Georgian Court University, the New Jersey Sea Grant Consortium,
and the Cape May Plant Materials Center present

INVASIVE SPECIES IN COASTAL DUNES & MARITIME FORESTS

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Conference Proceedings

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NRCS Natural Resources Conservation Service

About Georgian Court University

Established in 1908, Georgian Court University provides a comprehensive liberal arts education in the Roman Catholic tradition with a special concern for women. The university offers 29 undergraduate and 10 graduate degree programs in fields ranging from Biology to Business Administration and Education. Georgian Court's unique atmosphere is one of small college ambiance in a technologically advanced, highly esteemed university setting. Centered on the core values of the Sisters of Mercy---respect, integrity, justice, compassion and service---the university prepares students to succeed as ethical leaders who are committed to excellence in their careers and communities. For more information, visit georgian.edu.

About the New Jersey Sea Grant Consortium

The New Jersey Sea Grant Consortium is an affiliation of colleges, universities and other groups dedicated to advancing knowledge and stewardship of New Jersey's marine and coastal environment and meets its mission through innovative research, education and extension programs. For more information about NJSGC, visit njseagrant.org.

About the Cape May Plant Materials Center

The Cape May Plant Materials Center (NJPMC) provides plant solutions for natural resource conservation concerns pertaining to coastal shorelines, sand dunes, mined lands/critical areas, and coastal grassland habitat. The Center serves a nine-state area, including parts of Connecticut, Delaware, Maryland, Massachusetts, Long Island- New York, New Jersey, North Carolina, Rhode Island, and Virginia. For more information about NJPMS, visit plant-materials.nrcs.usda.gov/njpmc/.

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Introduction and Executive Summary

The desirability of scenic ocean views, combined with the high human population densities on the Atlantic Coast, mean that coastal dunes and their associated maritime forests have been disproportionally impacted by development. For example, in New Jersey, only 31.2 of the 130 miles of shoreline between Sandy Hook and Cape May Point have not been developed by humans. Since many of the plant species found in these habitats are found nowhere else, contraction of these habitats means that those species are becoming increasingly rare.

Invasive species are now recognized to be one of the leading threats to global biodiversity. Nearly half of the species currently on the US endangered species list have been negatively impacted by invasive species. Moreover, unlike chemical pollution, the "biological pollution" of invasive species, when left untreated, creates problems that increase, rather than dissipate, over time. Thus, the additional threat posed by exotic and invasive species in the few remaining areas of dune and maritime forest is a matter of particular concern.

The "ribbon like" nature of coastal ecosystems means that professionals dealing with these ecosystems are often widely separated in space, so they rarely have the opportunity to meet to exchange information and expertise. One of the goals of this conference was to counteract this isolation by bringing together interested academics, managers, decision-makers, scientists, plant experts, representatives from Federal and State Agencies, landscape and horticultural professionals and environmental consultants from along the Atlantic and Great Lake shorelines to discuss the issues created by invasive species in these ecosystems. Participants (see Appendix) shared information about the impacts of invasive species in these habitats, as well as effective management strategies. They also worked together to generate recommendations for policies and strategies to effectively combat the spread of these species in coastal ecosystems in the future.

This conference had a number of positive outcomes. The first of these was a **comprehensive documentation of the impacts of invasive species on dunes and coastal systems at all ecological levels, from geomorphology (changed dune shape) to decreased community diversity and native species' population size, changes in native plant morphology and vigor, to cascading effects on upper trophic levels.** Conference participants shared a number of clear examples of the negative effects of Asiatic sand sedge (*Carex kobomugi*) and beach vitex (*Vitex rotundifolia*) at the community and ecosystem level. The effect of natural and anthropogenic disturbances in facilitating invasion in these habitats was also demonstrated. In addition, there is an indication that the biology of the Asiatic sand sedge changed in its invaded range such that it participates in mycorrhizal associations that are absent when it grows its native habitat. Researching the contribution of those associations to the invasiveness of the sedge in North America will be an important next step in our understanding of this invasion.

A recurring theme within conference presentations was the **need for effective Early Detection Rapid Response (EDRR) Programs** to forestall invasions before they get out of control. The IPANE program from New England was shared with the group as model that could be implemented elsewhere. This model makes effective use of citizen scientists, which was

another theme of the conference: The need to build public engagement both to provide the manpower for EDRR efforts and also to act as advocates for programs and legislation and behaviors that are needed to help curb future invasions.

The appropriate relative balance between use of legislative tools to prevent invasions versus the more "bottom up" approach of educating both consumers and vendors to change behaviors and practices at a more "grass roots" level was another theme that received much attention. There was clear consensus for the need for regulatory tools such as prohibited species lists and clean lists that are enforced in cooperation with nurseries and other vendors. However, it was also clear that regulations alone can't be expected to prevent invasions. There is also a strong need for an educated and engaged populace. Effective use of both charismatic species, which can motivate public support for programs combating invasive species (as in the case of sea turtles and beach vitex, or piping plovers and *Carex kobomugi*), and charismatic people to lead the charge (as in the case of Betsy Brabson and beach vitex) are pivotal to this effort.

Finally, several case studies were presented that provided insights into **best management practices (BMPs) for eradication of dune invasives** such as *Carex kobomugi* and *Vitex rotundifolia*, as well as for the more diverse assemblage of invasive plants growing in Maritime Forests. However, it was clear from the presentations and discussion that this research is still in its infancy. Additional research on BMPs is needed to help guide the efforts of managers working to restore invaded ecosystems.

Based on the presentations and panel discussion the following actions are needed to improve state's ability to manage invasive coastal and dune species:

- Develop Early Detection Rapid Response Programs to train and engage citizen scientists in invasive species monitoring and management
- Create and enforce prohibited species lists and clean lists
- Improve communication within and between agencies and between these groups and the public
- Recognize that managing dunes for habitat IS managing dunes for shore protection
- Fund and carry out research on BMPs for eradicating coastal invasives and restoring damaged ecosystems
- Build on existing infrastructure to create a more aggressive and dynamic public education program to raise awareness of invasive species and the problems that they cause and to build support for the actions described above.

This conference has already had a number of outcomes. For example, removal of *Carex kobomugi* is now underway at several locations in New Jersey. In addition, information on BMPs shared at the conference is informing efforts at controlling both *Carex kobomugi* and *Vitex rotundifolia* from Rhode Island to the Carolinas. In NJ, the Coastal Management Zone rules

are currently under revision. Informed in part by the presentations and discussions from this conference, there have been several efforts to propose rule / regulation changes over the past several years including meeting and letters sent from the USFWS to the DEP requesting that removal of this species be explicitly addressed in the revised version of those regulations. And finally, upon returning home to Assateague Island National Seashore (Maryland and Virginia), Conference Participant, Jonathan Chase discovered a new population of Sea Beach Vitex in Assateague. Having just seen presentations on this species Jon immediately recognized the plant and pulled it up, thus providing a perfect example of EDRR in action!

This document contains a compilation of papers based on the posters and talks presented at the Conference on Invasive Species in Coastal Dunes and Maritime Forests. It also contains a transcript of the panel discussion held on the last day of the conference along with a brief summary of the main ideas in that discussion. Many of the speakers from the conference also provided copies of their slides. Those slides are posted, along with the abstracts from the presentations, at http://www.georgian.edu/dunes/program.htm

We would like to acknowledge the following for their invaluable help in organizing and helping to implement this conference: Bob Bonardi, Mary Cranwell, Kate Guilfoyle, Rory Joyce, and Marsha Samuel. We also wish to thank Cathleene George for transcribing several of talks and the panel discussion from the conference for us.

Louise Wootton and *Peter Rowe* (Conference Organizers)

Memorial Biographical Sketch

Leslie J. Mehrhoff, Ph.D.

Botanist and Director
Invasive Plant Atlas of New England
University of Connecticut
Storrs, Connecticut USA

March 16, 1950 – December 22, 2010

Les Mehrhoff was born in Morristown, New Jersey in 1950. He received a B.S. in Biology from New England College, in Henniker, New Hampshire, in 1972. He received an M.S. in Botany from the University of Connecticut, in 1976. He received a Ph.D. in Plant Ecology and Biogeography from the University of Connecticut in 1996. His dissertation was on the plant biogeography of Connecticut.

From 2001 until his untimely death at the age of 60, Les served as Director of the Invasive Plant Atlas of New England at the University of Connecticut (WWW.IPANE.ORG). Under his leadership over 750 volunteers were trained to detect and report on 100+ invasive plants throughout the New England Region. The results were astonishing - over 12,000 new invasive plant distribution records in the IPANE database.

From 1996-2006, Les served as the Curator of the George Safford Torrey Herbarium at the University of Connecticut. Prior to that, he was the Supervising Biologist of the Connecticut Geological and Natural History Survey. His research interests involved eastern Asian plants that are invasive in New England and New England natives that are invasive in eastern Asia. He was an active field naturalist and plant collector.

Les served on the Board of the Josselyn Botanical Society in Maine. He was also a former president of the New England Botanical Club, and vice-president of the Connecticut Botanical Society.

Like all true botanists, Les wore a hand lens around his neck, pressed plants, and was often found hanging around a herbarium. Les Mehrhoff will be missed.

Editor's Note: Our sincere thanks to Randy Westbrooks for agreeing to write this tribute for Les, a man with no equal in this field. Les will, indeed, be greatly missed.

Keynote Speaker Profile

Randy Westbrooks

Randy Westbrooks, a native of Gaffney, South Carolina, received B.S. and M.S. degrees in biology from the University of South Carolina in 1976 and 1978. He received a Ph.D. in botany and weed science from North Carolina State University in 1989. Since 1979, Dr. Westbrooks has served as an Invasive Species Prevention Specialist with the U.S. Government, in the U.S. Department of Agriculture, as well as the Department of the Interior. He is currently with the U.S. Geological Survey.

At the national level, Dr. Westbrooks is working with numerous interagency groups to develop new capacity for early detection and rapid response in states and provinces across the U.S. and Canada. In the U.S., the effort is focused on the establishment of **State EDRR Committees** to lead the development of state and local elements of the **National EDRR System for Invasive Plants**.

This includes **State Early Detection and Reporting Networks** (trained volunteers and agency field personnel), **Regional Invasive Plant Atlases** (data archival and analysis, modeled after the Invasive Plant Atlas of New England), **State Invasive Species Councils** (interagency coordination), and **Invasive Plant Task Forces** (e.g., the Carolinas Beach Vitex Task Force – for rapid response).

Internationally, Dr. Westbrooks is working to develop a Global Early Warning System for Invasive Species – in cooperation with the World Conservation Union - Invasive Species Specialist Group, based in Auckland, New Zealand. As part of this effort, he recently launched an effort with partners from the 2008 Weeds Across Borders Conference in Banff, Alberta, Canada, to develop a North American Early Warning System for Invasive Plants.

Picture Credits: Randy Westbrooks and http://www.news-journal.com/news/local/article_b6e961c5-f84e-55e7-9e29-31971a1200f4.html?mode=image

Keynote Presentation

Invasive Species Coming to America... An Overview of Traditional Single Agency Led Approaches and Interagency Partnerships for Early Detection and Rapid Response to New Invasive Plants in the United States. Randy G. Westbrooks. U.S. Geological Survey, Whiteville, North Carolina, and Elizabeth N. Brabson. South Carolina Coordinator, Carolinas Beach Vitex Task Force, Georgetown, South Carolina.

Abstract

Over the past 500 years, about 50,000 plants and animals have been introduced into North America. Of this total, about 4,200 species of introduced plants have escaped from cultivation – of which more than half have become economically or ecologically significant. Losses and control costs for invasive species in the United States are now about $150 billion per year. The USDA-Carolinas Witchweed Eradication Program is a good example of a 'single-agency led' weed management effort. Over the past 50 years, federal and state personnel have reduced the infestation of this U.S. Federal Noxious Weed from 432,000 acres in croplands of the eastern Carolinas to about 2,200 total acres. Beach Vitex, a woody vine that was first introduced from Korea as a dune stabilization plant in the mid-1980s, is a good example of an invasive species that does not fit the traditional 'single-agency led' profile for action. It is not an agricultural or aquatic weed, it is not (potentially) quarantine significant, and it occurs in multiple jurisdictions – It is primarily a threat to natural resources, including sea turtle reproduction. The Carolinas Beach Vitex Task Force was established to address the problem. The task force has shown that volunteers can be very helpful in early detection, reporting, and eradication of new invaders that cannot be effectively addressed by a single agency. To help prevent the establishment of new invaders such as Beach Vitex that don't fit the 'single-agency led' profile for action, efforts are being made to develop a U.S. National Early Detection and Rapid Response System (EDRR) for Invasive Plants. This includes a coordinated framework of interagency partner groups to build new capacity for early detection and reporting, ID and vouchering of suspected invaders, archival of new invasive plant records in designated plant databases, rapid assessment of confirmed new records, and rapid response to confirmed new invaders. Currently, the effort is focused on development of system processes (e.g., protocols for early detection, reporting, and assessment), and operational elements (e.g., State EDRR Committees and State Early Detection Networks).

Introduction

Since the advent of European colonization in the early 1500s, about 50,000 species and varieties of plants and animals have been introduced into North America. Of this total, about 4,200 species of introduced plants have established free living populations outside of cultivation. This includes generally non-invasive species such as daffodils (*Narcissus pseudonarcissus* L.) that grow along roadsides, as well high profile invaders such as kudzu [*Pueraria montana* (Lour.) Merr.], Witchweed (*Striga asiatica* (L.) O. Kuntze], and more recently, Beach Vitex (*Vitex rotundifolia* L. f.). Currently, it is estimated that losses and control costs for invasive species in the United States are now about $150 billion per year. Invasive plants represent about 1/3 ($50 billion) of this total cost (FICMNEW, In Press). Clearly, Early Detection

and Rapid Response is an important management strategy in efforts to prevent the establishment and spread of new invasive plants at all landscape levels from the local level (farms, parks, forests), to the state, and national level.

Witchweed – A Successful 'Single-Agency Led Weed Eradication Program. The concept of early detection and rapid response (EDRR) as a preferred management strategy for new invasive plants in the United States first developed as a guiding principle in the federal/state Witchweed Eradication Program in the eastern Carolinas in the early 1960s. Witchweed is a parasitic weed from Asia and Africa that parasitizes the roots of grass weed such as crabgrass and Johnsongrass, and grass crops such as corn. Witchweed, which was first discovered in the United States in 1956, was eventually found to infest over 432,000 acres of cropland in the eastern Carolinas. In response to the threat of Witchweed to the nation's cereal crops, a federal/state quarantine was established in September, 1957, in 38 counties of North and South Carolina to regulate the movement of soil contact commodities (e.g., sweet potatoes), and soil contaminated vehicles and equipment out of the quarantine area. Over the years, witchweed in the quarantine area has been detected by program personnel, with occasional help from impacted farmers. In the early 1990s, a $25.00 bounty was instituted to provide an incentive for land owners and others to report new infestations of witchweed. However, unlike a number of other current day invasive plant eradication efforts that utilize volunteers to assist in detection and reporting of target species, the Witchweed Program still relies primarily on seasonal technicians to survey infested lands. Through the work of federal and state plant quarantine inspectors over the past 50 years, this single-agency led weed eradication program has reduced the witchweed infestation in the United States to about 2,100 acres in North Carolina and 80 acres in North Carolina (Iverson, 2009) (Iverson et al, In Press).

Image: Witchweed parasitizing corn in Columbus County, North Carolina. August, 1982. Rebecca S. Norris, USDA APHIS PPQ, Whiteville, North Carolina. URL: http://www.invasive.org/browse/detail.cfm?imgnum=1148083

The Carolinas Beach Vitex Task Force – An Example of Interagency Partnering to Address New Invasive Species. Witchweed, which is obviously a serious agricultural threat, is clearly within the mandate of the U.S. Department of Agriculture to 'protect American Agriculture', and thus can be managed through a single-agency led approach. However, for a variety of reasons, many other introduced invasive plants do not fit the 'single-agency led' profile for action [e.g., they are not agricultural or aquatic weeds, they are not quarantine significant (known invaders, of limited distribution), or they occur on/in multiple land units or jurisdictions]. In the past, such species were generally ignored (from a plant regulatory standpoint) and have become some of our worst invaders. Examples include purple loosestrife (*Lythrum salicaria* L.) and oriental bittersweet (*Celastrus orbiculatus* Thunb.). A current example of this old problem is Beach Vitex (*Vitex rotundifolia* L. f.).

Beach Vitex was first imported from the beaches of Korea by the North Carolina State University Arboretum in the mid-1980s for use as a beach stabilization plant in the southeastern United States. By the mid- to late 1990s, dune restoration specialists with the U.S. Army Corps of Engineers began to notice Beach Vitex spreading from landscape plantings on beaches along the South Carolina coast, crowding out native species like Sea Oats (*Uniola paniculata* L.) and Sea Beach Amaranth (*Amaranthus pumilus* Raf.). Unlike native Sea Oats which has fibrous roots that help anchor sand dunes against storm waves, Beach Vitex has long tap roots that anchor the plant itself during major storm events, but do little to help protect the dunes against erosion. The thick, deep root system also prevents sea turtles from nesting on primary dunes.

