project to determine the most effective variety for the South Carolina coast was planted in limited areas.
- Clemson crews continued to re-survey for re-growth of treated beach vitex. The survey of beaches south of Charleston began.

**Outreach and Education**

- NC/SC Task Force members continued to make presentations and hold workshops in the Carolinas and around the country: garden clubs, festivals, expos, schools, town councils, Weed Science Society of NC, NC Colonial Waterbirds Working Group, NC and SC Sea Turtle Volunteer Workshops, SEWEE Assn. Teachers Workshop, Early Detection Rapid Response Training Workshop (Manitoba, Canada).
- The 5th Beach Vitex Symposium was held March 19 in North Myrtle Beach, SC. The Clemson crew conducted a workshop in treatment methods for beach vitex. Coastal Ecoscapes demonstrated the proper way to plant native vegetation once the dunes have been cleared.
- Beach vitex continued to have excellent media coverage helping to raise public awareness:
  - **Magazines**
    - BASF’s Latitude, NC Sea Grant’s Coastwatch, Clemson Impacts
  - **Television**
    - SCETV’s Making It Grow, Carolina TV Now, WPDE-Myrtle Beach
  - **Newspapers**
    - (NC) Wilmington Star News, Snows Cut Monthly, Lumina News
    - (SC) Coastal Observer, Georgetown Times, Sun News
    - (VA) Virginian-Pilot Newspaper
  - **Video**
    - The beach vitex video produced by the US Fish & Wildlife Service (USFWS) was shown continuously on the New Hanover County (NC) government cable channel.
    - Huntington Beach State Park played the USFWS video in its’ Education Center estimating it was viewed by more than 23,000 visitors.

**Awards**

- The National Fish & Wildlife Foundation presented the Carolinas Beach Vitex Task Force with its Community Spirit Award during a reception during National Invasive Weed Awareness Week (NIWAW).
- The USFWS Southeastern Regional Director’s Conservation Award was given to the SC Beach Vitex Task Force at the annual May awards ceremony in Atlanta, GA.
Vitex eradication effort gains traction

Group tallies past year's accomplishments

By Gareth McGrath
Staff Writer

Published: Friday, March 13, 2009 at 2:18 p.m.
Last Modified: Friday, March 13, 2009 at 2:26 p.m.

Fort Fisher | The invasive plant has been discovered in Virginia and in places in North Carolina thought to be vitex-free.

Kudzu of the coast
NAME: Beach vitex (Vitex rotundifolia). Native to Hawaii and the Pacific Rim.
DESCRIPTION: Round green leaves are 1-2 inches long and have a spicy fragrance. Flowers are bluish-purple.
SIZE: Coastal shrubs can grow up to 12 feet wide and 4 feet tall.
HABITAT: Thrives in full sun, sandy soils and moderate temperatures.
INTRODUCTION: Used as an ornamental plant for years. First used as a beach-stabilization plant in South Carolina in the 1980s. Labeled a 'problem invasive' around 2000.
THREAT: Prolific seed producer and fast grower; crowds out native beach plants; impedes sea turtle and shorebird nesting; doesn't stabilize dunes.
For more information or to report an infestation, go to www.beachvitex.org or call Melanie Doyle at 458-8257, ext. 250.

But that's not necessarily a bad thing, since it shows that the educational and outreach efforts of the Carolinas Beach Vitex Task Force about the menace posed by the foreign invader are working.

It also shows, however, that there's a lot of work to do to eradicate the shrub. It is native to the Pacific Rim and was once viewed as the savior of the coast, but it's turned out to be a huge biological menace.

On Friday members of the task force gathered at the N.C. Aquarium at Fort Fisher to celebrate the past year's successes and discuss the remaining challenges facing the multi-state effort to eradicate beach vitex.

Among the 2008 accomplishments included getting North Carolina to declare beach vitex a noxious weed, making it illegal to be sold or possessed by nurseries or individuals, and securing a $128,000 grant for coastal eradication and educational efforts.
But Melanie Doyle, the state's beach vitex task force coordinator and horticulturist at the aquarium, said there's been an even bigger success over the past year.

"What I'm most proud about is nothing's been mandated by anyone," she said, ticking off the local and voluntary support up and down the coast that the task force has received in promoting eradication efforts. "This has all come about because of people who care."

But with greater awareness of the threat posed by vitex has come the reality of how big the problem is in North Carolina.

"We've got vitex in the northern part of the state," said Dale Suiter, a Raleigh-based biologist with the U.S. Fish and Wildlife Service. "Just a year ago, we didn't know that."

So far there are more than 400 known locations, including worrisome outbreaks along inland waterways that dramatically increases the amount of shoreline to survey.

But task force officials believe they are slowly getting the upper hand.

"We're going to do this," said Doyle to the nearly three-dozen government officials, researchers and environmentalists gathered in the aquarium's auditorium. "It might take a bit longer than we hoped, but we're going to get this plant off our beaches."

Gareth McGrath: 343-2384

gareth.mcgrath@starnewsonline.com
Beach Vitex Eradication Moving Forward

Beach vitex eradication efforts continue up and down the South Carolina coast. One of the areas most recently treated was a site owned and operated by the city of Charleston along Concord Street in downtown Charleston. Landscaping at the city-owned site contained beach vitex (Vitex rotundifolia), a non-native woody vine that was planted along the beaches of North Carolina and South Carolina in the early 1990s for erosion control. As dune restoration experts and sea turtle volunteers took note of these plants spreading uncontrollably along the beaches and crowding out native dune plants like sea oats and the Federally threatened plant, Seabeach Amaranth (Amaranthus pumilus), a volunteer Task Force was formed to address its eradication.

Hal Drotor, a technician with Clemson University in Georgetown, began work on the Concord Street site in October 2008. Since October, Hal has not only treated and cleared this site but has replanted it with native grasses. The Concord Street location was one of the last untreated locations identified in Charleston County. Work will continue up and down the South Carolina coast to monitor for beach vitex regrowth and retreat any areas that are identified.