Image: Beach Vitex at DeBordieu Colony Beach, Georgetown, South Carolina. Randy G. Westbrooks, U.S. Geological Survey, Whiteville, North Carolina. URL: http://www.invasive.org/browse/detail.cfm?imgnum=2116039

In November, 2003, following several unsuccessful attempts to get state agencies to address the Beach Vitex problem, concerned sea turtle volunteers collaborated with the U.S. Geological Survey to host the first Beach Vitex Symposium at the Belle W. Baruch Institute near Georgetown, South Carolina. At that meeting in November, 2003, it was concluded that no single agency had the authority or resources to address the problem alone – an interagency task force would be needed. Following the meeting, the South Carolina Beach Vitex Task Force was organized to address the problem. In the spring of 2005, when it was realized that Beach Vitex was a threat to beach communities in both Carolinas, the effort was expanded into a bi-state effort with the formation of the Carolinas Beach Vitex Task Force (www.beachvitex.org). The task force, which has made significant progress over the past six years in eradicating Beach Vitex from beach communities along the Carolina coast, utilizes volunteers to remove Beach Vitex seedlings from public beaches, and to detect and report large Beach Vitex plantings to task force coordinators. Seedlings of the plant are removed from public beach areas by volunteers, while large plantings are being removed by task force crews (in South Carolina) and by contracted labor (through affected beach communities in North Carolina. The Carolinas Beach Vitex Task Force is a good example of the new trend in interagency partnering to address invasive species that do not fit the 'single-agency led' profile for action (Westbrooks and Brabson, In Press)

Overview of the U.S. National EDRR System for Invasive Plants.

To help minimize the establishment and spread of new non-native invasive plants in the United States that do not fit the traditional single-agency led profile for action (e.g., Beach Vitex), the U.S. Geological Survey is leading a cooperative effort develop a National Early Detection and Rapid Response System (EDRR) for Invasive Plants. To achieve this goal, a coordinated framework of interagency partner groups is being organized at the local, state, regional, and national levels to build new capacity for early detection and reporting of unknown plants (by trained volunteers and agency field personnel); ID and vouchering of suspected invaders (by cooperating botanists); archival of new invasive plant records in designated regional and national plant databases (e.g., the Invasive Plant Atlas of New England); rapid assessment of confirmed new records (federal and state scientists); and rapid response to confirmed new invaders (invasive plant task forces and cooperative weed management areas, e.g., the Carolinas Beach Vitex Task Force). Currently, the effort is focused on development of system processes (e.g., protocols for early detection, reporting, and assessment), and operational elements (e.g., State EDRR Committees and State Early Detection Networks) (Westbrooks, 2004).

Once implemented nationwide, the National EDRR System will provide an important second line of defense against invasive plants, and will complement federal efforts to prevent further introductions of foreign invaders at U.S. ports of entry. With both exclusion and early detection systems in place, the nation will be better able to defend against future economic and environmental losses due to 'plants out of place'.

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Additional Presentations

Initial comparison of arthropod communities of the invasive Asiatic sand sedge (*Carex kobomugi*) and native American beach grass (*Ammophila breviligulata*) in New Jersey coastal dunes. Liza Baskin. Georgian Court University, Lakewood NJ and Marine Academy of Science and Technology, Sandy Hook, NJ and Louise Wootton, Georgian Court University, Lakewood NJ

Abstract

Asiatic sand sedge (*Carex kobomugi*) is an invasive species of plant that is currently spreading in the coastal dunes of the Northeast and New Jersey in particular. This species like many invasive plants has been shown to have negative effects on native plant biodiversity and abundance. What is not as well known, in this and other plant invasions, is whether or not those changes are having cascading effects at higher trophic levels. I am currently conducting a two-year assessment of arthropod communities in both Asiatic sand sedge and native American beach grass (*Ammophila breviligulata*) plant communities. Six paired sites of *C. kobomugi* and *A. breviligulata* were selected in the Sandy Hook Unit of Gateway National Recreation Area and Island Beach State Park. A combination of pitfall trapping and sweep netting methods were utilized to catch both ground dwelling and flying arthropods. Initial analyses of the arthropods captured show no significant difference in biodiversity between the *C. kobomugi* and A. *breviligulata.* However, there was a statistically significant difference in abundances of specific orders between the plant types. In the *A. breviligulata* sites there were higher abundances of Collembolans (springtails), Hemipterans (aphids, cicadas and their relatives) and Homopterans (plant hoppers). Further analyses within orders and seasonal differences will be discussed.

Invasive species and their effects are becoming a common and increasingly alarming theme in ecology. The ecological cascading effects of plant species invasions are diverse but can include changes to species composition and abundance in communities, and altered nutrient cycling and rates of erosion and sediment deposition, just to name a few (Crooks 2002). What is not well known is how invasions at lower trophic levels (e.g. primary producers) impact higher trophic levels. What is known is that, while the majority of invasions take place at lower trophic levels, the resulting extinctions tend to occur disproportionately often at higher trophic levels (Byrnes et al. 2007). However, the specific effects of invasive species on organisms at higher trophic levels within the affected ecosystem seem to vary between ecosystems. For example, Herrera and Dudley (2003) found that abundance of flying arthropods in a native stand of mixed trees and shrubs was nearly twice that of the abundance of arthropods in a monoculture stand of the invasive giant reed, *Arundo dona*x. They concluded that this decrease in arthropod abundance was linked to the decreased plant diversity associated with the invasion. Similarly, Gerber et al. (2008) found that invasive knotweeds (*Fallopia* spp) were associated with a large reduction in both morphospecies diversity and invertebrate abundance. By contrast, De Groot et al. (2007) found that, while an invasion of Canada goldenrod (*Solidago canadensis*) into "semi-natural" habitats in Slovenia did reduce arthropod species richness and evenness, it had little effect on the abundance of most of the local arthropods, despite strong impacts on native plant species richness.

A few studies have specifically addressed the impacts of invasive plants in sand dune communities. In California, invasive European beach grass (*Ammophilia arenaria*) stands have lower abundance and species diversity for burrowing arthropods (Slobodchikoff and Doyen 1977). Also in European beach grass dunes, stiletto flies were completely absent as compared to dunes with native vegetation (Holston 2005). While the majority of research on the impacts of invasive plants at higher tropic levels seems to indicate a loss of biodiversity, this result is by no means universal. In New Zealand, shrubland communities there was no difference in species diversity between areas that were invaded vs. native (Harris et al. 2004.) Harris and his colleagues suggest that this may be an artifact of the "temporary" nature of shrubland communities since in this case the non-native species is eventually replaced by native trees.

New Jersey's coastal dune system is a complex ecosystem that is subject to harsh conditions from salt spray, overwash from storms, high winds and human activities. The dominant native plant species in New Jersey dunes is *Ammophila breviligulata*, American beach grass, a typically delicate plant that cannot withstand human disturbance, such as being stepped on. In addition to the dominant species *A. breviligulata*, there are several other commonly associated species including seaside goldenrod *(Solidago sempervirens*), panic grass *(Panicum amarum*), little blue stem *(Schizachyrium scoparium*) and wormwood *(Artemisia* spp.) (MDDNR ND, Burkitt 2007). Many animal species make their home in or near the dunes, including shore birds that may nest in front of or between dunes, reptiles such as the eastern hognose snake (*Heterodon platirhinos*) and the northern diamondback terrapin (*Malaclemys t. terrapin*), and many species of insects including the endangered northeastern tiger beetle (*Cicindela* spp.) (MDFW ND). Asiatic sand sedge, *Carex kobomugi*, is an invasive plant that has been introduced into beach dune communities throughout the Mid-Atlantic and Oregon (USDA ND). Compared to *A. breviligulata, C. kobomugi*, has roots of a similar depth but is more dense in its growth pattern, lower in overall height and results in increased detritus. Additionally, *C. kobomugi* is now expanding at an exponential rate in the coastal dunes of New Jersey and now occupies thousands of hectares of dunes throughout the state (Wootton et al. 2005).

Along with the exponential growth, *C. kobomugi* is not just replacing *A. breviligulata* but changing the entire plant community. Within the beds of *Carex kobomugi* the abundance other species of plants commonly making up the dune community was greatly reduced (50-70%) as compared to paired areas of native vegetation outside the C. *kobomugi* beds. Species diversity was also significantly lower within stands of *C. kobomugi* as compared to those of uninvaded dune areas (Wootton et al. 2005). Given that it has already been found that there is an overall decrease in plant diversity in the *C. kobomugi* dunes, it seems logical to hypothesize that there may be a corresponding decrease in arthropod abundance, evenness and richness.

Materials and Methods

In 2008, an assessment of arthropod communities for Island Beach State Park (IBSP) and the Sandy Hook Unit of Gateway National Recreation Area (SHU) was started that consists of three parts. First, at both SHU and IBSP, three permanent sampling sites have been selected. Criteria for site selection were presence of dunes dominated by native and non-native plants in close proximity to each other (less than 5m apart on the same dune) with similar conditions

including, but not limited to proximity to ocean, dune aspect, wind direction and level of disturbance. Each site has both a "native" and an "invaded" plot with each plot being at least 10 m in width. A plot was designated as a "native" plot if it contains no stems of *C. kobomugi* and "invaded" if it contains greater than 75% cover (by the Braun-Blanquet scale) of *C. kobomugi*. Within both the "native" (or control) and paired "invaded" plots at each site 10 pitfall traps where placed in a circular pattern approximately one meter apart. Between sampling periods the traps were covered with a tile to prevent accidental sampling. Sampling periods occurred once a month from April to November. During the sampling period traps were filled to a depth of three centimeters with a collection fluid that was a mixture of water, acetic acid and ethyl alcohol. Samples were retrieved three days after traps were set, and returned to the laboratory for identification. Arthropods were identified to at least family level and genus and species, when practical, using dichotomous keys. A t-test was run to compare overall abundance and diversity was calculated using a Shannon-Weiner index.

Results

So far of the 156 pitfall trap samples taken 65 have been analyzed, the majority of which came from the first three sampling dates, consisting of the spring and early summer of 2008. Eighteen orders or subclasses have been represented with twelve common to both the *C. kobomugi* and *A. breviligulata* sites. Five orders or subclasses, parasitiformes, prostigmata, hymentoptera, collembola, and acari , account for 97.6% of all arthropods found with the other seven orders having less than five individuals present.

For four of the largest groups, Hymenoptera (sawflies, ants, bees, etc), Prostigmata (mites that primarily feed directly on plants), and Parasitiformes (parasitic mites of other arthropods) and Acari (mites not in Prostigmata or Parasitiformes subclasses) there was no significant difference found between *C. kobomugi* and *A. breviligulata*. For the Collembolans, aka springtails, (plant matter detritovores) the single most abundant found in all samples subclass was found to be significantly different between sites. In the *C. kobomugi* sites there were a total of 1956 collembolana found compared to 6472 found in the *A. breviligulata* sites (p-value = 0.014). The only other orders found to have significantly different abundances in the *C. kobomugi* sites compared to the *A. breviligulata* were Hemipterans (plant hoppers and other true bugs) and Hompterans, (leafhoppers) both with a p-value of 0.012. In *C. kobomugi* sites only one hemipteran was found and three homopteran. In *A. breviligulata* there were 11 hempiterans and 20 homopterans. Finally biodiversity at the order level was very similar in both sites. Using Shannon-Wiener biodiversity was 0.757 for *C. kobomugi* and 0.717 in *A. breviligulata*.

Discussion

For some of the orders in which there was no difference in abundance it is possible that due to their ecological niche they maybe able to adapt better. For example members of subclass parasitiformes tend to be small predatory mites that feed on smaller arthropods that inhabit the detritus. These organisms would not be affected directly by a shift in plant community unless it affected their prey species.

It is also possible that the apparent similarity in abundance is due to the level of taxonomic scale. For example, it is possible that within the order Hymenoptera, a very diverse group, some species of ants are being displaced within the invaded plant areas by other species of ants. Loss of one species could be offset by the gain of another.

In terms of the similar biodiversities of arthropods in *C. kobomugi* and *A. breviligulata* sites, this maybe due to the nature of the ecosystem itself. Dunes are typically high disturbance areas to begin with even with out invasive plants. It has been found that generally speaking areas of high disturbance typically have lower biodiversity than areas with intermediate levels of disturbance. Biodiversity is typically low in dune environments that remain un-invaded. But again the level of taxonomic scale may also play a role here. It is possible when examined at the species level, biodiversity may differ significantly between sites.

All of the orders that were significantly more abundant in the un-invaded *A. breviligulata* sites were those that are primarily herbivorous. Most of the hymenopterans, and all of the homoptera and collombolans found, are herbivorous. It is possible that these specific orders are not able to "switch over" to feeding on the *C. kobomugi*.

Conclusions

While it is too early in this study to make any real conclusions it appears that there are significant differences in overall abundance of herbivorous arthropods. Additionally, at the large taxonomic scale analyzed here there is no significant difference in biodiversity. In order to determine which, if any, differences occur at lower taxonomic levels, all samples will continue to be analyzed to at least family level particular those of the Collembola and Hymenoptera orders. Also as the project is completed differences due to seasonal effects, location specific and interference effects will also be examined.

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Impact of the Invasive *Carex kobomugi* on Native Dune Plant Populations in Undisturbed and Disturbed Areas of the Sandy Hook Unit of Gateway National Recreational Area. Jim Burkitt, Brookdale Community College. Lincroft, NJ 07738 and Louise Wootton, Georgian Court University, Lakewood, NJ 08701

Abstract

Non-native and invasive species are among the leading threats to global biodiversity. Habitat disturbance is a key determinant of invasion success in non-native species. The goal of this study was to examine the impact of the invasive sedge, *Carex kobomugi,* on native dune plants and to see if the effect of this impact changed with different levels of disturbance. Stem densities of many native plants, as well as species richness were generally significantly lower within areas invaded by *C. kobomugi* than in uninvaded areas. Species diversity and species richness inside invaded areas at the more highly disturbed sites were extremely similar to one another and were significantly reduced relative to the less disturbed site, suggesting that disturbance affects the ability of *C. kobomugi* to outcompete native plant species. Significant differences were found in plant abundances in beds of different sizes. However, when these differences were examined in detail, no clear relationship could be detected between *C. kobomugi* and species richness, diversity or native plant stem densities and bed size. In some locations the strongest negative effects of *C. kobomugi* were seen, as expected, in the largest beds. However, in others, the strongest negative effects were seen in small or medium beds, and in many others, no effects at all were detected between beds of different sizes. The lack of a consistent relationship between bed size and impact of the invasive species may mean that bed size does not directly relate to the age of invasion, as we initially postulated.

Introduction

One of the leading threats to global biodiversity is introduced non-native species (Lake and Leishman 2004). Invasive species are believed to be second only to habitat destruction in causing the decline of global biodiversity (Perrings 2005). Many exotic species, once established, negatively impact the native populations surrounding them. As well as simply out-competing native species, invasive species may create a number of changes within the impacted habitat, such as changes in water table levels or soil consolidation that further negatively impact native species (Hart 1999).

Typically invasive species are found more in disturbed areas, while native species tend to thrive in more pristine areas (Wiedemann and Pickart 1996, Lake and Leishman 2004). When native plants are weakened or die, space becomes available for other plants to exploit. Some studies suggest that the establishment and dominance of both native and exotic species is dependent on plant growth interactions, frequencies and mortality-causing disturbances (Lake and Leishman 2004). However, Huston (2004) suggests that the dominance of exotic species is maximized under highly productive conditions. Disturbances and disturbance types also have an effect on the establishment of non-native species. The presence of a high degree of natural disturbances like heavy wave action, or strong wind erosion, may create opportunities for exotic species to enter new habitats (Lake and Leishman 2004). Disturbances, either natural or man-made,

particularly favor non-native plant species because open habitats provide resources that were not available prior to the disturbance that can allow for seedling establishment and growth (Pauas et al. 2006).

Carex kobomugi is a perennial plant belonging to the Cyperaceae family. It is native to Japan, Korea, China and parts of eastern coastal Russia but, over the last century or so, it has invaded coastal dunes along much of the eastern US (Small 1954). This sedge is characterized by short height (approximately 0.3 meters) and long tapered leaves with finely serrated edges (Shisler et al. 1987). *C. kobomugi* has long rhizomes running 50-120cm connecting each shoot and produces one node per year (Ishikawa and Kachi 1998). Although *C. kobomugi* has the ability to reproduce by seed, typically it grows in large beds of clones referred to as "families" through the propagation of nodes through its sub-surface rhizomes (Ishikawa and Kachi 1998). Thus, once established, *C. kobomugi* grows in large homogenous stands along sand dunes.