Formed in 2003, the Carolinas Beach Vitex Task Force is recognized nationally as a model interagency partnership. In February 2008, the Task Force was awarded the National Community Spirit Award by the National Fish and Wildlife Foundation (NFWF). This award was presented to the Task Force at the 9th annual National Invasive Weed Awareness Week in Washington, D.C. In March 2008, the South Carolina project was approved for a fifth and final year of funding through NFWF’s Pulling Together Initiative Grant Program. Other sources of funding have been provided by NFWF’s Savannah-Santee-Pee Dee Ecosystem Restoration Fund, the U.S. Fish and Wildlife Service’s Private Stewardship Grants Program, USDA’s Natural Resources Conservation Service, the Gaylord and Dorothy Donnelley Foundation, and the Town of Pawley’s Island, SC.

Other noteworthy distinctions for the Task Force include an award for Betsy Brabson, the South Carolina Coordinator of the Carolinas Beach Vitex Task Force. In May 2008, Betsy received the U.S. Fish and Wildlife Service’s Southeast Region Regional Director’s Conservation Award for her personal dedication to the project. Betsy has spent an untold number of volunteer hours working to help restore South Carolina’s beaches from this newest invasive species. The U.S. Fish and Wildlife Service owes a huge debt of gratitude to dedicated volunteers like Betsy Brabson.

Thank you for all you’ve done, Betsy!
Beasley’s beach vitex program recognized

by Marimar McNaughton, Lumina News, Wrightsville Beach, NC
Thursday, March 26, 2009

Wrightsville Beach Parks and Recreation parks maintenance supervisor Billy Beasley earned bragging rights at a recent beach vitex conference held earlier this month at the North Carolina Aquarium at Fort Fisher when Melanie Doles, aquarium horticulturist, who is also the state’s vitex coordinator, suggested Beasley’s eradication program as a model for others to follow.

Last year, he identified 52 sites in Wrightsville Beach that were affected by the invasive plant species and noxious weed.

“We think we got 100 percent of the sites,” Beasley said, “and that’s way ahead of anywhere else that has any kind of infestation. We treated all that we had identified.”

With colleagues from coastal communities representing North and South Carolina, the group visited one site at the north end of Carolina Beach.

Beasley said he would not know until the weather warmed up significantly how successful his treatment program will be. Funded by a $15,000 grant from U.S. Fish and Wildlife, he applied a non-toxic herbicide to each site. Once he inspects the treated areas, to make sure there are no traces of the beach vitex, Beasley will eventually replant the areas with sea oats but not until early fall. In some cases he may just fertilize to encourage native plants to return to the landscape.

He cautioned homeowners, “If it’s on private property, don’t cut it out just yet. Give it a little bit longer.”
Beach Dune Sand Hydrophobicity Due to the Presence of Beach Vitex (Vitex rotundifolia L. f.)

MATTHEW M. COUSINS, § CHARLES A. GRESHAM, § MELISSA B. RILEY, * # and TED WHITWELL. †

Department of Horticulture, Department of Forestry and Natural Resources, and Department of Entomology, Soils, and Plant Sciences, Clemson University, Clemson, South Carolina 29634

Conservation and preservation concerns have led to efforts to understand mechanisms of invasiveness and the effects these mechanisms have on the environment. Vitex rotundifolia L. f. [beach vitex (BV)] was introduced as a salt-tolerant woody ground cover, but it has since become invasive on primary and secondary dunes in coastal areas of the southeastern United States. Much of its invasive potential may be the result of intense substrate hydrophobicity underneath established stands, which is believed to prohibit seedling establishment by other plants including native plant species. This research was conducted to better understand BV-induced sand hydrophobicity by carrying out dune surveys of BV-infested areas of the South Carolina coast, identifying the compounds responsible for this activity via chemical analysis, and quantifying hydrophobicity persistence by resampling sites following removal of above-ground BV. The findings indicated that sand under BV cover was significantly hydrophobic, that cuticular alkanes from leaves and fruits were responsible for this hydrophobicity, and that extreme substrate hydrophobicity persisted for >3 years following BV removal.

KEYWORDS: Invasive; alkane; cuticle; secondary metabolites

INTRODUCTION

In recent times, environmental concerns have led to the search for increased knowledge about the spread of invasive plants that were introduced as a result of agricultural or horticultural efforts. Researchers have conducted investigations to understand why these plants are invasive to better understand the ecology and interconnected nature of various plant traits, which were not taken into account prior to the introduction of the non-invasive plant. Better understanding of the ecology may also facilitate more efficient management of this invasive plant. This research sought to better understand the cause of beach vitex (BV) (Vitex rotundifolia L. f.) invasiveness through an investigation of a previously uncharacterized trait—creation of soil hydrophobicity.

BV was introduced to the Carolina coast of the United States around 1985. It is native to the southwestern Pacific and is found in coastal areas of both islands and continents (1, 2). It was transplanted with the hope that its attractive flowers and foliage, salt tolerance, and low-growing habit would allow it to become a widely planted, aesthetically pleasing landscape plant that would also help maintain dune integrity. Unfortunately, this tenaciously spreading shrub has since become a large-scale invasive plant problem. BV dominates primary dune areas and excludes native species (3). In places where BV is present in coastal areas of South and North Carolina, it has created large monocultures by shading out native species (4). Additional ecological concerns include the belief that BV can impede nesting activities of endangered and federally protected sea turtles (3).

Many mechanisms may be responsible for BV invasiveness. These traits include vegetative reproduction, rapid lateral growth, large seed production (3), and secondary metabolite production. The extensive, deep (up to 60 cm) root system and lateral growth capabilities are also important characteristics that allow large, intact plants to survive in the hydrophobic substrates they create.

This work focuses on secondary metabolites as a mechanism for helping the plant become invasive. BV fruits and leaves contain many complex metabolites that assist in its survival in the harsh beach dune environment. These compounds include an insect repellent (5) and thick layers of cuticular compounds to prevent dehydration. As a result, many studies relating to secondary metabolites of the fruits and their medicinal qualities have been conducted. Compounds discovered include various diterpenes (6–8) and flavonoids (9–11). BV has been noted as having thick coatings on leaves and fruits that appear to repel water. In fruits, this coating likely aides in water-based dispersal via ocean currents. This dispersal mechanism is responsible for the plant’s pervasiveness throughout the Pacific. BV is present on many volcanic islands, including some that have existed for only a short time (12). The absence of a nourishing, fleshy fruit coating suggests that BV is not bird dispersed. Because BV is
incapable of bird dispersal, it must employ a water-based dispersal mechanism in order to spread from island to island.