The purpose of this study was to investigate the role of human and natural disturbances in determining the impact of the invasive sand sedge *Carex kobomugi* on the species richness, species diversity and species distribution of native dune plants.

Materials and Methods

Site Selection

I chose to carry out this study at the Sandy Hook Unit (SHU) of Gateway National Recreational Area in northeastern Monmouth County, New Jersey, since this area is part of a United States National Park, and so contains a number of relatively undisturbed dune areas, which is rare for the east coast of the US, especially in New Jersey. However, the dune and coastal areas of the SHU also include a number of more disturbed areas due to recreational use by beachgoers, fishermen, and other outdoor enthusiasts.

Human-disturbed areas were defined as areas that were within a 50 meter buffer of roads, trails, or other human impacted areas, such as parking lots. Naturally disturbed areas were identified as those experiencing high levels of wind and wave energy (usually associated with spits and other oceanward-extending promontories). Undisturbed areas were defined as areas that have little to no human use, and which are also relatively sheltered from wind and wave energy (Figure 1). Within each area, a small, medium and large bed of *C. kobomugi* was chosen within each area for further analysis.

Field Data Collection

Counts of the species types and stem densities of all plants within a grid of $1m^2$ circular plots within and in a 5m halo around each population were used to assess species richness and abundance within the invaded areas selected for this study. Once stem counts were obtained, species diversity for each plot was calculated using the Shannon-Weiner Diversity Index.

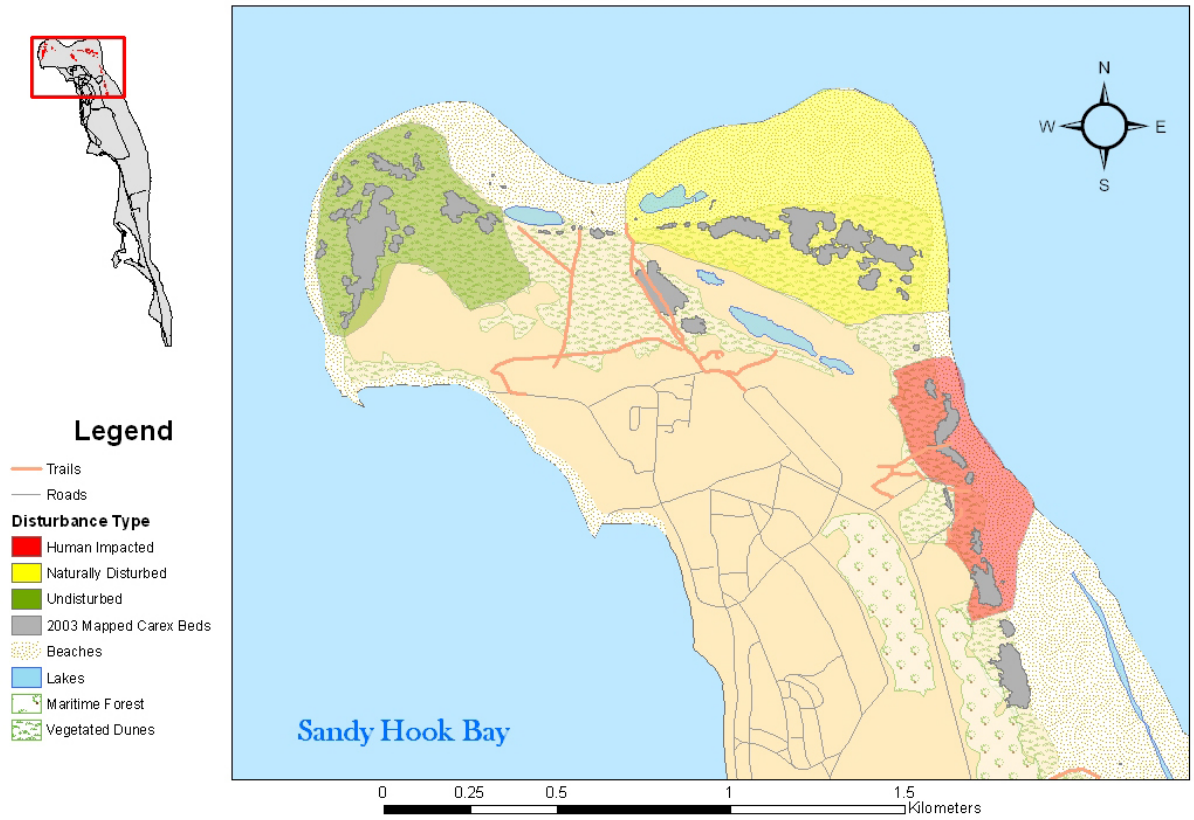

Figure 1: Sandy Hook *Carex kobomugi* study sites

Results and Discussion

No significant differences could be detected between species richness or species diversity within invaded areas relative to the surrounding areas (Table 1). However, significant decreases in stem densities of common species were detected within invaded areas, when compared to those of the same species outside the invaded areas (Table 1).

Table 1. Impact of *C. kobomugi* on species richness and species diversity and stem densities of common dune species

	Inside ± SE n = 824	Outside ± SE n = 474
Species Richness	2.74 ± 0.04[a]	2.41 ± 0.06[b]
Species Diversity	0.49 ± 0.01 [a]	0.51 ± 0.02 [a]
Ammophila breviligulata	14.87 ± 0.01 [a]	20.65 ± 1.16 [b]
Solidago sempervirens	1.26 ± 0.14 [a]	1.89 ± 0.02 [b]
Artemisia spp.	1.42 ± 0.17 [a]	2.81 ± 0.61 [b]
Schizachyrium scoparium	1.39 ± 0.20 [a]	1.38 ± 0.23 [a]
Spartina patens	1.84 ± 0.24 [a]	3.50 ± 0.54 [b]
Euphorbia polygonifolia	0.62 ± 0.17 [a]	1.07 ± 0.25 [a]

A strong negative correlation was detected within the pooled data set between *C. kobomugi* abundance and both species richness and diversity (Table 2). However, *S. scoparium* (Coastal Little Bluestem) and *A. breviligulata* (American Beach Grass) were the only species for which significant declines in abundance could be related to increased *C. kobomugi* abundance at the $p < 0.05$ level.

Table 2. Relationship between *C. kobomugi* densities and those of native plants. Data represent spearman's rho values for the correlations between *Carex kobomugi* abundance and species richness, diversity and native plant abundance in all samples pooled (n = 824).

Species Richness	Diversity Index	*Ammophila breviligulata*	*Solidago sempervirens*	*Artemisia* spp.	*Schizachyrium scoparium*	*Spartina patens*	*Euphorbia polygonifolia*
-0.194 (**)	-0.508 (**)	-0.210 (**)	-0.028	-0.040	-0.225 (**)	0.020	-0.052

** Designates relationships significant at the $p < 0.01$ level

There were no significant relationships between species richness and species diversity inside affected areas and those in surrounding areas (Table 3). This suggests that *C. kobomugi* is probably more important than natural heterogeneity in influencing both of these parameters.

However, *A. breviligulata*, *S. sempervirens* and *S. scoparium* showed strong relationships between stem densities within and outside invaded areas. This suggests that there is a strong influence of pre-invasion landscape on stem densities of these species

Table 3. Results of regression analysis of species richness, species diversity and stem densities of common species within invaded areas and those in the immediately surrounding areas (n = 9 beds).

	r^2	P
Species Richness	0.301	0.126
Diversity	0.038	0.615
Ammophila breviligulata	0.704	0.005
Solidago sempervirens	0.861	<0.001
Schizachyrium scoparium	0.730	0.001

Species diversity and species richness inside invaded areas at the naturally- and human-disturbed sites were extremely similar to one another and were significantly reduced relative to the less disturbed site (Table 4). On average, stem counts of *C. kobomugi* were highest at the naturally disturbed sites and lowest at the least disturbed (Coast Guard) sites. In general, abundances of individual species within invaded areas were significantly reduced at the geologically disturbed North Beach site compared to other locations (Table 4). However, *S. sempervirens* and *Artemisia* spp. stem densities were statistically similar at all three locations.

Table 4. Comparison of species abundance, diversity and stem densities per square meter of dominant species in low disturbance (Coast Guard), naturally disturbed (Tip) and human disturbed (North Beach) sites. All data represent mean ± SD for the populations inside the *Carex kobomugi* beds pooled across all bed sizes.

	Lower Impact (mean ± SD) n = 240	Naturally Disturbed (mean ± SD) n = 268	Human Impacted (mean ± SD) n = 316
Species Richness	3.07 ± 1.02[a]	2.57 ± 1.12[b]	2.63 ± 1.27 [b]
Diversity index	0.65 ± 0.32[a]	0.42 ± 0.32 [b]	0.42 ± 0.38[b]
Carex kobomugi	51.2 ± 40.5[a]	133.2± 103.7 [c]	91.7 ± 64.8[b]
Ammophila breviligulata	19.3 ± 23.4[a]	16.8 ± 26.7 [a]	9.9 ± 18.7[b]
Solidago sempervirens	1.4 ± 3.3 [a]	1.4 ± 6.2 [a]	1.0 ± 2.1[a]
Artemisia spp.	0.9 ± 5.4 [a]	1.7 ± 4.2 [a]	1.6 ± 4.9 [a]
Schizachyrium scoparium	4.2 ± 9.4 [a]	0.0 ± 0.0 [c]	0.4 ± 2.9 [b]
Spartina patens	1.7 ± 5.5 [a]	3.4 ± 10.0 [a]	0.5 ± 2.7 [b]
Euphorbia polygonifolia	2.0 ± 9.0 [a]	0.1 ± 0.7 [b]	0.05 ± 0.4 [c]

For each comparison (i.e. across rows), means denoted with the same letter are statistically similar (belong to the same homogeneous subsets as determined using a LSD post hoc test). Means denoted with different letters are statistically different at the $p < 0.05$ level.

When comparing species richness outside the invaded areas between sites, there were significant differences between all three locations, with the lowest richness being in the human impacted site and the highest being in the least impacted site (Table 5). By contrast, there was no significant difference in species diversity in the areas immediately outside the *C. kobomugi* beds at the two high disturbance sites. However, species diversity outside the beds was significantly higher at the less disturbed compared to the human impacted study area (Table 5). Abundances of *A. breviligulata* and *S. patens* on the dunes surrounding the invaded areas were significantly lower at the human impacted site than at the other two study areas. *E. polygonifolia* population densities in the areas surrounding the invaded beds at the lower impact site were significantly higher than those at the other two study sites (Table 5). By contrast, *Artemisia* spp. abundance was significantly greater at the geologically disturbed site compared with the other two locations (Table 5). Finally, there was a significant difference between all sites when comparing the *S. scoparium* populations outside the invaded beds, with the low disturbance site having the highest densities of this species and the geologically disturbed site having the lowest (Table 5). These results suggest that the varying degrees of

disturbance in our three study sites had a direct effect on species richness regardless of presence or absence of the invasive sedge.

Table 5. Assessing the influence of underlying landscape matrix **:** Comparison of species abundance, diversity and stem densities per square meter of dominant species in low disturbance, naturally disturbed and human disturbed sites. All data represent mean ± SD for the populations immediately adjacent to, but outside the *Carex kobomugi* populations, pooled across all bed sizes.

	Lower Impact n = 146	Naturally Disturbed n= 196	Human Impacted n = 133
Species Richness	2.86 ± 1.06 [a]	2.45 ± 1.12[b]	1.85 ± 1.45[c]
Diversity index	0.60 ± 0.34[a]	0.52 ± 0.38[ab]	0.40 ± 0.60[b]
Ammophila breviligulata	19.6 ± 21.1[a]	24.6 ± 29.7[a]	15.9 ± 20.6[b]
Solidago sempervirens	2.2 ± 4.0[a]	1.9 ± 5.5[a]	1.5 ± 3.1[a]
Artemisia spp.	0.8 ± 2.4[a]	4.9 ± 20.0[b]	1.9 ± 5.2[a]
Schizachyrium scoparium	3.4 ± 7.5[a]	0[b]	1.3 ± 5.0[c]
Spartina patens	4.2 ± 13.5[a]	5.0 ± 13.5[a]	0.5 ± 3.0[b]
Euphorbia polygonifolia	2.5 ± 9.4[a]	0.6 ± 1.7[b]	0.1 ± 0.4[b]

Conclusions

The results of this study confirm the observation of Wootton et al. (2005) that *Carex kobomugi* has a strong negative effect on native species abundances and diversities. Indeed, the increased data density of this study, allowed detection of impacts on a much wider array of species than was possible in the earlier study. For example, the negative impact of *C. kobomugi* on species such as *S. patens* and *S. scoparium* were clearly visible in this study (Table 1), whereas Wootton et al. (2005) were unable to detect these effects. Similarly, a stronger impact from the invasion of *C. kobomugi* on species such as *E. polygonifolia, S. patens* and *Artemisia* spp. (Table 2) was detected from these data than in the previous study.

It is important to know if native species stem densities were influenced by the presence of *C. kobomugi* or if some other factor has influenced the growth of these species. Habitat heterogeneity and natural distributions of native plant species may play an important role in the establishment of non-native or invasive species (Hansen et al. 2005). However, when a study is started after an invasion has occurred, it is sometimes hard to assess the relative roles of pre-existing habitat heterogeneity from those of post invasion effects of the invasive species. This is the case here, where there is potentially a degree of "circularity" that makes it hard to distinguish between cause and effect in interpreting the negative correlation between densities

of *C. kobomugi* and native plants observed in this study. Specifically, it is possible that stem densities of native plants within areas are low in areas with high densities of the invasive sedge because the native species were out-competed by the aggressively growing sedge. In this scenario, there is an implicit assumption that stem densities of native plants were high before invasion, but then declined as the area was invaded by *C. kobomugi* (i.e., the growth of the sedge is driving the correlation). Alternately, it is also possible that the reason that *C. kobomugi* was able to achieve high stem densities in certain areas was that those areas had low densities of native plants prior to its invasion. In this second scenario, the pre-existing condition of sparse growth by native plants (due to disturbance or other such factors) created an open niche that *C. kobomugi* was able to occupy. In this scenario, it was the very openness of the existing niche that allowed the invasive sedge to achieve the high stem densities that were later observed in these areas (i.e., the lack of growth of the native plants is what's driving the correlation). Since we have no data on the stem densities of native plants from the dune areas now invaded by *C. kobomugi* it is hard to know which of these scenarios is the best explanation for the observed negative correlations between it and native plant stem densities. However, the fact that there was a strong correlation between the stem densities of many of the native plants inside versus outside the invaded areas (Table 3), suggests that the latter scenario might actually be playing some role in the observed relationships between disturbance and the effects of *C. kobomugi* on native plant stem densities, species richness and species diversity in these habitats.

Nonetheless, the fact that native plant species such as *Ammophila breviligulata*, *Solidago sempervirens* and *Schizachyrium scoparium* showed reduced stem densities when in the presence of *C. kobomugi* (Tables 1 and 2), suggests that, whatever the impact of the background landscape factors, there is clearly an additional effect of *C. kobomugi* in terms of reducing native plant densities and species richness.

Lower native plant richness, species diversity and higher *C. kobomugi* stem densities at the higher disturbance Tip and North Beach study sites relative to those at the less disturbed Coast Guard study site (Table 4) supported the hypothesis that disturbance helps contribute to the invasion success of *C. kobomugi*. However, the species richness outside the invaded areas also showed significant differences between all three sites (Table 5), suggesting that varying degrees of disturbance also had a direct effect on species richness regardless of the presence or absence of the invasive species.

Disturbances have been shown to play a role in the invasion success of a non-native species in other studies. In many cases, disturbances (natural or human impact) favor plant species by providing needed resources for seedling development that were not available prior to the disturbance (Pausas et al. 2005). The fact that species richness and diversity were significantly higher within invaded areas in the relatively undisturbed site relative to the naturally- and human-disturbed sites (Table 4) suggests that disturbance of any type (natural or human impact) has a negative effect on the species richness and species diversity of native plant populations. Similarly, the fact that, within the invaded areas of the less disturbed population, stem densities of *Carex kobomugi* were significantly lower than both the naturally and human-disturbed sites (Table 4) also suggests that disturbance (either natural or human impact) has a

positive effect on the invasion success of *C. kobomugi*. Moreover, the similarities between the two disturbed sites and their differences with the less impacted, Coast Guard, site (Table 5) suggest that the presence of disturbance was more important in determining the impact of the invasive species than the nature of that disturbance.

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The Division of Land Use Regulation's Policy Response to Invasive Species in the Beach and Dune Environment. Chris Dolphin: New Jersey Department of Environmental Protection.