Hydrophobic soils have been documented in many areas of the world including beach dunes (13), areas subject to frequent fire (14), forests (15), and desert scrub communities (16). Hydrophobic soils were recently identified in the presence of BV (3).

The objectives of this study were to (1) characterize multiple sites in South Carolina to confirm the presence of substrate hydrophobicity under multiple stands of BV and the absence of hydrophobicity in areas not infested with BV, (2) understand the variation in hydrophobicity with soil depth, (3) identify the compounds responsible for substrate hydrophobicity, and (4) ascertain the length of time this activity persists in the dune environment following vegetation removal.

MATERIALS AND METHODS

Hydrophobic Soil Field Study. A composite sample of surface (0–5 cm deep) soil was taken from two or more locations under BV cover and under native dune vegetation cover (control sites) at 9 sites in June 2005, 14 sites in June 2005, and 8 sites in 2006. Samples from locations under BV cover were all taken within 10 cm of BV stems. Several sites had only one cover type. BV cover and native cover sites were the same except for the kind of vegetation present. There were no observable differences in topography, proximity to the surf, sun exposure, or substrate characteristics. A single site composite sample served as an experimental unit. The 2004 samples were air-dried, and the time for a 50 g subsample to absorb a drop (200 µL) of water [water drop penetration time (WDPT)] was recorded. The 2005 and 2006 samples were air-dried and sieved through a 1.1 mm mesh sieve, and a 30 g subsample was placed in the bottom half of a plastic Petri plate. A drop of distilled water (50 µL) was released from a glass Pasteur pipet held 1 cm above the sand surface. Timing began when the drop fell from the pipet and was stopped when the drop was absorbed into the sand (18). Three drops were timed for each Petri plate, and the mean time was calculated for that sample. Timing was stopped at 120 s if the water drops were not absorbed by that time. Timing stopped at 120 s because the authors’ observations over the course of 3 h indicated that drops not absorbed by 120 s typically evaporated prior to absorption.

Hydrophobic Tests of Subsurface Soil. During June 2005, soil cores were collected from BV-infested dunes and control dune areas of 13 beachfront sites. Cores were collected using a 1.5 m steel pipe (9.9 cm inner diameter, 1.7 mm wall) with one end sharpened to an inward bevel and with a thick collar welded to the outside of the other end. The pipe was driven 15 cm into the sand before being pivoted to a nearly horizontal orientation and carefully removed from the sand. A specially designed plunger was used to push the collected soil out through the sharpened end into a labeled bag. The pipe was reinserted in the hole and another 15 cm core was extracted and bagged separately. Finally, the pipe was again reinserted and driven (with a sledger hammer hitting a board on top of the steel collar) 30 cm deeper to a depth of 60 cm from the surface, and the 30 cm core was extracted and bagged. Two such cores were taken among the BV, and two cores were taken from the control dunes at each site. The soil was returned to the laboratory, and the root material was carefully removed from each sample. A subsample of the remaining soil was air-dried and sieved through a 1.1 mm mesh sieve before undergoing a test for WDPT as described above.

Chemical Identification of Compounds Causing Sand Hydrophobicity. Both the authors’ observations of plant organs and the findings of other researchers with regard to the diverse compounds present in BV suggested that the compounds responsible for sand hydrophobicity would be present on the surfaces of BV leaves and fruits.

An initial extraction solvent selection experiment was conducted at the beginning of the chemical identification phase of the research. Twenty-four glass screw-cap test tubes (25 x 150 mm) with Teflon-lined caps were filled with 100 fruits each. Six of the tubes were extracted with 20 mL of each of the following solvents: acetone, hexane, chloroform, or ethyl ether. The tubes were tumbled for 1 h. Twelve glass Petri plate bottoms were prepared with 25 g of nonhydrophobic beach sand. The extract from two tubes with the same solvent was applied to each Petri plate to give three plates from each solvent extraction method. Solvents were allowed to evaporate under a fume hood overnight. WDPT was determined the following day.

Analysis began with sand extraction and preparation for fractionation. Hydrophobic sand and nonhydrophobic sand (collected from Pawley’s Island, SC) in 600 g aliquots were extracted with 600 mL of chloroform each by placing the sand in glass columns and pouring chloroform through the sand matrix. The resulting sand extracts were concentrated to 10 mL using a Buchi rotavapor flash evaporator (Buchi Laboratory Equipment, New Castle, DE) and then further concentrated to 5 mL under a stream of industrial N₂ gas (Airgas Inc., Radnor, PA). BV fruits were surface extracted in chloroform. Four large (25 x 150 mm) glass screw-top test tubes with Teflon caps containing 100 fruits and 20 mL of chloroform each were laid horizontally on an Innova 2100 orbital shaker (90 rpm) for 1 h (New Brunswick Scientific Co., Inc., Edison, NJ). The resulting extract was gravity filtered twice using a Buchner funnel and filter paper (Whatman no. 1). The extract was concentrated to 5 mL under a N₂ gas stream. Similarly, four large screw top test tubes containing 20 fresh green leaves (bisected along the petiole) and 10 mL of chloroform each were tumbled end over end for 1 h. The resulting extract was concentrated to 1 mL under a N₂ gas stream prior to fractionation on TLC plates.

Fruit, leaf, and sand extracts (220 µL) were applied in a line across the absorbent strip at the base of a 5 x 20 cm, 250 µm silica gel plate (Whatman, Clifton, NJ). Hydrophobic bands were located by drying distilled deionized H₂O down the plate until it encountered the hydrophobic band. A multitude of solvent systems were investigated for separation of hydrophobic compounds from other materials present in the extracts. The mobile phase selected for use in compound separation was an 80:20 methanol/chloroform solvent system that was made in lots of 100 mL and acidified with 50 µL of 1.0 M HCl. The hydrophobic band remained at the plate origin, but other compounds moved from the origin, resulting in good separation. After development, plates were allowed to air-dry under the hood for a period of approximately 20 min before being dried over Drierite (W. A. Hammond Drierite Co., Xenia, OH) for a period of 2 h. The hydrophobic band was then scraped from the plate using a scalpel. The silica was suspended in 5 mL of chloroform in 15 mL conical vials and sonicated for 10 min. The silica was then allowed to settle for 10 min before the sample was filtered through a Pasteur pipet containing glass wool to remove the silica particles. The resulting extract was concentrated to 1 mL under a N₂ gas stream. A glass conical vial containing a 100 µL aliquot of each sample was utilized for GC-MS analysis. A 5 µL sample was injected and analyzed according to the method in the following paragraph.

Samples were run on a (Hewlett-Packard 5890 gas chromatograph with Hewlett-Packard 5971A mass selective detector) GC-MS (Agilent Technologies, Wilmington, DE). The column was a DB-5MS (30 m x 0.25 mm x 0.25 µm film, Agilent Technologies). The carrier flow rate (high-grade helium, 99.997%, Airgas Inc.) was 0.8 mL/min. The initial oven temperature of 60 °C was held for 12 min after injection and then increased at a rate of 12 °C/min to a final temperature of 300 °C, which was held for 12 min, for a total run time of 42.5 min. The split/splitless injector was maintained at 250 °C with a 50:1 split, and the mass transfer line was at 300 °C. The mass selective detector was run in electron impact mode and was turned on at 3.5 min, and fragment masses and abundances between 50 and 500 were tabulated. Two alkane standards (C5-C14, Supelco; and C12-C20, Fluka) were compared to sample compounds. A combination of retention times from total ion chromatograms and mass spectra were used to establish compound identity. A 1:10 (4 µg/mL) dilution of the C12-C20 alkane standard was injected into the GC-MS and used for comparison and quantification.

The alkane standards were also tested for their ability to induce hydrophobicity in sand. The n-alkane standard (Supelco, Bellfonte, PA) containing C5, C6, C7, C8, C9, C10, C11, C12, C14, C15, C16, C17, C18, C20,
Table 1. Water Drop Penetration Time (WDPT) of Surface (0–5 cm Depth) Sand from South Carolina Beach Dunes Collected in Three Consecutive Years

<table>
<thead>
<tr>
<th></th>
<th>June 2004</th>
<th>June 2005</th>
<th>June 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>BV cover</td>
<td>native cover</td>
<td>BV cover</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clemmons</td>
<td>0.1</td>
<td>0.1</td>
<td>17.5</td>
</tr>
<tr>
<td>Hughes/Perrin</td>
<td>7.7</td>
<td>0.2</td>
<td>120.0</td>
</tr>
<tr>
<td>Iby</td>
<td>114.4</td>
<td>0.2</td>
<td>120.0</td>
</tr>
<tr>
<td>King</td>
<td>0.1</td>
<td>0.4</td>
<td>4.3</td>
</tr>
<tr>
<td>Long</td>
<td>0.1</td>
<td>0.4</td>
<td>10.6</td>
</tr>
<tr>
<td>Miller</td>
<td>12.2</td>
<td>0.2</td>
<td>39.7</td>
</tr>
<tr>
<td>Pop's Rainey</td>
<td>120</td>
<td>0.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Richmond</td>
<td>120</td>
<td>0.1</td>
<td>21.7</td>
</tr>
<tr>
<td>Robinson</td>
<td>3.8</td>
<td>0.2</td>
<td>120.0</td>
</tr>
<tr>
<td>Schultz</td>
<td>120</td>
<td>0.1</td>
<td>120.0</td>
</tr>
<tr>
<td>Smith</td>
<td>30.3</td>
<td>0.2</td>
<td>2.7</td>
</tr>
<tr>
<td>Sturgis</td>
<td>120</td>
<td>0.1</td>
<td>120.0</td>
</tr>
<tr>
<td>Summer Academy</td>
<td>120</td>
<td>1.0</td>
<td>120.0</td>
</tr>
<tr>
<td>Williams</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>mean</td>
<td>66.71</td>
<td>0.21</td>
<td>41.70</td>
</tr>
<tr>
<td>standard error</td>
<td>21.06</td>
<td>0.11</td>
<td>13.67</td>
</tr>
</tbody>
</table>

Values presented are averages (n = 3). Samples tested in 2004 were classified as either <0.10 s or ≥120 s. Values are significantly different from control cover mean within year, where α = 0.05 as determined by an unequal variance t test.

C23, C26, C30, C36, C40, and C44 was diluted 1:10, 1:100, and 1:1000 in chloroform, and 200 μL aliquots of standard dilutions were applied to 0.25 g of sand in BPI dishes.

Longevity of Hydrophobicity Study. In 2008, all sites were resampled in a manner similar to the sampling conducted in the hydrophobic soil field study experiment. In many cases, this sampling was conducted after the BV had been killed using herbicides and the soil resampled in a manner similar to the sampling conducted in the summer of 2004. Samples collected in 2005 and 2006. Locations at sites that had never been under BV cover served as controls for comparison of sites to each other.

Statistical Analysis. Statistical comparisons for activity characterization and longevity listed at the ends of Tables 1 and 4 were calculated using an unequal variance t test. This test was selected because the variance of the native cover site WDPTs was different from the variance of the BV cover site WDPTs. Additionally, this test is more robust than Student’s t test or an ANOVA, allowing for statistical validity despite the fact that data set variation assumptions are skewed slightly by the large number of 0.1 and 120 s data values. Statistical comparisons for tests of subsurface soil listed at the end of Table 2 were conducted using ANOVA and linear contrasts. Statistical analyses were conducted using SAS version 9.1 (SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

Hydrophobic Soil Field Study. Five of the nine sites sampled under BV cover in 2004 demonstrated extreme hydrophobicity (WDPT > 120 s), whereas the other four exhibited no hydrophobicity (WDPT < 1 s) (Table 1; Figure 1). Only one of the nine samples taken in 2004 from control dunes without BV was weakly hydrophobic (WDPT = 1–30 s). In the more carefully measured 2005 and 2006 samples, all but one of the BV cover samples showed some level of hydrophobicity: 9 of 26 samples were extremely hydrophobic, 6 samples were moderately hydrophobic (WDPT = 30–120 s), and 10 samples were weakly hydrophobic. All but one of the control dune samples was not hydrophobic: 19 of 20 samples were not hydrophobic, with 1 sample being weakly hydrophobic. In all cases for the more carefully measured data (2005 and 2006), the hydrophobicity was much stronger in BV-infested areas than in nearby control areas (i.e., in the only hydrophobic control dune site, the WDPT was 11.3 s, whereas the corresponding BV-covered dune at the same location had a WDPT of >120 s).