Abstract

In understanding the Division's policy towards invasive species, it is necessary to distinguish between management of State owned lands and regulatory response. As the lead agency in regulating activities in the beach and dune environment, the Division of Land Use Regulation within the New Jersey Department of Environmental Protection employs a variety of approaches to address the issue of invasive species. Although the Division cannot compel property owners to eradicate invasive species, the Division maintains a willingness to work with those who wish to do so. In the recent past, the Division's focus has been primarily upon the protective value of dunes. With anticipated changes to the governing rules, it may be possible to increase the Division's focus on the value of dunes as habitat.

At the outset it is import to acknowledge that government has many different roles and when we think of government's response to invasive and nuisance species we observe three different but complimentary roles. Throughout the conference we heard from those whose role is that of property manager, in other words those who have the responsibility to manage public lands for a variety of public benefits. The control of nuisance and invasive species is very often a listed goal of these managers. We also heard from those who are advocates of native species. These individuals devote time and resources to working with other government agencies and private individuals to fight to eradicate those species that are non-native and cause damage to the environment by crowding out native plants. The third role of government is that of regulator. The Division of Land Use Regulation within the Department of Environmental Protection is the regulatory agency in New Jersey with the greatest oversight of activities within the beach and dune environment and thus has a say over activities aimed at controlling *Carex kobomugi*.

The Division of Land Use Regulation primarily regulates development in New Jersey under five State statutes: The Coastal Area Facilities Review Act (N.J.S.A. 13:19) (CAFRA), which provides authority over development activities within coastal areas; the Freshwater Wetlands Protection Act (N.J.S.A. 13:9B) (FWPA), which provides authority over most activities in and adjacent to freshwater wetlands; the Coastal Wetlands Act of 1970 (N.J.S.A. 13:9A), which provides authority over most activities within coastal wetlands; the Waterfront Development Law (N.J.S.A. 12:5-3), which provides authority over activities within and adjacent to tidal waters areas and the Flood Hazard Area Control Act (N.J.S.A. 58:16A), which provides authority over development activities in and adjacent to stream corridors and the 100 year floodplain. The Division also oversees the management of the state tideland resources, which are those areas of the state flowed by the tide and held in trust for the public by the State. Since *Carex kobomugi* makes its home in the beach and dune environment, CAFRA is the environmental statute of interest. Although the jurisdictional thresholds of CAFRA are complicated and change

with proximity to the beach, dune or mean high water, suffice it to say that CAFRA regulates just about every activity on the beach or dune.

The Division also has authority to regulate Federal activities under the Federal Coastal Zone Management Act of 1972. That Act allows states to establish coastal programs to manage the coastal resources within its boundaries and requires that all Federal activities be consistent with the State Coastal Zone Management Program. The implication of this is that the National Park Service and the Coast Guard must obtain a statement of consistency from the Division prior to undertaking activities, including activities aimed at eradicating invasive species.

The Division of Land Use Regulation has developed administrative and technical rules to guide its decision making process for the implementation of the above referenced statutes. The Coastal Program Rules (N.J.A.C. 7:7) are the administrative rules that govern the implementation of CAFRA, the Wetlands Act of 1970 and the Waterfront Development Law. The technical rules for these statutes are found within the Coastal Zone Management Rules (N.J.A.C. 7:7E). The administrative and technical rules governing the implementation of the FWPA are found within the Freshwater Wetlands Protection Act Rules (N.J.A.C. 7:7A). The administrative and technical rules governing the implementation of the FHACA are found within the Flood Hazard Area Control Act Rules (N.J.A.C. 7:13).

As mentioned, the Coastal Permit Program Rules are the administrative rules for CAFRA. These Rules outline the application process and establishes three categories of permits: permit-by-rules, general permits and individual permits. Permits-by -rules are paperless, and are reflective of a determination that some activities, although regulated by statute, have little to no impact on the environment and as such do not warrant review by the Division. The next category is general permits. General permits are very basic. The Rules lay out specific cookbook approach to what one can and cannot do in a particular situation. Currently there are approximately 27 different general permits available. We have general permits that include such things as building a single family home, shoreline protection, and habitat improvements. The approach with general permits is to lay out exact requirements for activities. If an applicant meets the general permits, the assumption is that the environmental impacts of the activity are acceptable without detailed environmental studies. Overall, these permits require considerably less time, energy, information and cost to obtain. The last category is individual permits. These permits are very difficult to come by. They have extensive notice and procedural requirements and require detailed environmental studies. Whereas a general permit may take up to 90 days to obtain, an individual permit may take up to year and a half to obtain. For the individual permit, significant emphasis is placed on the applicant demonstrating that there is no alternative to the activity; that it is necessary to solve a particular need; that impacts are minimized; and that those impacts that may occur, can be successfully mitigated. Please note that the permit categories listed above are not applicable to consistency requests made by Federal agencies, under the Coastal Zone Management Program. Under the Federal Consistency program, Federal agencies are not seeking permits, but rather are seeking a concurrence that their project is consistent with the substantive rules discussed below.

Our substantive rules for CAFRA and the State Coastal Zone Management Program are the Coastal Zone Management Rules. These Rules are the nuts and bolts of our review. They describe a wide variety of special areas and resources the Division wishes to protect along with a wide variety of activities that it wishes to control. The Management Rules are broken into specific rules that include rules governing special areas and resources of both natural and cultural significance such as habitat areas, dunes, beaches, marinas, and historic and archeological resources. The Division is concerned with those locations and resources that have value to the environment; to the economy of our coastal zone; and to our culture, and thus deserve protection. However, it is not enough to concern ourselves with just special areas and resources; we must also evaluate the appropriateness of certain human activities. The Rules on Coastal Zone Management cover a wide variety of issues and concerns.

The focus of the conference was what we can and cannot do about *Carex kobomugi* in the beach and dune environment. Focusing on the regulatory role, the Division reacts to specific questions, posed by an applicant, whether that is an individual or a municipality. The question may be: is there something I can do on the dunes in terms of protecting the dunes, or is there something I can do on the beach in terms of increasing habitat for piping plover, or is there something I can do to increase the blanket space.

With respect to managing vegetation on a beach or dune, it is important to note that both the CAFRA statute and the Coastal Permit Program Rules, state that all development activities on a beach or dune, including grading, excavation and filling are regulated. What the law and the rules do not say is that vegetation removal is regulated. As such, the hand removal of vegetation from the beach and dune is not regulated. If a property owner, whether public or private want to manage their vegetation by hand cutting, or by herbicidal treatment, the Division is of the mind that it is not a regulated activity. However, vegetation management becomes a regulated activity if the property owner uses equipment that moves sand around or disturbs the root mass since the Division sees these activities as constituting grading or excavation. There is a sense among the public however, that nobody can touch the dunes; that you can't walk on the dunes let alone remove vegetation by hand. Under Division's rules and regulations, that simply is not true, and here is an opportunity for those who serve as advocates to become involved and help educate the public. One note of caution: the possibility exists that the local community has an ordinances that controls activities on the beach and dune. Before one undertakes management activities it is recommended that they consult the municipality.

Obviously there are times where, whether it is for habitat creation or to maintain the beach for tourism, property owners and municipalities wish to undertake activities on the beach or dune that require permits, as such there are general permits available for a certain activities. One general permit allows for routine beach and dune maintenance. This general permit allows activities such as beach raking, installation of sand fencing and vegetation planting. What is not allowed is the removal of vegetation.

Remember, when we look at the general permit, the first step is to determine whether it is a regulated activity. Once it is determined that an activity is regulated, the Division then has a

greater say as to how you actually undertake that activity. The general permit for beach and dune maintenance allows individuals and communities to supplement but not remove vegetation. If the individual or community wish to go beyond the activities listed in the general permit, they must obtain an individual permit. It is important to note that the need for an individual permit is not synonymous to a denial of the activity. Just because the Division is a regulatory agency, doesn't mean the answer is always no. In fact the answer is often yes, but it is dependent upon the argument presented by the applicant. The Division tries to balance between the needs of a community, with protection of the beach and dune environment. With respect to managing vegetation on dunes, the Division recognizes that there is a need to control invasive species or to provide for habitat while protecting the storm protection functions of the dune. The arguments presented by an applicant must address that balance.

In addition to having a say regarding direct beach and dune maintenance activities, the Division can require specific beach and dune maintenance as mitigation for other activities on the dune. By way of example, if an individual seeks a permit for expansion of a home on a dune, and provided it meets the rules, the Division will require enhancement and stabilization of the dune. Our rules limit the vegetation that may be used in stabilizing the dune. *Carex kobomugi* is not an accepted plant.

When we consider the overall government response to the control of invasive and nuisance species, it is useful to consider some of the limitations of the regulatory approach, and to begin to contemplate how the other roles of government, i.e. property managers and advocates can work together to create a comprehensive program. One apparent limitation is that the Division does not and can not require management plans for the beach and dunes in terms of individual property owners. It is very difficult in a state like New Jersey where home rule is a key component of our society. Individuals feel very strongly about what they can and cannot do with their property. Although there are many in the department who would agree with the need to control invasive plants, the Division has to walk that line between individual freedoms and controlling what people do. It is often difficult to control individual behavior. Those whose role is that of advocate are in the best position to educate the public about the impacts of invasive species. Those whose role is that of property managers, are in the best position to serve as role models for what is the appropriate way to manage our beach and dune environment.

Another clear limitation is the Division's regulatory focus on maintaining dunes as shore protection structures. It is not that the Division does not recognize the habitat value of dunes, but the history of our approach to dunes has been to maintain their ability to provide hazard mitigation even at the detriment of habitat value. As we move forward, it would be worthwhile for the department to try and change that paradigm. Support from property managers who have had success in the eradication of invasive species, or in the maintenance of beach and dune areas for habitat, while maintaining the protective functioning of the dunes would be welcomed.

Our rules, our guidelines, our recommendations were written years ago, and may be based upon information that is out of date. In this age of shrinking budgets and doing more with less,

it is difficult for Division staff to keep up with the latest information. It would be helpful if academia and or the resource agencies created clearing houses to provide access to the latest information. We need to start thinking about other avenues of communication. I think we need to be diligent about continually re-educating ourselves and re-educating our staffs, re-educating the public, and making sure that we are all coming together and are on the same page.

As of the summer of 2011, the Department of Environmental Protection was beginning an overhaul of both the Coastal Permit Program Rules, and the Coastal Zone Management Rules. The Department welcomes input on how to craft better rules. To address the challenges facing our planet, we must all come together and forge a new partnership.

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Managing Invasive Woody Plants in Maritime Forests and Meadows. Glenn D. Dreyer, Charles & Sarah P. Becker '27 Director, Connecticut College Arboretum, New London, CT

Abstract

The dense human settlements of the coastal Northeastern United States have served as the epicenters of exotic plant introduction for hundreds of years. Many woody plants, including Japanese barberry (*Berberis thunbergii*), Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*) and Oriental bittersweet vine (*Celastrus orbiculatus*), were imported for aesthetic and conservation purposes and have escaped and proliferated in preserves and other undeveloped coastal habitats. A variety of tools and techniques are available for successfully managing invasive woody plants, ranging from hand pulling through the use of chemicals and fire. Examples from the Connecticut College Arboretum in coastal New London and the Sachuest Point National Wildlife Refuge in coastal Rhode Island provide illustrate a variety of control strategies for Oriental Bittersweet and other invasives.

Species Biology

Successful management and control of invasive species starts with a thorough understanding of the biology and ecology of the problem species. In general, the biological information for plants should include physiology, reproduction, dispersal mechanisms, germination requirements, occurrence of vegetative reproduction, and phenology (vegetative and reproductive). The ecological aspect is information about the plant's known tolerance of environmental factors including temperature, soils, light levels, and moisture, plus its sociology, i.e. interactions within biological communities. Another significant piece of the management puzzle is understanding the human cultural interactions – is the plant being sold or gathered or otherwise moved by people, and what does the average person know or care about it?

In coastal Southern New England, the most problematic invasive woody species are Oriental bittersweet, Japanese barberry, Japanese honeysuckle, multiflora rose, tree of heaven (*Ailanthus altissima*), black locust (*Robbinia psuedoacacia*), autumn-olive (*Elaeagnus angustifolia*) and burning bush (*Euonymus alata*). Detailed summaries of biology and management information for most of these species are available through the iMapInvasives website.

Oriental Bittersweet Biology and Ecology Example

One of the most abundant and aggressive coastal invasives in this region is Oriental bittersweet, a woody vine that climbs by twining its stems around any available support feature including shrubs, trees, utility poles and houses, among others (Dreyer 1992, 2004). It eventually may kill other plants either by constricting stems as the host and vine both continue to grow in diameter, or by covering over the leaves of the plants below it.

Male and female flowers are typically found on different plants. Females produce distinctive clusters of berry-like fruit, located at leaf attachment nodes, which have a yellow outer

covering that opens to reveal a red fleshy aril with an average of about 4 seeds in each. Seed dispersal is by birds and mammals. Germination rates are high and can occur at low light levels. Thus plants can become established in shady understories as well as sunnier sites.

My early observations led me to believe that the vine produced shoots from the root system (root suckering) and thus formed clones. After having hand pulled many plants, I now think that it is only a weakly root suckering species, and that many individuals in bittersweet patches begin as seedlings. However, cut stems will vigorously resprout with multiple new shoots, like most other woody plants.

Although restricted to terrestrial locations, it has broad tolerance of habitats and moisture regimes, growing vigorously in pure coastal sands, dry roadsides, stream banks and rich, mesic slopes.

Humans are one of the major dispersers of this vine. It was introduced from Eastern Asia as an ornamental plant in 1860 (Rehder 1977), and was extensively planted throughout the Eastern US during the 20th Century. In addition to landscape plantings, shoots with fruit are often used in floral arrangements.

Oriental bittersweet is easily confused with the native *Celastrus scandens*, and the two can only be reliably distinguished by comparing female plants in flower or fruit. The native has clusters of flowers that produce clusters of fruit only at the ends of branches. The exotic species has clusters with fewer flowers and fruit (3-7) and these are only located at the point where leaves join the stem. This results in a significant difference in growth potential, since flowering stops stem length extension in the native *C. scandens* stem, but Oriental bittersweet can continue growth past the axillary flower and fruit clusters. Another, more subjective, difference between the two species is that the native has orange colored coverings around their red fruit, while the introduced has a yellow covering.

The fact that the introduced, naturalized vine looks so much like a fairly well known, but never very abundant, native plant clearly slowed recognition of the invasive's spread and also slowed acceptance of the new plant as a problem species. Artificial crosses between the two species have resulted in fertile hybrid offspring (White and Bowden 1947), which has led to speculation about the possible genetic dilution and eventual elimination of purely native populations of *Celastrus*.

Invasive Management Techniques

Management techniques for invasive woody plants can be categorized into mechanical, chemical and biological methods. A few general principles should guide the choice and implementation of any method. First, site disturbance should be minimized when removing invasives. Creating new patches of bare soil only serves to invite germination of plants that may be unwanted. Closely related is the idea of being as accurate as possible in applying a method. Removing only the problematic species, and causing a minimum of damage to nearby, non-target plants, allows the latter to fill in the newly created space rather quickly. It should be understood that not every technique is appropriate for every species in every situation, and the full spectrum of management tools should be considered when beginning a control program.

One source of accurate management information for many invasive plants can be found on the Connecticut Invasive Plant Working Group web site.

Mechanical. One tried and true mechanical method for controlling invasives plants entails removing all or most of the plants root system from the ground. Well known methods include hand weeding of small plants in limited numbers, digging with shovels and other hand tools, pulling larger plants out of the ground with devices such as the Weed Wrench. Tractors and bulldozers to push or pull large individual trees or shrubs from the ground is often employed for larger individuals and or larger areas. With the exception of hand pulling and the Weed Wrench, these mechanical methods cause considerable site damage and may invite reinfestation.

Cutting is another widely used technique, and methods range from hand clippers and axes to chain saws, brush cutters, brush hogs and even bigger cutting machinery. Cutting usually results in woody plants producing new stems, either from dormant buds in the crown/root collar area (stump sprouting) or from dormant buds in the root system (root suckering). Thus if cutting is to be used alone, it often must be done many times in a single growing season to exhaust plant resources stored in the roots. Cutting combined with herbicide application can be very effective.

Chemical. Herbicides are chemicals specifically formulated to kill plants, but unfortunately not every chemical is effective with every plant species. Herbicides are often found to be the most economical way to get reasonably complete control of infestations. Only the most selective or accurate application technique available should be utilized with the goal of minimizing both the amount of chemical used and damage to non-target species. For example, spraying the stumps or stubs of cut and removed plants is preferable to foliar applications to uncut plants. Backpack foliar applications are preferable to aerial applications. A secondary goal is to try to find a chemical which will root kill the target species with one application.