BV had been present on most of the sites that were sampled since 1990 or 1991. It was widely planted as an erosion preventative in the aftermath of Hurricane Hugo (landfall in September 1989). As a result, it had been present at most of the sites for approximately 15 years, and its presence resulted in substrate hydrophobicity that is both intense and pervasive.

Chemical creation of substrate hydrophobicity would be an effective defensive mechanism against competition. Seedling establishment would be prohibited because the upper soil layers would not contain water in sufficient quantities to allow seedlings to survive. Running vegetatively reproducing plants (such as BV) with large root systems would be favored in such conditions. Adams et al. (16) reported a similar phenomenon for desert shrub vegetation in southern California. Hydrophobic layers were found in soils beneath hummocks of desert vegetation but not in soils where hummocks were absent.

Hydrophobic Tests of Subsurface Soil. The results of the WDPT tests are summarized in Table 2. Only 1 of 10 control (native cover) sites demonstrated weak hydrophobicity in the surface layer. None of the control sites were hydrophobic at a depth of 0–5 cm, whereas the other four exhibited no hydrophobicity (WDPT < 120 s). In the more carefully measured 2005 and 2006 samples, all but one of the BV cover samples showed some level of hydrophobicity: 9 of 26 samples were extremely hydrophobic, 6 samples were moderately hydrophobic (WDPT = 30–120 s), and 10 samples were weakly hydrophobic. All but one of the control dune samples was not hydrophobic: 19 of 20 samples were not hydrophobic, with 1 sample being weakly hydrophobic. In all cases for the more carefully measured data (2005 and 2006), the hydrophobicity was much stronger in BV-infested areas than in nearby control areas (i.e., in the only hydrophobic control dune site, the WDPT was 11.3 s, whereas the corresponding BV-covered dune at the same location had a WDPT of >120 s).

Table 2. Water Drop Penetration Time (WDPT) of Beach Sand from South Carolina Beach Dunes at Three Depth Ranges (0–15, 15–30, and 30–60 cm) at 13 Sites

<table>
<thead>
<tr>
<th></th>
<th>BV cover</th>
<th>native cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>0–15 cm</td>
<td>15–30 cm</td>
</tr>
<tr>
<td></td>
<td>0–15 cm</td>
<td>15–30 cm</td>
</tr>
<tr>
<td>Clemmons</td>
<td>76.04</td>
<td>37.36</td>
</tr>
<tr>
<td>Hughes</td>
<td>4.90</td>
<td>1.14</td>
</tr>
<tr>
<td>Iby</td>
<td>4.25</td>
<td>0.21</td>
</tr>
<tr>
<td>King</td>
<td>0.20</td>
<td>0.16</td>
</tr>
<tr>
<td>Long</td>
<td>0.15</td>
<td>0.19</td>
</tr>
<tr>
<td>Miller</td>
<td>0.20</td>
<td>0.17</td>
</tr>
<tr>
<td>Perrin</td>
<td>0.16</td>
<td>0.18</td>
</tr>
<tr>
<td>Robinson</td>
<td>1.88</td>
<td>0.24</td>
</tr>
<tr>
<td>Schultz</td>
<td>120</td>
<td>15.27</td>
</tr>
<tr>
<td>Smith</td>
<td>1.68</td>
<td>0.16</td>
</tr>
<tr>
<td>Sturgis</td>
<td>45.15</td>
<td>0.17</td>
</tr>
<tr>
<td>Summer Academy</td>
<td>62.66</td>
<td>18.93</td>
</tr>
<tr>
<td>Williams</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>mean</td>
<td>26.44</td>
<td>6.18</td>
</tr>
<tr>
<td>standard error</td>
<td>11.61</td>
<td>3.41</td>
</tr>
</tbody>
</table>

Values presented are averages (n = 6). Value is significantly different from all other depth × cover means, where α = 0.05 as determined by ANOVA.

Figure 1. Water droplets placed on hydrophobic (left) and nonhydrophobic (right) sands. Note rounded drop on hydrophobic sand compared to completely absorbed water on nonhydrophobic sand [video showing water droplet on nonhydrophobic sand located at http://www.northinlet.sc.edu/resource/vitex_files/aug05/Hydro1.wmv (Charles A. Gresham)].
depth of 15–30 or 30–60 cm. With regard to surface layer hydrophobicity at the BV sites, 1 of the 12 sites was extremely hydrophobic, 3 sites were moderately hydrophobic, 4 sites demonstrated weak hydrophobicity, and 4 sites were not hydrophobic. The hydrophobicity decreased with depth at the hydrophobic locations. In fact, only 4 of the BV sites were weakly hydrophobic at the 15–30 cm depth layer, and none of the sites were hydrophobic 30–60 cm below the dune surface. An ANOVA indicated that there was a highly significant cover effect (mean WDPT for BV cover over all depths and sites was 14.24 s, whereas the mean WDPT was 0.35 s for control soil at all depths and sites). A significant depth effect was also noted in the BV cover areas as part of the significant depth by cover interaction. The mean WDPT for the 0–15 cm depth was 26.44 s, whereas the mean WDPT values for the 15–30 and 30–60 cm depths were 6.18 and 0.19 s, respectively. The mean WDPT for the 0–15 cm depth under BV was much lower than the WDPTs of surface soil samples (0–5 cm, Table 1) at the same sites. This indicates that the compounds responsible for the hydrophobic response were present in the highest concentrations in the first few centimeters of the soil surface. Some hydrophobic effect was seen at deeper depths, but the effect was less intense.