The controlled use of fire can be considered another chemical management option. One technique is to use a portable propane torch to burn the crown of the woody plants as recently described by Ward et al. (2009). Another is the controlled burning of patches, fields or forest understories. Generally, burning the tops of woody plants does not result in root kill, and thus functions much like cutting or mowing. This type of burning is also not selective, in that it does not target only the invasive plants. However, burning has been shown to exclude the establishment of invasive species by seed in coastal southern New England (Niering and Dreyer 1989), and thus may be an appropriate preventative technique in certain situations.

Biological. Biological control entails the use of living organisms to control invasive species. One approach is to use grazing animals such as sheep and goats that browse on woody plants. Animals may be appropriate in situations where the desired vegetation is pasture or pasture-like.

Classical biological control of unwanted plant species utilizes insect herbivores from the plant's original native range which are carefully screened and selected so that only those that are very specialized to eat only that single species are imported. After additional testing of the insect's

eating preferences with plants native in the new location, it is released onto the invasive species. The goal of these programs is for the biological control agent to greatly reduce, but not eliminate, the pest plants so that some remain to support small populations of the biological control organism. Originally only used for agricultural plant pests, these techniques are now being adopted for invasive plants in natural habitats.

Oriental Bittersweet Management Example

Oriental bittersweet seedlings can be easily pulled by hand, and even larger vines can often be successfully pulled out of the ground. With tall/long vines attached to trees, the stems can be cut at a convenient height and allowed to rot in place, a process that can take up to 4 years in Connecticut. For stems too large to pull up by the roots, cutting them a ground level with a saw and spraying the cut surface with a 25% solution of a Glyphosate concentrate such as Roundup, in water, will prevent resprouting (personal observation).

In the Connecticut College Arboretum, I have observed that mowing large bittersweet patches only 2 or 3 times in growing season does not suppress the vine, but encourages it to spread.

Foliar sprays of Triclopyr containing herbicides, such as Garlon, mixed at rates as low as 1% in water have been shown to rootkill bittersweet with one application (Dreyer 1988). This chemical is also preferred because it does not kill Monocots, so grasses, sedges and members of the lily family, among other plants, survive the treatment. Foliar Roundup applications do not rootkill bittersweet (Dreyer 1988), but do affect a much broader range of plants, so there is much greater non-target mortality and site disturbance when it is used.

In meadows, grasslands and shrublands, an effective technique is to mow or otherwise cut the vegetation to ground level early in the growing season, then apply Triclopyr to the re-growing foliage of the target plants via back pack sprayers approximately one month later (Dreyer 1988). Compared to spraying uncut vegetation, this technique uses much less chemical because there is much less foliage to treat. It also allows more accurate application and thus entails less non-target damage, and it decreases the amount of chemical drift, since the plants are very low to the ground. In the Connecticut College Arboretum, when dealing with bittersweet in conjunction with other woody invasives, we often use a combination of Triclopyr and 2,4-D herbicides which increases control, especially of Japanese honeysuckle.

Similar techniques can be used on large scale infestations by employing agricultural equipment, although boom sprayers on tractors are not a selective application technique. Sachuest Point National Wildlife Refuge Rhode Island was a post agricultural coastal shrubland heavily infested with Oriental bittersweet. Experimental applications to quarter-acre test plots showed that very low concentrations of Triclopyr herbicide provided excellent control of bittersweet, with varying effects on other woody and herbaceous species (Dreyer and Kline 2005). Based on that study, management recommendations for the refuge were to remove bittersweet by mowing all vegetation, spraying the regrowth a month later, and then initiating a controlled burning program to deter reinfestation by invasives and encourage the many fire tolerant native plants in that coastal habitat.

Resources

Connecticut Invasive Plants Working Group:
http://www.hort.uconn.edu/cipwg/art_pubs/GUIDE/guideframe.htm

iMapInvasives website http://www.imapinvasives.org/index.html

Red Dragon Propane Torch:
http://www.flameengineering.com/Red_Dragon_Propane_Torch_K.html

Weed Wrench: http://www.weedwrench.com/

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The Influence of Nitrogen Deposition on the Competition between the Native *Ammophila breviligulata* and the Exotic, Invasive *Carex kobomugi.* Barbara Edelhauser. Maser Consulting, Redbank NJ and Georgian Court University, Lakewood NJ and Louise Wootton. Georgian Court University, Lakewood NJ.

Abstract

The invasive sedge, *Carex kobomugi,* increasingly competes with *A. breviligulata* on NJ sand dunes. Increases in nitrogen input such as that resulting from atmospheric nitrogen deposition, favor some invasive species. Plots on sand dunes at Sandy Hook, NJ containing a mixed community of *Carex kobomugi, Ammophila breviligulata* and a variety of other native plant species, were fertilized over the course of a year. Stems were counted to determine if increased nitrogen inputs correlated with increased stem counts in either species. Mycorrizal infection and sand deposition were also investigated. Contrary to findings in its native range, *C. kobomugi* growing in New Jersey was found to be mycorrhizal. Neither species was influenced significantly by increases in nitrogen input. However, the agricultural weed, *Conzya canadensis*, showed increased stem counts with increasing nitrogen input.

Introduction

Asiatic Sand Sedge, *Carex kobomugi* Ohwi, is a common sand dune plant found in China, North and South Korea and Japan (Small 1954). In its native, far eastern coastal sand dune habitats, *C. kobomugi* is a dominant species in some communities. *Carex kobomugi* is believed to have been accidentally introduced to the United States early in the 1900s, either as a result of release of propagules from materials used as packing material for Oriental porcelain (Halsey 2002) or, more probably, from materials associated with solid ballast (Small 1954). However it got here, the first published record of *C. kobomugi* in the United States was at Island Beach, New Jersey in 1929 (NPS 2005). In addition to expansion through natural propagation from these original plants, from the 1960s to the 1980s, the species was widely planted on dunes along the Eastern seaboard to stabilize dunes (Wootton et al. 2003). *Carex kobomugi* was first observed at the Sandy Hook Unit (SHU) of the Gateway National Recreational Area by Richard Stalter in 1979. Stalter (1980) estimated the oldest of those *C. kobomugi* beds to be more than ten years old. Further spread of the species at SHU resulted in an increase of 780% in the area occupied by this species between 1985 and 2003. Another increase in coverage by 300% increase has occurred between 2003 and 2008. In excess of 54 acres of dunes at SHU are now infested by *C. kobomugi* (Wootton 2010). One of the negative effects of the invasion of New Jersey dune ecosystems with *C. kobomugi* is that native plant diversity is lower in *C. kobomugi* stands than in stands of *A. breviligulata* (Wootton et al. 2005a).

Little is known about the factors that influence the competitive success of *C. kobomugi* in the coastal dunes of New Jersey. Increased nitrogen availability has been shown to provide a competitive advantage for certain invasive species in several studies. For example, on Dutch dunes, nutrient enrichment from atmospheric deposition correlated with the encroachment of exotic grasses (Kooijman et al. 1998). It is not known if nitrogen enrichment is a significant factor affecting competition between *C. kobomugi* and *A. breviligulata*, or even if mycorrhizal

associations are consequential in the relationship between the two species. What is known is that the increase in *C. kobomugi* on New Jersey coastal dunes has occurred over a century of increasing atmospheric nitrogen deposition. A reconstruction of trends in total atmospheric N-deposition in the northeastern United States shows an increase of 0.26 kg N ha^{-1} per decade over the last century (Bowen and Valiela 2001).

A difference in the mycorrhizal status between *A. breviligulata* and *C. kobomugi* may influence competition between the species, particularly in regard to their ability to respond to increasing nitrogen deposition. *Ammophila breviligulata* is known to form mutualistic relationships with arbuscular mycorrhizal (AM) fungi, which is considered to be an important factor in its success in sand dune communities (Gemma and Koske 1997). Until recently, the family Cyperaceae had been considered to be nonmycorrhizal. However, this assertion has now been challenged (Miller et al. 1999, Muthankumar et al. 2004). Mycorrhizal status in the Cyperaceae appears to be associated with environmental conditions. For instance, while many of the wetland species are nonmycorrhizal, many upland species are mycorrhizal (Miller et al. 1999, da Silva et al. 2001, Muthankumar et al. 2004). However, neither Wang and Qui (2006) nor Wang and Shi (2008) include *C. kobomugi* on their updated list of mycorrhizal land plants. *Carex kobomugi* was found to be weakly mycorrhizal on Solonchak soils (saline soils in hot, arid locales) in Inner Mongolia (Sheng et al. 2007). Khan et al. (2009) isolated nine endophytic fungi from the roots of C. kobomugi plants in Korea. However, only one species is named, *Arthrinium phaeospermum*, Family Xyeriales, which is not an arbuscule forming fungus. Mack and Rudgers (2007) note a negative correlation between endophytic and mycorrhizal colonization. It is, therefore, unlikely that the endophytic fungi isolated in *C. kobomugi* are vesicular-arbuscular mycorrhizae (VAM) fungi. Funatsu et al. (2005) reported no mycorrhizal colonization of *C. kobomugi* in a study located on Japanese sand dunes. The American literature is silent on the mycorrhizal status of *C. kobomugi* in the U.S.

Small amounts of nitrogen enrichment have been shown to affect mycorrhizal communities in oligotrophic sandy soils in New Jersey (Dighton et al. 2004), it seems likely that existing N-deposition levels may be affecting the interactions between mycorrhizae and their host plants. If *C. kobomugi* is not mycorrhizal, or is weakly mycorrhizal, or differs in the nature or extent of its mycorrhizal associations relative to *A. breviligulata*, then increases in atmospheric deposition would be expected to affect each species differently. This, in turn, would have the potential to change the competitive balance between these two species. Because non-mycorrhizal plants are capable of responding quickly to increasing nitrogen inputs (Keenan et al. 2008), a lack of, or minimal reliance on, mycorrhizal associations might be expected to provide a competitive advantage to *C. kobomugi* over *A. breviligulata* under conditions of increased nitrogen availability. Other factors, which may affect competition between the species are sand deposition (known to increase *A. breviliguta* vigor) and differences in their ability to absorb and utilize nutrients.

The goals of this study were thus (1) to determine the mycorrhizal status of *C. kobomugi* in New Jersey's coastal dune ecosystems and (2) to explore the effects of nitrogen deposition and mycorrhizal status on the nutrient status of and competition between *A. breviligulata* and *C.*

kobomugi.

Materials and Methods

Twelve, monthly fertilizer applications were performed to simulate levels of atmospheric discharge to these test plots. Four control plots received no fertilizer but received an approximately equal volume of water used to apply the fertilizer in other plots. Four plots received nitrogen fertilizer at a concentration of 8.25 kg total N ha^{-1} $year^{-1}$, which represents a 50% increase over the atmospheric nitrogen deposition levels measured at Washington Crossing (NADP 2004). Four plots received nitrogen fertilizer at a concentration of 33.0 kg total N ha^{-1} $year^{-1}$ per ha per year, which represents a doubling of the Washington Crossing atmospheric nitrogen deposition rate. The final four plots received nitrogen fertilizer at a concentration that will equal 165.0 kg total N per ha per year, which is approximately 10 times the recently measured deposition rate. The fertilizer consisted entirely of NH_4. The NH_4 to NO_3 nitrogen ratio was observed in the Washington Crossing data (NADP 2004). A fertilizer with these nitrogen ratios was not available. Thus, Simplot® urea fertilizer 46-0-0 was utilized, since it only contained nitrogen and was water soluble.

Stems of all species within one half of the plots were counted and recorded. This data provided a measure of whether *C. kobomugi* or *A. breviligulata* increased in response to N fertilization. The data allowed observations on changes in diversity and species numbers in relation to N fertilization. Soil and plant samples were taken from the other half of the plot to avoid disturbance related effects on stem counts. Nutrient analysis was performed on soils and leaves of *C. kobomugi* and *A. breviligulata*. Nutrient analysis was performed on soils for the macronutrients phosphorus, potassium, magnesium and calcium and the micronutrients zinc, copper, manganese, boron and iron. Leaf tissue analysis was performed for the nutrients nitrogen, phosphorus, potassium, calcium, magnesium, manganese, boron, zinc, molybdenum and copper.

Roots of *C. kobomugi* and *A. breviligulata* were stained with Trypan Blue dye and viewed under a compound microscope to search for arbuscular mycorrhizal infection. Sand deposition at landward and seaward ends of plots measured on clear Perspex rulers established in plots to eliminate sand deposition as a confounding factor in competition between *C. kobomugi* and *A. breviligulata*.

Results

Effect of Nitrogen Amendment on Stem Counts

When pooled across all plots, a significant difference between the stem densities of *A. breviligulata* and *C. kobomugi* stems was observed (2 Way ANOVA $F= 44.168$, 3df, $p < 0.001$), with *C. kobomugi* stem counts being significantly higher than those of *A. breviligulata*. Stem counts for *C. kobomugi* in control plots were consistently lower than those in treatment plots, suggesting a positive effect of increased nutrient levels, particularly early in the second year. However, this effect was not statistically significant ($F=0.621$, 3df, $p = 0.608$). The response of *C. kobomugi* to the addition of water and nitrogen appeared qualitatively to be proportionally

stronger than that of *A. breviligulata* (control is more consistently lower, and the percent increase between the two years is larger.

Again, though, the difference in the species' responses to the treatment was not statistically significant (Interaction Effect F= 0.434, 3df, p= 0.731). It should be noted, however, that the low number of replicates in this study resulted in low statistical power for these comparisons: (1 – β = 0.16) for analyses of different fertilizer levels and (1 – β = 0.056) for the interaction between plant type and fertilizer level. Since there were no significant effects of fertilizer on stem counts of either species, data on stem counts were pooled within species across all fertilizer levels and compared between August 2006 and August 2007. A significant increase in stem densities of both *A. breviligulata* and *C. kobomugi* was observed (*C. kobomugi* t=5.982, 15df, p<0.001, *A. breviligulata* t=2.630, 15df, p=0.019) between years (Figures 1 and 2).

*Conyza canad*ensis (horseweed) stem counts did show a significant response to N-fertilization F=5.558, 3 df, p=0.13 (Figure 3). The control plots and the lowest fertilization levels were characterized by the lowest stem counts. The intermediate fertilization rate yielded intermediate numbers of *C. canadensis* stem counts. The high fertilization rates resulted in significantly higher stem counts. Also observed was a large increase in stems counts from the first to second years. Post hoc Tukey tests confirm the significance of a time related increase in horseweed stem counts (F=12.669, 5 df, p=0.006), but do not detect a significant effect of nitrogen fertilization level (F=1.141, df=24.000, p=0.383).

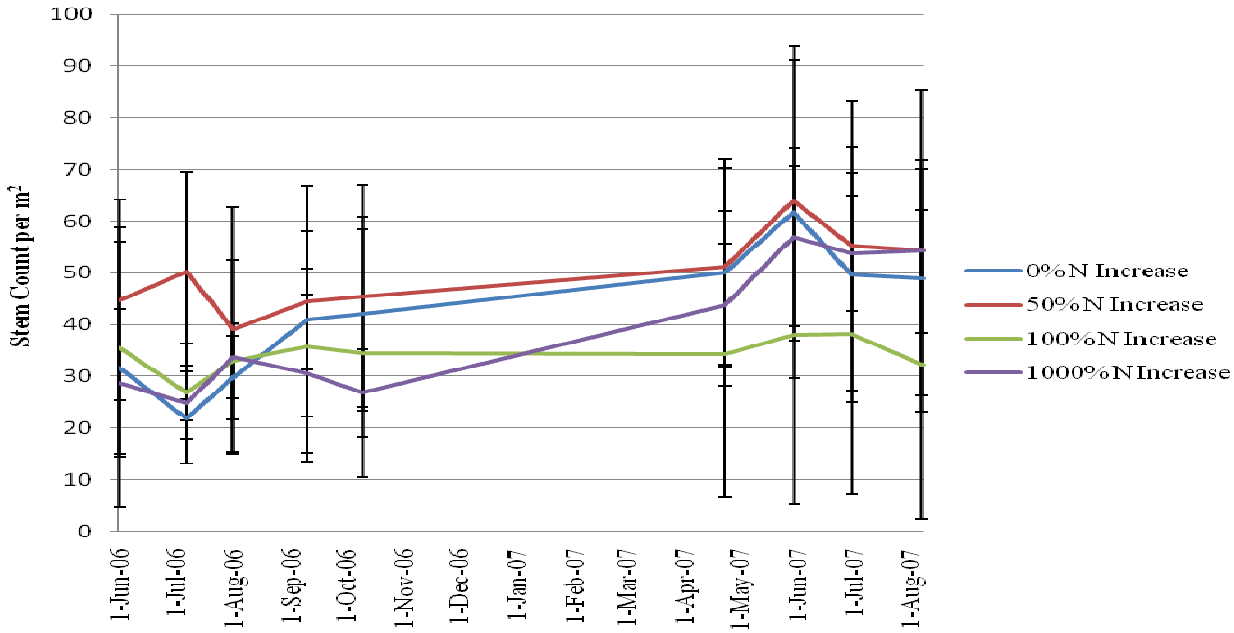

Figure 1. Variation in *Ammophila breviligulata* stem counts over time under different levels of nitrogen ammendment Error bars represent 1 SD

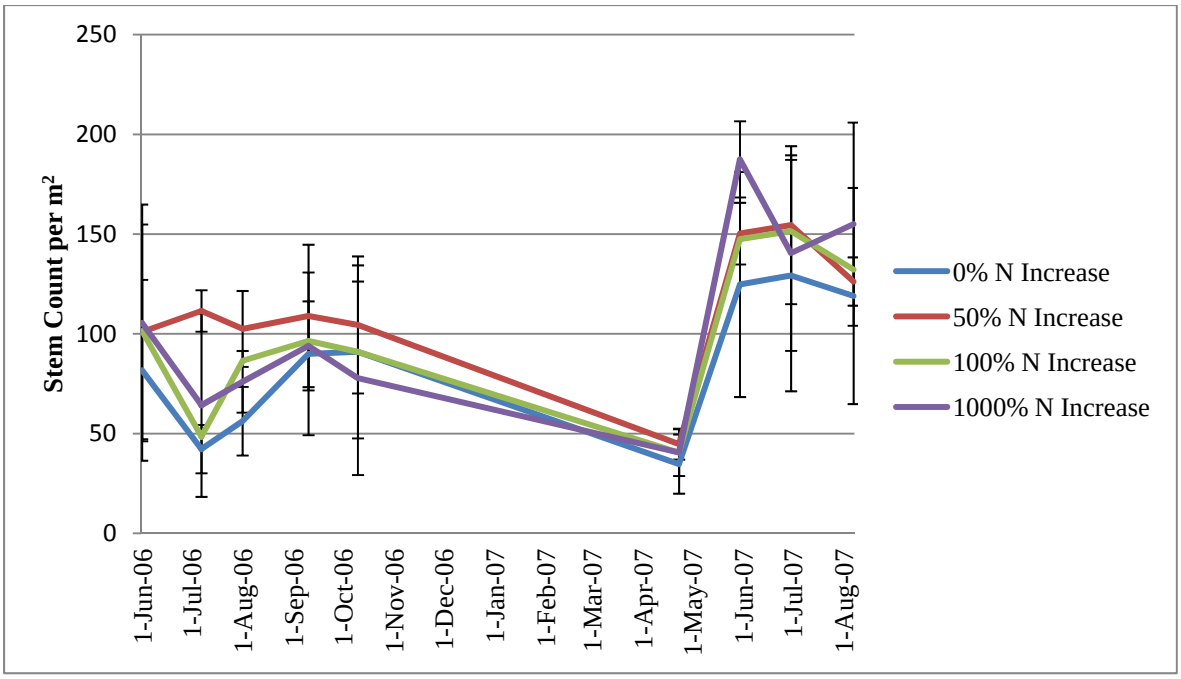

Figure 2. Variation in *Carex kobomugi* stem counts over time under different levels of nitrogen ammendment. Error bars represent 1 SD.

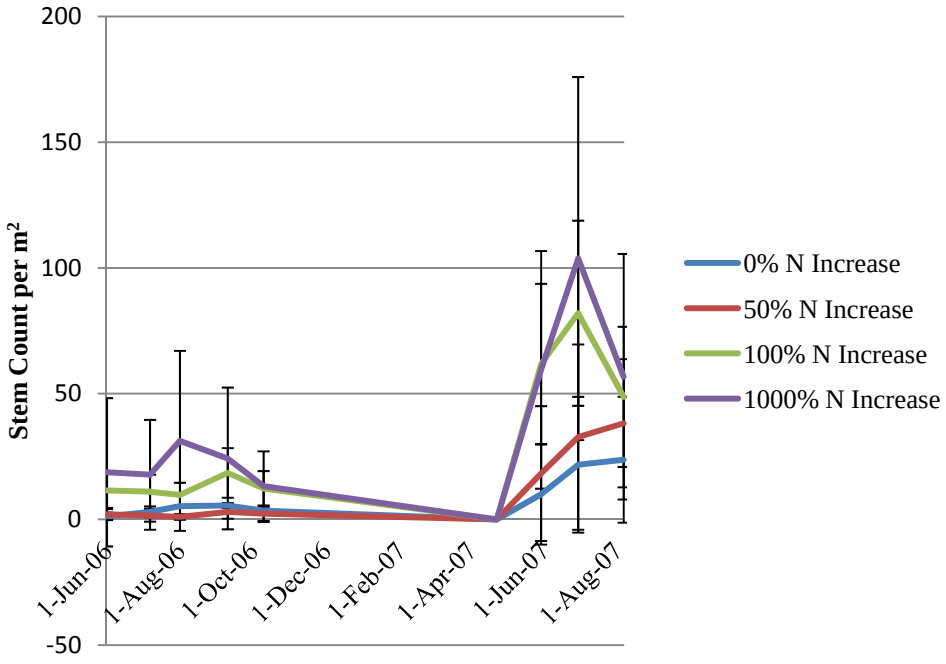

Figure 3. Variation in *Conyza canadensis* stem counts over time under different levels of nitrogen ammendment Error bars represent 1 SD

Sand Deposition

No significant difference in sand deposition was found between in plots receiving different levels of fertilizer amendment (2 Way ANOVA, F = 1.104, 3df, p = 0.367), or between landward and seaward ends of the plots (F = 0.494, 1df, p = 0.489). No interaction effects were detected between treatment and location within the plot (1.021, 3df, p = 0.401). However, the power of the analysis was low (0.104 for plot location, 0.26 for fertilizer level and 0.242 for the interaction effect).

Soil Nutrient Levels

Prior to fertilization, the mean initial soil pH was 7.05. As might be expected for sandy coastal dune soils, a deficiency in iron, copper, manganese, zinc and boron for the growth of crop plants was noted in the majority of plots. The level of calcium in these soils was more than six times higher than any other nutrient. The level of nitrogen in nitrate and ammonium form was significantly different $p<0.001$). The mean NO_3 level was 1.44 ppm (SD=0.73). The mean NH_4 level was 3.63 (SD=0.96).

The final mean soil pH was 7.12. No significant difference in the pH was observed between the control and plots receiving nitrogen amendments at the start of the experiment (F=1.504, df=3, p=0.264). There was, however, a significant increase in pH in the control plots between years (F=2.840, df=4, p=0.045). When comparing data on soil nutrient levels in plots receiving different levels of nitrogen amendment at the end of the experiment, no significant influence of nitrogen fertilization levels on other soil nutrient levels was observed.

Plant Tissue Nutrient Concentrations

Previous to nutrient application, the whole plant tissue concentrations of all of the macronutrients and micronutrients differed significantly between *A. breviligulata* and *C. kobomugi* Nitrogen F=61.314, df=3, p<0.002; Phosphorus F=10.799, df=3, p<0.001; Potassium F=69.238, df=3, p<0.001; Calcium F=46.842, df=3, p<0.001; Magnesium F=12.131, df=3, p< 0.001; Manganese F=26,113, df=3, p<0.001; Boron F=42.123, df=3, p<0.001; Zinc F=12.582, df=3, p<0.001; Molybdenum F=3,570, df=3, p=0.021; Copper- F=5.755, df=3, p<0.001) (Table1). *Ammophila breviligulata* exhibited higher concentrations of nitrogen, phosphorus and zinc in whole plant tissue, while *C. kobomugi* was higher in the remaining nutrients.
Pre–experiment root tissue concentrations of all of the macronutrients, except for calcium and all of the micronutrients except for manganese and molybdenum differed significantly between A. breviligulata and *C. kobomugi* (Tukey's HSD: Nitrogen p=0.034; Phosphorus p=0.045; Potassium p=0.001; Magnesium p=0.001; Boron p<0.001; Zinc p<0.001; Copper p=0.067). *Ammophila breviligulata* exhibited higher concentrations of nitrogen and zinc in root tissue, while *C. kobomugi* was higher in the remaining nutrients

Table 1: Comparison of Initial Mean Nutrient Concentration of Pooled Plant Tissue

	N	P	K	Ca	Mg	Mn	B	Zn	Mo	Cu
A. breviligulata (n=22)	8350	1676	8972	3607	1384	55.97	3.941	35.47	11.58	5.321
C. kobomugi (n=29)	8856	1650	15100	4359	1442	90.75	5.761	15.85	13.60	4.575

An N:P ratio lower than 14 indicates nitrogen limitation (Koerselman and Meuleman 1996). The initial N:P ratios of *A. breviligulata* and *C. kobomugi* (4.31 ± 0.88 and 4.96 ± 0.69 respectively; appear to confirm nitrogen limitation in the dune community at the SHU of Gateway National Recreation Area.

No significant variation in macronutrient levels was associated with nitrogen amendment in A*. breviligulata tissue*. Among micronutrients measured in *A. breviligulata* leaves, only copper showed a significant response to the differing nutrient additions (Copper F = 4.537; 3,12df; p = 0.024). The only nutrient in the leaf tissues of *C. kobomugi* which showed a significant response to nitrogen additions was potassium (F = 4.584; 3,12 df; p 0.023).

Plant Species/Diversity

The following species occurred in one or more of the study plots: *Ammophila breviligulata, Carex kobomugi, Conyza canadensis, Oenothera biennis, Prunus maritima, Chamaesyce polygonifolia, Solidago sempervirens, Arenaria serpyllifolia*. Species diversity was similarly low in all plots (F=0.361, df=3, p=0.782). *Ammophila breviligulata* and *C. kobomugi* make up the majority of stems in the study plots. These two species do not appear to change much in frequency over the course of the study.

Mycorrhizal Status

Structures associated with VAM fungi were observed in preliminary root samples collected from both *A. breviligulata* and *C. kobomugi* plants. The evaluation of root samples collected from the experimental plots is currently undergoing evaluation and statistical analysis to determine if differences in the mycorrhizal status of the subject species exists.

Discussion

Given the likely nitrogen-limited status of the plant community in the study area, responses to nitrogen amendment such as changes in stem densities or root to shoot ratios were anticipated even for *A. breviligulata* (Chapin 1980, Tilman and Cowan 1989; Wilson and Tilman 1991; Scade and Lewis 1996; Boudreau and Houle 2001; Day et al. 2004). The N:P ratios observed in the focal species suggested the presence of nitrogen limitation. However, the stem counts of *A. breviligulata* and *C. kobomugi* did not respond significantly to nitrogen amendments and nitrogen deposition does not appear to be influencing the competition between the two species. Since no measurable sand deposition occurred in the experimental plots over the course of the study, neither species could have gained any competitive advantage over the other associated with sand accretion. The apparent presence of significant levels of VAM fungal

association in *C. kobomugi* roots may explain the lack of results.

If *C. kobomugi* is found to be mycorrhizal to a similar degree as *A. breviligulata,* other questions will be raised regarding the influence of mycorrhizae on the competition between the two species. Mycorrhizal diversity and/or species composition may be potentially more affected by nitrogen availability than actual degree of colonization (Dighton et al. 2004), so it is possible that despite the lack of a numerical response in stem counts, other changes in the AMF community did occur here but went undetected, since we did not assess species composition of the AMF encountered. *Ammophila breviligulata* could potentially be affected differentially by a change in species composition. It would be of interest to know if *C. kobomugi* is obligately or facultatively mycorrhizal in North America. Is it always mycorrhizal or only mycorrhizal in association with *A. breviligulata*, or in response to some environmental factor not present in its native habitat?

Nitrogen amendments also did not affect plant diversity, as measured by the Shannon-Weiner Index. However, some changes in the plant community were occurring. *Conyza canadensis* (horseweed) exhibited a statistically significant increase in stem counts in response to nitrogen treatments. Diversity was already low in the study plots at the initiation of the experiment. *Carex kobomugi* in this study had higher stem counts than *A. breviligulata*. Unlike *A. breviligulata*, *C. kobomugi* showed an increase (if insignificant) in stem count in response to nitrogen amendments, which could potentially become statistically significant if the study had occurred over a longer period of time. A longer period of nitrogen amendment study could also potentially produce the anticipated decrease in diversity.

In terms of nutrient status, *A. breviligulata* and *C. kobomugi* were similar in that most nutrients were present in higher concentrations in leaves than roots. This is likely a seasonal effect. Since the tissues used in nutrient analysis were collected during the growing season, plants would be expected to allocate biomass and nutrients more strongly toward aboveground tissue. At the end of the growing season, those nutrients would be translocated to the plants' roots (Chapin 1980).

Ammophila breviligulata had significantly higher concentrations of nitrogen, zinc and copper in roots compared to *C. kobomugi*, while *C. kobomugi* roots were higher in phosphorus, potassium, magnesium and boron. This points to differences in plant stoichiometry and physiological nutrient requirements and interactions with soil processes affecting plant uptake of certain nutrients.

Upon first glance, the coastal sand dune appears to be a simple ecosystem containing few plants and a great deal of bare ground. However, in reality, the adaptations of the plant species that do thrive there are potentially numerous and complex. A great deal remains to be learned about the ways dune species obtain nutrients and how they interact when they compete for sparse resources. In particular, the possibility that *C. kobomugi* is mycorrhizal to a significant degree suggest a host of possible interactions affecting the success of *C. kobomugi* on New Jersey sand dunes. An exploration of the species, distribution and other characteristics of the

mycorrhizal community on New Jersey sand dunes may provide insight into competitive interactions between *A. breviligulata* and *C. kobomugi*.

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Non-indigenous *Salvia sp.* (sage) advice for educators; a bag of tricks to foster learning about invasive species and aquatic invasive species. Ann Faulds, Associate Director, Pennsylvania Sea Grant

Abstract

There are many ways that invasive and aquatic invasive species (AIS) topics can be integrated into classroom and field activities on the middle and high school level. Below I summarize some successful approaches learned from two Pennsylvania Sea Grant AIS teacher workshops. One key approach for successful integration is to use invasive species topics to satisfy existing curriculum requirements in the science, biology, and agricultural education classroom. Teacher professional development programs that require teachers to engage their students in field activities and involve practicing ecologists can be especially successful.

Introduction

School-based programs, including teacher workshops, can increasing the understanding of invasive species and aquatic invasive species (AIS) issues. What follows are some lessons learned from the author's experience with two school-based teacher education projects, *Invasive Species; the Good, the Bad, and the Prolific*, funded through the NOAA National Sea Grant College Program, and *The Susquehanna Aquatic Biodiversity Network* funded through the NOAA Chesapeake Bay B-WET Program.

Invasive Species; the Good, the Bad, and the Prolific Program was a collaboration between the Maryland, Delaware, and Pennsylvania Sea Grant programs (headed up by the Delaware Sea Grant). We did a total of seven teacher workshops in Baltimore, MD, Lewis, DE, Philadelphia, PA and Chester, PA. Most activities were classroom and laboratory oriented with some field activities. We also invited practicing scientists to present their research findings and many curriculum materials and equipment were provided. Activities were demonstrated to give teachers ideas for integrating invasive species topics in their classrooms. Teachers received credit for attending, but the adoption of invasive species topics was left up to the teachers.

The Susquehanna Aquatic Biodiversity Network **(SABN)** went a step further by requiring teachers and their principals to sign an agreement to take students into the field and organize them into a volunteer effort to share data among participating schools. Workshops were in the Pennsylvania portion of the Chesapeake Bay included Towanda, PA in Bradford County, Lock Haven University in central Pennsylvania, and Millersville University, in Lancaster County. Again, many materials were provided and teachers were eligible for field trip implementation grants to cover field equipment or bus transportation.

Below are some general strategies learned from these two programs that provide ideas for middle and high school teacher professional development.

Teach invasive species issues in the broader context of biodiversity. A basic understanding of natural systems and aquatic communities is necessary for students to fully understand aquatic invasive species impacts.

Help teachers connect new content with existing state and national curriculum standards. There's more than one way to meet a curriculum requirement! One of the keys for integrating invasive species topics into the classroom is to piggy back AIS topics with existing curriculum requirements. It's a matter of showing teachers how to put a slightly different spin on what they have always taught. Below are just a few examples from the Pennsylvania Standards:

- **Threats to endangered and extinct species** – Rusty crayfish introductions can be used as an example of endangering native Pennsylvania crayfish.
- **Human Impacts on the Environment** – Examples abound of how an invasive species like *Phragmites* can transform a complex plant community into a monoculture and raise a wetland elevation.
- **Environmental Health Issues** - West Nile virus can be covered as an example of how an invasive species has impacted human health.

Tap into local researchers. Teachers are hungry for exposure to practicing scientists, such as university professors and agency researchers, who can demonstrate their research and accompany teachers into the field. Professional development that features the latest research findings really helps teachers stay on top of current issues and recent developments. Practicing scientists can be extremely helpful in planning and teaching programs. An example is how Professor John Wallace from Millersville University recounted how his ecology class surveyed local bait shops to find how many were selling invasive rusty crayfish. John's class project actually helped to change the fishing regulations in Pennsylvania so now it is illegal to possess or sell rusty crayfish. It was a really inspiring talk that got the teachers in our workshop all fired up.