**Chemical Identification of Compounds Causing Substrate Hydrophobicity.** Chloroform was found to be the best solvent for the extraction of compounds causing hydrophobicity. In all tests, chloroform extracts of BV fruits caused nonhydrophobic sands to hold drops of water for an excess of 120 s, whereas nonhydrophobic sands treated with hexane, acetone, and ethyl ether extracts held drops of water for averages of 2.9 s (standard deviation = 1.7), 15.0 s (standard deviation = 28.7), and 23.5 s (standard deviation = 22.3), respectively. As a result, chloroform was selected as the extraction solvent for use in the remainder of the extraction and purification studies.

Initial GC-MS examination of complete extracts from hydrophobic and nonhydrophobic sands demonstrated complex metabolite profiles in the hydrophobic sand that contrasted significantly with the small number of compounds detected in nonhydrophobic sand. Fractionation was required to identify compounds responsible for substrate hydrophobicity.

Extracts of fruits were found to produce areas of hydrophobicity on silica TLC plates. TLC separation and hydrophobic band detection method development was employed so that simplified total ion chromatograms with fewer peaks could be obtained. Hydrophobic sand extracts, fruit extracts, and leaf extracts behaved similarly on TLC plates in response to various mobile phases with regard to how the hydrophobic bands migrated. Movement and solubility of compounds causing hydrophobicity matched solubilities of compounds found in cuticular alkanes and lipids of plants previously examined (19). Due to difficulty moving the hydrophobic compounds from the origin without dispersing them widely across the plate, a solvent system was selected that retained the hydrophobic band at the origin while moving other compounds that were seen visually and through exposure of plates to short- and long-wave UV light ranges away from the origin.

GC-MS total ion chromatograms of fractionated extracts (Figure 2) indicated that GC retention time and MS fragmentation patterns of compounds found in TLC-fractionated extracts of BV leaves and fruits matched chromatograms and spectra of compounds from similarly prepared hydrophobic sand extracts. The compounds of interest were not found in nonhydrophobic sand extracts or solvent controls. MS library comparison identified peaks of interest as alkanes. This was confirmed through inspection of MS data and comparison with alkane standards. Comparisons were conducted using the base peak, the mass ion, and eight additional major fragments based on fragment size and frequency in relation to the base peak. Alkane standards produced MS spectra that were nearly identical to the spectra of the peaks of interest. All samples had base peaks at 57. Mass ions and percentages of base peaks are presented in the following paragraphs in brackets and parentheses.

The two lightest alkanes in the C_{21}–C_{44} alkane standard were observed only in the standard: C_{21} [296 (0.9)] and C_{32} [310 (0.7)]. The next six alkanes (C_{33}–C_{38}) were identified in the alkane standard and in hydrophobic sand only and were C_{35}−standard [324 (0.7)], hydrophobic sand [324 (0.4)]; C_{34}−standard [338 (0.8)], hydrophobic sand [338 (0.7)]; C_{35}−standard [352 (0.8)], hydrophobic sand [352 (0.9)]; C_{26}−standard [366 (0.8)], hydrophobic sand [366 (0.8)]; C_{27}−standard [380 (0.7)], hydrophobic sand [380 (0.7)]; and C_{28}−standard [394 (0.7)], hydrophobic sand [394 (0.8)]. The next nine alkanes (C_{29}–C_{37}) were identified in the alkane standard, hydrophobic sand, fruit extract, and leaf extract and were C_{29}−standard [408 (0.6)], hydrophobic sand [408 (0.6)], fruit extract [408 (0.7)], leaf extract [408 (0.7)]; C_{30}−standard [422 (0.5)], hydrophobic sand [422 (0.7)], fruit extract [422 (0.5)], leaf extract [422 (0.4)]; C_{31}−standard [436 (0.5)], hydrophobic sand [436 (0.6)], fruit extract [436 (0.2)], leaf extract [436 (0.2)]; C_{32}−standard [450 (0.5)], hydrophobic sand [450 (0.5)], fruit extract [450 (0.6)], leaf extract [450 (0.7)]; C_{33}−standard [464 (0.4)], hydrophobic sand [464 (0.6)], fruit extract [464 (0.1)], leaf extract [464 (n.d.)]; C_{34}−standard [478 (0.3)], hydrophobic sand [478 (0.5)], leaf extract [478 (0.5)], leaf extract [478 (0.6)]; C_{35}−standard [492 (0.4)], hydrophobic sand [492 (0.5)], fruit extract [492 (0.5)], leaf extract [0.02]; C_{36}−standard [506 (nd)], hydrophobic sand [506 (nd)], fruit extract [506 (nd)], leaf extract [506 (nd)]; and C_{37}−standard [520 (nd)], hydrophobic sand [520 (nd)], fruit extract [520 (nd)], leaf extract [520 (nd)].

A summary of alkanes found in hydrophobic sand, fruit, and leaf samples can be found in Table 3. Following identification of compounds, the alkane concentrations were determined for the nonhydrophobic and hydrophobic sand as well as the fruit and leaf extracts. Leaves contained more cuticular alkanes per gram of tissue than fruits (>10 times more in some cases). This may be partially explained by the fact that leaves have a much greater surface area to mass ratio than fruits.

In the hydrophobic sand, the average content of the alkanes numbered C_{21}–C_{37} was 0.477 µg/g of sand. Fruits produced an average of 0.212 µg of each alkane numbered C_{29}–C_{37} per gram of fresh weight, whereas leaves produced an average of 4.907 µg of each alkane numbered C_{29}–C_{37} per gram of fresh weight. When calculations were conducted on a per fruit or per leaf basis, average production of alkanes C_{29}–C_{37} was 4.424 µg/fruit and 12.116 µg/leaf. Each fruit produces enough alkanes to make more than 10 g of sand hydrophobic, whereas each leaf produces enough alkanes to make >30 g of sand hydrophobic. It is unlikely that this level of efficacy would be achieved in nature because alkane transfer would occur through physical interaction of fruit, leaf, and sand surfaces and not through solvent extraction, which is a more efficient process.