Don't be afraid to ask participating teachers to make a commitment to implement what you're teaching them. A written agreement can be very useful to clarify what's expected. Participants in the SABN program were eligible for a field trip implementation grant to cover school costs to take class field trips. Schools receive the reimbursement <u>after</u> teachers report their class's findings.

Teachers love free stuff. Offer schools travel reimbursement, curriculum guides, factsheets, posters, GPS units, field guides as a carrot to participate and to encourage adoption of invasive species topics.

A good activity guide with a lot of useful field experiments is the Cornell University *Invasion Ecology* published by the National Science Teacher Association (NSTA). It's available through Cornell or from NSTA. The activities can be adapted for a range of ages from middle school to college level. Here are some ideas modified from activities in this text:

- *Invasion Ecology* activity guide contains a number of plant plot sampling techniques. Hula hoops make great as a sample plot delineators. You can do all kinds of math if you

want to figure out the density per unit area or you can just compare plots of equal size. At a teacher's workshop in Seven Springs, Pennsylvania we identified native and introduced plants and then determined "hula hoop" plot density at different locations. An excellent comparison is a disturbed area versus a relatively undisturbed area for instance, a lawn versus an undisturbed forest.

- Many transect sample techniques are presented in *Invasion Ecology.* To survey invasive and native dune plant populations, a transect may the preferred method where there is a lot of distance between plant patches.

- Something else you can do is take an area well invaded with a plant like Beach *Vitex*, use a hula hoop sampler, and count how many native species you find within a well colonized patch. It's difficult to find more than one species within a thick *Vitex* plot. Invasive *Phragmites* and native cattail plot also make a nice comparison. Many more different kinds of plants can be found within a cattail plot – it's pretty remarkable. These comparisons can make good demonstrations that don't require a lot of time or expertise.

- When classes do plot samples for educational purposes, you don't necessarily have to identify everything. You can call something species A or species B if species richness is what you're interested in.

- Often the graphs of numbers and kinds of plants in contrasting communities are dramatic – for instance, a lawn sample that has zero native species compared to a diverse forest plot with few or no invasive species.

And here are some additional ideas:

- **Digital Herbarium**. Place a fresh plant cutting on a scanner to get top notch images. If you scan at a high enough resolution you can zoom in on an image to get very fine detail – almost like using a hand lens. It is also a very good way to communicate about identification characters. A good high resolution scan makes a very attractive image that might be mistaken for a pressed plant.
- **Environmental gaming** - a fun way to reinforce factual material. Here are a few examples:
    - **Aquatic Supertramp Roulette** is a spinning game with a pie shaped picture board placed on top of a sturdy lazy susan turntable. I call it *the game of chance where everybody wins and cheating is encouraged* (because all the reference fact sheets are provided). After the player spins, the pointer lands above a picture of an invasive species. The player is asked identifies the invasive plant or animal and tells why it's a problem. Teachers can make their own with transparent pockets that allow you to change the photos and the lesson. It's a fun way to reinforcing factual information. By modifying the rules, you can also play with younger kids or provide an activity for a special event.

- **Make a giant playing board drawn on a tarpaulin.** We adapted an AIS game from the Great Lakes Sea Grant *Rival for Survival* game (RFS). RFS is basically a team trivia game where you accumulate points depending on how well players answer multiple choice questions. Use a large magic maker to draw the lines on a big tarp. Instead of using playing pieces, the players walk the board. This idea has been modified by teachers, and students can also make their own game and playing board. And, of course, we used fuzzy dice to make it more fun.

I mentioned that we went a step further with the Susquehanna Project and what we are doing in this project; we are mostly focusing on bivalves and crayfish, both native and invasive because in Pennsylvania, these are the two most in peril taxa and complete surveys have not yet been done for either of these taxa, particularly the crayfish. We know less about crayfish populations. At the same time we are just being inundated with rusty crayfish, particularly from, they seem to be spreading from the main stem of the Susquehanna up the tributaries. There is a genuine biodiversity issue here that we are dealing with. We also have in tread waters of the Susquehanna, Zebra mussels that are coming down from NY. We had our first encounters with Zebra mussels in Koweneski Lake in north central Pennsylvania and they more than likely extended from the Finger Lakes but they've been in the upper head waters for quite some time and they seem to be coming downstream and we had what was probably an isolated outbreak in the lower Susquehanna, which got MD upset and at the same time motivated to do outreach. These are real world issues and from the time I wrote the grant to the time now that we are implementing it lost of news of mussels occurrences have taken place. It's not targeting in this project but we've had a lot of problems with scuba divers spreading Quagga mussels in diving cars. It's been a real challenge to reach divers and send a conservation message.

What we ask the teachers to do is take at least one field trip with their students and then fill out this survey form. We started out using modifying basically the survey we were using for our Zebra mussel monitoring program. We have a volunteer monitoring program that combines 8 agency reports with reports from volunteers that we have trained. We have latitude and longitude. We are also providing some training on how to identify crayfish and mussels. Definitely crayfish in the first year were much easier to study than mussels because come of the mussels are in pretty fast moving water where schools can't really go because it's not necessarily the safest. We are providing them with lists which are very helpful to reduce, in this case the native crayfish in this area only amount to a few, and rusty would be the most common exotic crayfish. We do provide the teachers with a carrot and that is a very key part to teacher training to figure out what you really want the teachers to do and how to motivate them to do it. We have used a field trip implementation grant as a motivator and they have to agree to take the field trip but we also will not reimburse them until after they have filled out their paperwork, which after a few years of trial and error, we figured this is the best way to ensure that we are getting good data from them. The teachers are very conscientious about taking the kids out and they do some of their recording but people being people, it's difficult to get them to get the data to you. It's a challenge in any volunteer program. It's amazing sometimes that a small implementation grant can go a long way in motivating the teachers. In many cases we have found that money for transportation was the key part that was missing in

getting kids out into the field. Just a couple of hundred dollars to get the buses can make a major difference. So many of the young teachers starting out in teaching have never had the opportunity to take a field trip because of the expense and many districts have policies against collecting money for field trips because it's a burden on those who can't necessarily pay. We found this to be very key and I was surprised how few problems we had in paying the school or the district to reimburse them for the expenses. We give the teachers a lot of latitude on how they want to spend the money. We just ask them for a budget. We also give them a GPS unit which they can use in the field to find the latitude and longitude. They can take that out of their grant money if they want and some of them bring their own equipment. That was why we went with the grant process because for many years I was giving equipment to teachers not necessarily knowing if they needed it as some of them already had it and some of them weren't inclined to use it. I feel like the money is better spent this way.

This is a view of some of the native mussels we found in Tuwandum, which is not too far from NY, on what would be the north branch of the east branch of the Susquehanna. We found a really great place to find mussels and we had a really good expert in mussels that helped us find them and identify them. It was really quite exciting.

After we get the data, this is an example of data collected all over the state, our Zebra mussel monitoring program, where the green dots were places were surveyed and they found no zebra or quagga mussels, red were established places and yellow are collected but maybe not established. In Pennsylvania, we had one purple place that was a false alarm. Live mussels were found on a boat ramp but they did not naturalize so we are very proud of that purple dot. This is a model for what we are doing with all the other species that we are adding with the school monitoring. So we have about 20 target species of plants and animals that we trained the teachers to identity and we give them field guides that are specialized in the Susquehanna. We have lists of things likely they will find. Of course what happens is that when you go out into the field for the first time and you find Chinese mystery snails instead of Zebra/Quagga Mussels. We are figuring out how to incorporate these unusual observations as well. So this is Google Earth and we will probably be moving to Good Map but both of those products are really emerging so the differences between the two are becoming less and less. We are just about ready to release last spring's findings from the schools. You will be able to click on each of those dots and find an info box that will give the name of the school and the latitude and longitude where it was collected. The whole idea is that students will be able to exchange information, see what other schools found, and get recognitions for what their school accomplished. It is a lot of work getting all this together but we are just about there. It's an ongoing process so we anticipate changes over the years. We are trying to look around at programs like IPAN and IMAP and EdMAP to figure out what good features they have and what direction the field is going in geographic presentation.

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The Biology of Beach Vitex. Charles A. Gresham, Retired. Baruch Institute of Coastal Ecology and Forest Science, Georgetown, South Carolina

Abstract
Beach vitex, *Vitex rotundifolia,* has many characteristics that make it nearly an ideal invasive species. Our field, and greenhouse research sought to quantify the growth, reproductive and competitive characterizes of this introduced species. Field measurements of growth and seed production, were made in the summers of 2002 and 2003. Greenhouse tests of allelopathy were made to asses this means of competition. We found that beach vitex has rapid shoot growth rates, quickly completely covers frontal beach dunes and produces a heavy woody root system. The shoot and leafy cover produces thick shade, and releases a waxy substance that coats the sand grains in the upper 2 to 3 cm of the beach sand to make them hydrophobic. We did not notice any insect or disease damage over five years of observation. The high density of deep blue flowers in early summer makes a cover of vitex attractive, but such a cover does not allow native species to survive. Also we found that it is a strong competitor of sea oats and sea shore elder when grown in the same nursery pots. The results of this research indicated that beach vitex was a strong invasive species that displaces native vegetation and thus should not be allowed on frontal dunes in South Carolina.

Background
Beach vitex, *Vitex rotundifolia*, is a member of the Laminaceae Family with 250 to 300 species in tropical and temperate regions. There are five species in the U.S. none of which are native. The genus name is from the Latin word meaning to bind or twist referring to the vine-like stems, and the specific epitaph refers to the round leaves. *Vitex agnus-castus*, known as Chastetree, is a widely planted ornamental that has the flowers of *V. rotundifolia*, but a different growth form, leaf shape, and is not at all invasive. Beach vitex has a documented history of medicinal uses including as a female hormone substitute and a cancer therapeutic in its native range.

In coastal South Carolina beach vitex grows as a low, prostate, woody, vine-like shrub. It has deciduous, opposite, round to slightly elliptic, dark green leaves, 2 to 5 cm in diameter, with a smooth, fine-leather feel, and a spicy eucalyptus scent when crushed. Terminal spikes of light purple flowers appear in mid-summer and quickly drop to expose hard, green 0.5 cm diameter fruits that dry out and turn black by late summer. These dry fruits remain quite visible after leaf-fall and throughout the winter. The growth habit is a thick, waist to chest-high mass of woody stems up to 10 cm in diameter that forms a complete cover of frontal dunes. Below the canopy is a thin litter layer of dried leaves and fruits. This thick dune-covering characteristic caught the attention of volunteers monitoring sea turtle nesting along the northern South Carolina coast and lead to the formation of a Task Force with a goal of eradicating beach vitex.

The natural range of beach vitex is the Pacific Rim from China, Korea and Japan south to to Indonesia, and the southern Pacific islands to Hawaii. It is found along the coast of southeast Asia to India and Sri Lanka. In the Southeastern U.S., it was found predominately in the northern coast of South Carolina and all along the North Carolina coast. It has been reported to

be a problem as far west as Galveston Island, Texas, and was recently found in Virginia and Maryland.

U. S. National Arboretum records indicate that beach vitex was collected and brought to the U. S. as early as 1955. It was evaluated as an ornamental during the 1960s and 1970s. In 1978 it was collected by the Raulston Arboretum in North Carolina, evaluated as a dune species and released for commercial culture in 1986. Hurricane Hugo struck the middle of the South Carolina coast in 1989 and destroyed the frontal dunes of the northern coastline. To meet the subsequent huge demand for planting stock of dune stabilizing species, a single nurseryman got beach vitex stock from North Carolina, propagated it and planted it widely on the newly rebuilt frontal dunes of Georgetown and Horry Counties South Carolina in 1990 and 1991.

By 1995 volunteers monitoring the nesting of the federally endangered loggerhead sea turtles noticed the potential of an unknown vine-like plant to cover dunes thus altering nesting habitat. A sample was sent to Clemson University for identification and in response, Clemson provided the identification as beach vitex along with the recommendation that this plant be monitored. Numerous seedlings were noticed on an undeveloped beach south of know plantings in early 2003 and later that year a workshop was held to educate interested natural resource managers of the situation. That meeting lead to the formation of the South Carolina Beach Vitex Task Force, a partnership of nearly 20 federal, state, and private organizations interested in stopping the spread of this non-native plant. The Task Force quickly established a web page explaining the concern about beach vitex and provided a reporting form that allowed concerned individuals to advise the Task Force of the location of suspected populations.

Biological Research

The lack of any information about the biology and management of beach vitex was apparent during the 2003 meeting and lead to many field and greenhouse projects to better understand basic biological and ecological characteristics.

During the summers of 2003 and 2004, numerous PAR measurements were made at the soil surface below a vitex canopy and the canopy of sea oat covered control dunes. In one test we found that the PAR below vitex was 15 % to less than 1% of above canopy PAR in 13 of 14 sites measured. We also noticed that although beach vitex produces deep shade, leaves of beach vitex are not found on vitex stems that are in the shade of boardwalks crossing dunes.

Also during these summers, the vegetative composition of vitex covered frontal dunes and near-by control dunes were sampled. We found vitex covered dunes had an average of 84% vitex cover, with up to 59 vitex stems/m^2. Sea oats covered 27% of control dunes with an average of 34 stems/m^2.

During the summer of 2005 we sampled the root biomass of vitex covered dunes and control dunes by driving a thin-walled, 10-cm ID steel pipe with one end sharpened to cut roots when driven into the ground. We collected soil cores to 60 cm below the surface and extracted roots by 15-cm layers. We found that the root biomass of vitex-covered dunes was 3.1 times that of control dunes, with the greatest biomass in the 0 to 15 cm and 30 to 60 cm layers.

We noticed that beach vitex flourishes on the frontal dunes where it is exposed to salt-laden wind and salt spray. But we also noticed that both on the frontal dunes and on the banks of saltwater creeks, vitex stems do not survive saltwater inundation.

While setting up a greenhouse experiment, we noticed that surface soil samples taken below a vitex canopy repelled gently applied water. Subsequent sampling and testing indicating that this hydrophobic characteristic was present in most vitex populations, and that the hydrophobic soil was only within a few centimeters of the surface. On campus gas chromatographic analysis of soil samples, dried fruits and leaves identified three compounds not found in the soil or litter of control dunes. The production of a hydrophobic soil surface could be a defensive mechanism whereby any seed of another species may germinate below a vitex canopy, but the seedling will quickly perish due to the lack of moisture in the upper soil layers.

Seed crop measurements made in 2003 and 2004 indicated that a full canopy of vitex produces approximately 2,700 fruits /m^2. Of the four chambers of a vitex fruit, we estimated that about 1.2 chambers had a developed seed, giving a seed production density of 3,300 seed /m^2. We did not notice any bird species foraging on vitex seed, probably because there is little fleshy material surrounding the seed that would provide food for birds. The seed tend to accumulate in low inter-dune areas and the seed will germinate during moist periods. Repeated seed bank sampling indicates that buried vitex seed remain viable for at least five years.

Greenhouse research focused on testing for allelopathic effects of solutions made from water running off vitex leaves and water percolated through potted vitex plants. The test species were vegetable species watered with the test solutions or growing in soil from under vitex plants. We also tested a treatment of vegetable seed below a thin mulch of vitex leaves. None of these experiments gave a consistent indication of allelopathy.

We also conducted a competition experiment in which beach vitex, sea oats and two another dune species, bitter panicum and seashore elder were grown in split and unsplit nursery pots. Split pots had a thick plastic sheeting barrier between pot halves that prevented across-pot root and watering solution interaction. Split and unsplit pots were planted with vitex and another species, two vitex plants or two non-vitex plants. Aboveground and below ground biomass were measured after several weeks of growth. Sea oat and seashore elder growth was reduced by root contact with beach vitex, but bitter panicum growth was not.

The results of these experiments supported field observations and uncovered characteristics not easily seen. The rapid growth, seed production, and shade data confirmed what is clearly visible. However the discovery of a soil hydrophobic condition, the large root biomass and growth reduction of sea oats and seashore elder in the competition was not expected and helps explain the invasive potential of beach vitex.

Management of Beach Vitex. Charles A. Gresham, Retired, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, South Carolina

Abstract
Beach vitex, *Vitex rotundifolia,* is an invasive shrub that was successfully controlled along the South Carolina coastline through a multi-step procedure under the oversight of a Task Force composed of public and private stakeholders. This project sought to devise a safe and efficient method to kill beach vitex, restore the site with native vegetation on privately owned beach front sites. First we tested several woody plant herbicides and methods of applying them. Then we designed a procedure to locate beach vitex infestations, then we worked with the landowners to obtain permission to eradicate only beach vitex from their property. Finally we applied the beach vitex eradication procedure and site restoration techniques developed earlier. We estimated that the eradication procedure was 95% effective in killing the beach vitex and that the site restoration procedure was 100% successful in establishing sea oats, bitter panicum and American beachgrass on treated sites. We also found that the planted bitter panicum initially dominated many planted sites and that the sea oats grew slowly among the thriving bitter panicum. Beach vitex infestations can be eradicated and the site restored with native species; but the effort is labor intensive and requires at least two years.