Some alkanes (C_{21}–C_{28}) were found in the hydrophobic sand but not in the fruit or leaf extract samples. These compounds are likely degradation products of the other longer n-alkane chains that are produced on the surfaces of BV leaves and fruits. Beach sands are subjected to massive amounts of heat from the sun. Other researchers have noted that high temperatures
can cause a reduction in chain length of alkane chains, resulting in an increase in shorter alkane soil content (20). Biological degradation is unlikely to have been responsible for the presence of shorter alkanes because most microbes do not break down alkanes of this length, and major breakdown products would be fatty acids (21). Because no alkanes were found in the nonhydrophobic sand samples, the alkanes identified in the hydrophobic sand are the result of BV presence. Stems and roots were not investigated in this experiment. Stems were not investigated because they are responsible for a small portion of the total plant material surface area on the dune. Roots were not investigated because the majority of the hydrophobicity was found in the surface layer of the sand (a layer that contains few roots). Additionally, alkanes C_{31}, C_{33}, C_{35}, and C_{37} were the most abundant alkanes in hydrophobic sand under BV vegetation. These four compounds were also the most prevalent in the leaves and fruits.

As a confirmation that the compounds identified in the GC-MS total ion chromatogram were indeed those responsible for sand hydrophobicity, extracts were added to nonhydrophobic sand and evaporated to dryness. Fractionated hydrophobic sand extracts, leaf extracts, and fruit extracts were shown to induce significant hydrophobicity in nonhydrophobic sand. A 200 µL aliquot of a solution containing 0.4 µg/mL each of C_{21}–C_{40} caused weak hydrophobicity in 0.25 g of previously nonhydrophobic sand. This equates to 0.32 µg of each alkane/g of sand as opposed to an average of 0.477 µg/g present in natural hydrophobic sand. An alkane standard (Supelco C_5–C_{40}) was also used to successfully create hydrophobic sand in the laboratory setting. The 1:10 dilution (Supelco C_5–C_{40}) (880 µg of alkane/g of sand) failed to evaporate and dry on the sand, whereas higher dilutions did evaporate, allowing WDPT determination. Sand treated with a 1:100 dilution (88 µg of alkane/g of sand) had a WDPT of 3 min, whereas sand treated with a 1:1000 dilution (8.8 µg of alkane/g of sand) had a WDPT of approximately 10 s. Control sand held a drop for <1 s. Because two-thirds of the alkanes contained in the standard were shorter chains (chains that would cause less substrate hydrophobicity), these values support the total alkane values from Table 3.
alkanes ranging from C\textsubscript{37} to C\textsubscript{41}.

Table 3. Quantification and Identification of Alkanes in Various BV-Associated Extracts\textsuperscript{a}

<table>
<thead>
<tr>
<th>carbon no.</th>
<th>RT\textsuperscript{b} (approx)</th>
<th>hydrophobic</th>
<th>nonhydrophobic</th>
<th>fruits</th>
<th>leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>17.8</td>
<td>nd\textsuperscript{d}</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>22</td>
<td>18.6</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>23</td>
<td>19.4</td>
<td>0.057</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>24</td>
<td>20.1</td>
<td>0.172</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>25</td>
<td>20.8</td>
<td>0.304</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>26</td>
<td>21.5</td>
<td>0.348</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>27</td>
<td>22.2</td>
<td>0.380</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>28</td>
<td>22.9</td>
<td>0.358</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
</tr>
<tr>
<td>29</td>
<td>23.6</td>
<td>0.352</td>
<td>nd</td>
<td>0.028</td>
<td>0.123</td>
</tr>
<tr>
<td>30</td>
<td>24.5</td>
<td>0.309</td>
<td>nd</td>
<td>0.015</td>
<td>0.030</td>
</tr>
<tr>
<td>31</td>
<td>25.6</td>
<td>0.423</td>
<td>nd</td>
<td>0.382</td>
<td>2.225</td>
</tr>
<tr>
<td>32</td>
<td>26.7</td>
<td>0.232</td>
<td>nd</td>
<td>0.057</td>
<td>0.180</td>
</tr>
<tr>
<td>33</td>
<td>28.3</td>
<td>0.825</td>
<td>nd</td>
<td>0.649</td>
<td>7.148</td>
</tr>
<tr>
<td>34</td>
<td>29.8</td>
<td>0.184</td>
<td>nd</td>
<td>0.043</td>
<td>0.519</td>
</tr>
<tr>
<td>35</td>
<td>31.8</td>
<td>1.775</td>
<td>nd</td>
<td>0.524</td>
<td>22.545</td>
</tr>
<tr>
<td>36</td>
<td>34.4</td>
<td>0.194</td>
<td>nd</td>
<td>0.028</td>
<td>1.205</td>
</tr>
<tr>
<td>37</td>
<td>37.5</td>
<td>1.240</td>
<td>nd</td>
<td>0.185</td>
<td>10.188</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td></td>
<td>nd</td>
<td>1.911</td>
<td>44.163</td>
</tr>
</tbody>
</table>

\textsuperscript{a}There was no correction for percent recovery. \textsuperscript{b}Retention time of GC column. \textsuperscript{c}Retention time of GC column; retention time of GC column; \textsuperscript{d}nd, none detected.

The results show that the compounds responsible for sand hydrophobicity near areas infested with BV are long-chain alkanes ranging from C\textsubscript{37} to C\textsubscript{41}. These results are supported by those of Horn and McIntosh (22), who found that alkanes were responsible for causing beach sand hydrophobicity in New Zealand; however, they did not link this hydrophobicity to the presence of specific plants. These compounds are produced by BV and accumulate in the cuticles of BV fruits and leaves. As leaves and fruits drop into the substrate, these surface wax components are deposited in the soil matrix. This deposition is likely aided by heating as a result of direct solar exposure and physical contact with sand particles. Over time, a buildup of these compounds in the substrate yields the hydrophobicity observed in the presence of BV. Substrate hydrophobicity likely plays an important ecological role as it helps maintain BV monocultures by preventing seedling establishment and slowing ecosystem recovery following removal of this highly invasive exotic shrub.

Longevity of Hydrophobicity Study. Resampling and analysis of sites in 2008 (Table 4) demonstrated that the sand hydrophobicity persisted in the substrate long after the removal of BV from the area. Results at some sites showed that areas where BV had been absent for two to three seasons maintained extremely hydrophobic substrates. The fact that some sites exhibited lower hydrophobicity than others is likely the result of variation in the amount of vegetation that covered each individual site prior to vegetation removal.

These findings indicate that substrate hydrophobicity induced by BV has a negative impact on the fragile dune environment that persists long after this exotic invasive plant has been eradicated (more than three seasons following vegetation removal). As a result, plants that are more able to survive in this hydrophobic substrate should be considered for planting as part of site revegetation efforts. The introduction of container-grown plants as an alternative to broadcasting seeds might yield greater success. Dune hydrophobicity would be more likely to negatively affect small seedlings than larger plants. We are currently investigating methods for remediation of substrate hydrophobicity so that dune community recovery might be accelerated.

ABBREVIATIONS USED

BV, beach vitex (Vitex rotundifolia); GC, gas chromatograph; MS, mass spectrometer; TLC, thin layer chromatography; WDPT, water drop penetration time; WDPT > 120 s, extremely hydrophobic; WDPT = 30–119 s, moderately hydrophobic; WDPT = 1–30 s, weakly hydrophobic; WDPT < 1 s, not hydrophobic.

Table 4. Water Drop Penetration Time (WDPT) for Site Resampling Conducted in June 2008\textsuperscript{a}

<table>
<thead>
<tr>
<th>site</th>
<th>BV cover</th>
<th>native cover (control)</th>
<th>vegetation removal date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clemmons</td>
<td>0.1</td>
<td>0.1</td>
<td>June 2005</td>
</tr>
<tr>
<td>Hughes</td>
<td>120</td>
<td>0.1</td>
<td>Sep 2005</td>
</tr>
<tr>
<td>Irby</td>
<td>108</td>
<td>0.1</td>
<td>March 2007</td>
</tr>
<tr>
<td>Long</td>
<td>2.0</td>
<td>0.2</td>
<td>June 2007</td>
</tr>
<tr>
<td>Miller</td>
<td>120</td>
<td>0.1</td>
<td>still vegetated</td>
</tr>
<tr>
<td>Pop's</td>
<td>120</td>
<td>0.3</td>
<td>April 2007</td>
</tr>
<tr>
<td>Rainey</td>
<td>120</td>
<td>0.1</td>
<td>June 2006</td>
</tr>
<tr>
<td>Richmond</td>
<td>1.0</td>
<td>0.1</td>
<td>Nov 2005</td>
</tr>
<tr>
<td>Robinson</td>
<td>3.1</td>
<td>0.1</td>
<td>aug 2007</td>
</tr>
<tr>
<td>Smith</td>
<td>58.8</td>
<td>0.1</td>
<td>March 2007</td>
</tr>
<tr>
<td>Sturigis</td>
<td>5.2</td>
<td>0.1</td>
<td>still vegetated</td>
</tr>
<tr>
<td>Summer Academy</td>
<td>120</td>
<td>0.1</td>
<td>July 2007</td>
</tr>
</tbody>
</table>

\textsuperscript{a}BV cover includes areas remaining under BV cover and also areas where BV cover had been removed. Native cover areas never had BV cover. \textsuperscript{b}Value is significantly different from native cover control mean, where \( \alpha = 0.05 \) as determined by an unequal variance t test.

LITERATURE CITED

(4) Socha, T.; Roecher, R. “Kudzu of the beach” threatens Carolina dunes; Engineer Update; U.S. Army Corps of Engineers: Washington, DC, 2004; 28(2).


(22) Horne, D. J.; McIntosh, J. C. Hydrophobic compounds in sands in New Zealand—extraction, characterisation and proposed mechanisms for repellency expression. *J. Hydrol. (Amsterdam)* **2000**, *231–232*, 35–46.

Received for review August 15, 2008. Revised manuscript received November 7, 2008. Accepted November 10, 2008. Technical Contribution 5508 of the Clemson University Experiment Station.

JF8025259
From the April 16, 2009 issue of the Coastal Observer

By Sarah L. Smith

Waccamaw High School seniors won’t walk on the dunes after working hard to dig up invasive beach vitex and plant native sea grass.

Stephen Canada was one of 11 seniors in Beau Gee’s biology 101 class who were out working in the dunes on Friday, the first day of their spring break.

After working up a sweat, getting bug bites and sunburns, Canada and other students said they wouldn’t set foot on the dunes again.

It is part of the learning experience Hal Droter of Clemson University’s Baruch Institute thought the students would have.

Although they did the hard labor for extra 100 test grades in their biology class, the students were also helping the environment by removing an invasive species and replacing it with sea oats, bitter panicum and American Beach grass.

Droter and students from the forestry department at Horry-Georgetown Technical College began killing and removing the vitex in 2007. Droter said Pawleys Island was one of the first places to offer money, $15,000, to get rid of the vitex. As a result, the removal and replanting work is almost done.

The dead vitex the students dug up was on Myrtle Avenue in one of 250 vitex sites in the state.

Of the 250 sites, only 20 remain active, Droter said.

Killing the vitex took time, Droter said, because he and the Tech students had to cut vitex vines with a machete and dab on herbicide with a sponge paint brush.

They put the island on a grid and did one small section of the island at a time. Droter said he used to spend one week on a lot, now he can cover 20 in one day.

After the herbicide was on the plant, Droter and his helpers would wait 120 to 150 days for the vitex to die. Then they’d go in, cut it out and remove all of the dead material. Debris are kept on the Baruch property.

Byron McDaniel, a forestry student at Horry-Georgetown Tech, said the work is tedious, but the students were doing a good job.

After doing hard labor to get the vitex out and the grasses in, Canada said there is a level of sentimentalism he and other students feel for the property.

So after he worked on the dunes one day, Canada became protective. When he heard about friends who were going to run in the dunes, he made sure they changed their minds.

“Whoa,” he said he told them, “not through all the grass I planted.”
Students also respect the dunes more now that they put work into them.

Ben Bracket, Michael Gilligan and Becca Harper said no one would ever find them on the dunes again.