Keywords: *Vitex rotundifolia*, invasive plants, South Carolina beaches, herbicides, site restoration, Task Force.

The beach vitex problem

Beach vitex, *Vitex rotundifolia,* is an invasive shrub that was planted on many South Carolina front beach dunes that were rebuilt after Hurricane Hugo. The choice to plant beach vitex was a good one at the time because it has all of the characteristics of an excellent dune building and stabilizing plant. Although it is a woody shrub, it grows as a prostrate vine rarely growing more than 1.2m high. It is able to tolerate the harsh temperatures and desiccating salty, windy conditions of sandy beach dunes. It has an extensive deep woody root system that not only provides water but also contributes to its dune holding ability. Vitex is deciduous so there is a litter layer under the shrub cover which no doubt conserves soil moisture and prevents incoming seed from toughing soil during germination. It grows in a thick colony with nearly 100% ground cover which also contributes to its ability to hold beach sand. The thick canopy also slows sand bearing winds which then deposit the sand. Finally it grows rapidly by sending out shoots up to about 10m per year and these shoots root at the nodes thus providing establishment on previously open beach dunes. In South Carolina beach vitex did not appear to suffer from any insect or disease pathogens. Because it was leafless and dormant during the winter, it did not appear to be affected by winter low temperatures.

Beach vitex was first collected from Asia and brought into the United States National Arboretum in 1955 and was evaluated there during the 1960s and 1970s. In 1978 it was collected by personnel from the Raulston Arboretum of North Carolina State University and evaluated there as a potential dune stabilizing plant as part of the dune creation and

restoration projects of NC State during the 1970s. In 1986 beach vitex was released to commercial culture in North Carolina. Apparently it was not in South Carolina at this time.

Hurricane HUGO's landfall at Mt. Pleasant South Carolina on September 21 1989 caused significant damage to the front beach dunes that were north of the point of landfall. The dunes of Pawleys Island, 100km north of Mt. Pleasant, were destroyed at several sections of the island and were quickly rebuilt in 1989 and 1990. Beachfront landowners knew that the dunes had to be planted to resist wind erosion. For some reason, there was little to no sea oats available for planting at that time. However one nurseryman in Georgetown County, who was contacted by several people on Pawleys Island, heard of this new plant being evaluated by NC State University for dune stabilization. During 1990 and 1991 approximately 50 sites on Pawleys Island were planted with beach vitex on the newly created dunes. Apparently the plantings were successful and other dunes were planted with beach vitex.

In 1995 volunteers monitoring loggerhead sea turtle nests noticed that several front beach dunes were covered with this non-native plant that was unfamiliar to them. The volunteers were concerned about the plant's completely covering the dunes and having rapidly growing shoots at the toe of the dune where the sea turtles dig nests. The plant was identified as beach vitex by Clemson University and the volunteers were warned to keep an eye on the plant. They did and the more they observed the more vitex they found and the more vitex covered dunes they discovered. In November of 2003 concern among the volunteers had reached a point that they realized that something had to be done. An invasive species expert, Dr. Randy Westbrooks was consulted and a workshop was convened of local natural resource agencies and concerned citizens to present the situation and formulate a plan. From this meeting the South Carolina Beach Vitex Task Force was formed to investigate the situation and initiate solutions.

Although the sea turtle monitoring volunteers saw beach vitex as an undesirable invasive species, several property owners with vitex argued that their dunes were larger than adjacent dunes with native vegetation. Unfortunately there was no published research available about the biology or management of beach vitex, thus these arguments could not be refuted. At this point researchers at Clemson University's Baruch Institute began an extensive series of studies of the biology of beach vitex to provide data to determine the desirability of beach vitex on front dunes. After about two years of studying the biology of vitex enough data was obtained to conclude that this plant should not be allowed on beach dunes, and the focus of Clemson's research then shifted to methods of eradication and dune restoration.

Management options

The previous research on the biology of beach vitex was used to guide research on which of three basic eradication methods would be most effective. Biological eradication methods involve the use of herbivores or insect and/or disease pathogens. Field observations indicated that vitex did not suffer from herbivory nor was any evidence of insect or disease damage. This indicated that biological control would not involve native species and that pathogens would have to be imported from its native range, thus creating the possibility of another invasive species. The second method of eradication is mechanical removal of the above and below ground stems and roots. This method was used in early eradication efforts in North Carolina

where backhoes would dig up vitex plants from the dunes, then afterwards re-shape the dunes. This approach was rejected because of small scale experience indicating that small sections of vitex roots would sprout and produce new plants, and the realization that front beach landowners would not tolerate heavy machinery tearing up their dunes. This is also a very expensive. We did hand clear a few small lots and immediately had to deal with the disposal of the clipped material. With great effort you can haul the debris off the beach area, spreading vitex seeds everywhere, but then what do you do with it? Clemson set up an experiment with the Georgetown County Landfill which had a composting system to handle the yard debris they received. Their composing system did produce a mulch, that when put in a greenhouse mist bed, did not produce vitex plants from either seeds or stem material. Also Clemson did a debris drying experiment that indicated a minimum of 15 days of drying was necessary to prevent vitex stems from sprouting in a mist bed. Similar composting experiments in the landfill of Mecklenburg County North Carolina indicated that their composting of yard debris did not kill vitex seed. Thus the experience from small scale mechanical removal and the results from experiments dealing with the clipped debris indicated that a mechanical approach was probably not the way to proceed.

The final eradication method considered was the use of herbicides to kill beach vitex. We were familiar with chemical vegetation control from a forestry perspective and knew of several herbicides that would kill woody species. Also we were familiar with several application methods that ranged from broadcast spraying to individual stem injection. We first did an herbicide trial of four herbicides applied as a foliar spray and evaluated the regrowth the next season. This trial indicated that the herbicide, Habitat, applied as a foliar spray was the most effective in killing beach vitex. However we realized that many landowners would not allow broadcast spraying of a wide spectrum herbicide on their front beach dunes, nor were we going to spray such a powerful herbicide realizing that non target species would be affected. We then set up a second herbicide trail with four replications of three treatments. The first treatment involved cutting the vitex stem at groundline and painting the stump with a Roundup herbicide solution. The second treatment was to wound the vitex stem with a machete and painting the wound with a Habitat solution, and the third treatment was to paint a solution of a third herbicide, Garlon, in a light oil that would allow the herbicide to penetrate the bark and enter the plant's vascular system. The treatments were applied in the fall and the plant survival was evaluated in the spring of the next year. Clearly, applying a solution of Habitat in the wounds of vitex stems was the most effective way to kill the vitex. We realized that not only was this procedure effective at killing vitex, it was a very controlled application of the herbicide to the target plants thus there was little chance that non-target plants would be killed. This trial also indicated that the technique was far more time consuming than broadcast spraying, but required about the same amount of time as the other two methods. Thus we had a method that effectively killed beach vitex and previous dune restoration work in North Carolina provided techniques to restore native dune species in areas where the vitex had been killed and removed.

Clemson's dune restoration method

After we determined that beach vitex was not desirable on beach dunes and after an effective eradication and dune restoration technique had been developed, we were faced with applying this information on numerous privately-held front beach properties that were infested with beach vitex. This change of focus involved less biology and herbicide research and an emphasis on dealing with the public and working on their land. The approach that evolved from our efforts included seven tasks that were sequential for each infestation, but were not sequential on an area-wide basis. The tasks were: 1, search the target area for infestations; 2, evaluate and describe each located infestation; 3, obtain permission from the landowner to eradicate the vitex and restore the dune vegetation; 4, apply the herbicide to the vitex; 5, clear the dead aboveground vitex; 6, plant native dune species; and 7, monitor and re-treat as necessary. Scheduling and coordinating these seven tasks on over 200 sites required almost a full time person in the office keeping up with the paperwork. Also the seasonality of some of the tasks complicated scheduling. For example, searching was more effective in the summer when the leaves were still on the plants, applying the herbicide was most effective in the late summer and fall, and planting native vegetation was a spring activity. In contrast, evaluating each infestation and obtaining the landowner's permission could be accomplished at any time.

To simplify the searching task, we chose to initially focus on the northern South Carolina beaches from Charleston to the North Carolina state line. Although we knew of many infestations in this area, we felt that we needed to walk all the beaches to be confident that we knew where all of the infestations were. To this end, we divided the area by the municipality having jurisdiction of the beaches, ownership of large areas or residential development involved. This simplified obtaining permission to walk the beaches and using a four-wheeler to transport the searchers to the next beach section. For each section, one of the personnel of the vitex research project would walk on the front beach and another would walk in the inter-dune area behind the front dunes. In developed areas without a dune field, a single walker could easily observe the dune vegetation from the front beach to the landscaped yard. If an infestation was found the address of the property was noted or a GPS location taken and this information was recorded on the top section of the evaluation sheet.

In the beginning of the program we knew we did not have the resources to treat all infestations, so we went back to most of the larger infestations and did a detailed evaluation. The evaluation sheet used is included at the end of this report as Appendix 1. We selected 75 sites based on several criteria including size of the infestation, proximity to the front beach, ease of removing the killed vitex and whether or not this infestation had spread to adjacent lots. We favored areas that had several contiguous lots that would reduce transportation time. The evaluation sheets enabled the selection of lots to treat in the most efficient manner and constituted a written record of information about that site.

Once the sites were selected, the surprisingly easy task of obtaining landowner permission was next. If the lots were in municipalities, such as Pawleys Island, the mayor or town manager was willing to give us contact information for the property owner. Both Georgetown and Horry Counties had publically available GIS systems that allowed identification of property owners and contact information. We also found that managers of developments, like Debordieu

Colony, were willing to provide the names and addresses of property owners once we explained what we wanted to accomplish. A letter was written to each property owner, and to all owners in the case of multiple owners of a single lot. The WORD Mail Merge template of the letter is Appendix 2. Two copies of the letter, both signed, were included in the envelope and the owner was asked to sign and return one copy; the other copy was for their reference. Most landowners returned their letters within a few weeks, and those that did not respond were called by the Principal Investigator to see if they objected or simply had not gotten around to returning the letter. The follow-up phone call got most of the outstanding letters in and only a few owners objected to the treatment, that was free of charge. For those who objected, the town Mayor was helpful in persuading them to agree, in one case the neighbors applied peer pressure and in another case the landowner died and the new owners agreed. Of the now 200+ lots identified, only one owner has staunchly refused.

With the permission letter in hand, we were ready to kill the vitex. We treated the vitex from June to mid-December, by using ½ sized machetes to wound the stems of vitex plants about 4-5 mm (1/8 to ¼ inch) deep. Deeper wounding is not better; the purpose of wounding the stem is to break through the bark to allow the herbicide solution to enter the outer layers of xylem which are located just below the bark. For multiple stems we wounded each runner and each stem was wounded at several locations from the root crown to the distal end. An 18% solution of Habitat herbicide was prepared with 1% blue dye and no adjuvants. Habitat herbicide was chosen because it is formulated to kill broadleaf woody plants and it is labeled to be used in fresh water. Because Habitat is a restricted use herbicide, the crew chief was a licensed applicator. A liter or so of the solution was poured in a large plastic bucket and applied to the wounds with a 1" foam paint brush attached to a 50cm handle. Depending on the crew size, one person could both wound and paint or two people would wound and a third person follow them painting the wounds. We used a foam paint brush because it was less likely to drip the herbicide solution, and the blue dye indicated which wounds were painted. Because the treated areas were not greatly disturbed, they looked very much like untreated areas, which pleased the landowners. On a daily basis the crew chief would note which lots were finished. On the largest site, disregarding transportation time, we could inject 25.6 square meters of vitex per man-hour and a liter of Habitat was needed for 332 square meters of vitex.

We then waited 150 days to allow the herbicide solution to travel to the rootsystem and kill the plant. This means that the herbicide would be applied in the fall and the vitex would drop its leaves without any apparent effect of the herbicide. However the stems would not produce new shoots and leaves the following spring. Occasionally the stems would produce a mass of stunted shoots at certain nodes, which indicates that it is trying to overcome the effects of the herbicide. Most of these shoots eventually died that spring. Once the plants were killed, the stems were cut at ground level with lopping shears, hand saws or chainsaws and severed into manageable lengths. The cut stems were then piled on a small tarp with poles secured to two opposite edges and the poles were then lifted by two people in a stretcher-like fashion. This way the debris was removed from the beach area in a tarp to minimize the spread of seeds. The debris was carried to the street side of the beach house and chipped in a 24hp gasoline engine powered chipper with a capacity of a 15cm diameter log. The chipped debris was blown

directly into a plywood box on the bed of the pickup truck pulling the chipper. Chipping the cut debris allowed the crew to work all day without having to leave the site to dump the debris. At the end of each day, the chips were unloaded from the truck onto a pile in a field of property with controlled access. Here the chips slowly decomposed and no evidence of sprouting or establishment from seed was noticed. This method also allowed the pile to be safely burned if desired. After the stems were cleared from a site, accumulations of vitex seeds in low areas were collected and processes as were the chips. The clearing process did not disturb the dune soil because only the above ground biomass was removed. The rootsystem (killed by the herbicide) was left undisturbed to hold the dune sand until the dune vegetation was restored.

Once the site was cleared of the beach vitex, it was planted with a mixture of sea oats and bitter panicum, the two most abundant grasses on undisturbed dunes. Seedlings of both species were raised in a local nursery within an hour's drive from the vitex sites. Sea oats were raised from seed obtained within 83 km of Pawleys Island SC and the bitter panicum was the NRCS 'northpa' variety. A 'sharpshooter' type shovel was used to dig a 20cm deep hole, and a seedling, a small amount of slow release fertilizer and an hydrated water-holding polymer was added, then the hole was closed. We sought to plant two bitter panicum stems for every sea oat stem. After planting an area we would set up sprinklers and moisten the soil to 15-20 cm. Replanting was often necessary during the summers with less than average rainfall. In areas where the summer planting failed, we planted American Beachgrass, 'Hatteras' variety. We also found that a light (4 lbs/1000 sqft) application of 30-10-0 fertilizer with the nitrogen in a slow release product gave and residual vegetation a boost and helped any ingrowth from the seed bank.

The final step was to monitor all treated sites and note and vitex sprouting and planting failures. The preliminary research indicated that the eradication technique was at least 95% effective, thus there would be some plants sprouting. Retreatment of the sprouting vitex was by wounding and painting with a Habitat solution as before, or foliar spraying with a Garlon herbicide following labeled directions. Sea oats and bitter panicum was replanted in areas where drought had killed the first attempt. The initial research indicated that beach vitex was a tough plant and we knew that eradication would be a multi-year process.

Results of the restoration effort

As of June, 2008, 246 sites in South Carolina were located and 222 were treated with the Habitat and cleared of the dead vitex debris. We feel this is 90 to 95% of the original vitex that was planted in 1990 and 1991. We have searched all of the beaches north of Winyah Bay near Georgetown, and have sea turtle volunteers alerted to notify us of any vitex on beaches south of Winyah Bay.

Another result of this effort was the ability of the Task Force and Clemson University to secure grant money that covered all of the costs. The Fish and Wildlife Service and the Natural Resources Conservation Service were the two major sources of grants. We also received money from the Donnelly Foundation, Bunnelle Foundation, and the Town of Pawleys Island. The Baruch Foundation provided in-kind support by accepting the chipped debris and logistical and administrative support.

Future actions

Task Force plans for 2009 and beyond are to survey the South Caroling beaches south of Winyah Bay for beach vitex and treat and restore any sites found. We do not expect to find much vitex south of Charleston because Hurricane Hugo damaged the southern beaches far less than it did the northern beaches. The Task Force also intends to pursue funding that will allow the continued monitoring and re-treatment of restored sites.

Conclusions

From our experience with the invasive shrub, beach vitex, we have learned several lessons that could apply to the management of other invasive species.

1) A knowledge of the biology of the species greatly facilitates designing a management strategy and procedure. If little is known about the species, then original research should be started to provide a basis for management decisions.

2) Once a decision has been made to eliminate an invasive species, the public must be educated as to what the group is doing and why. The effort with beach vitex was greatly aided by a sympathetic public that, though hours of work by the Task Force, understood the problem and was in favor of the proposed solution.

3) Invasive species, if not widespread, can be controlled and probably eliminated from defined areas. However the effort will be expensive and require several years.

4) Invasive species management is best done by a group of agencies and organizations; not a single group.

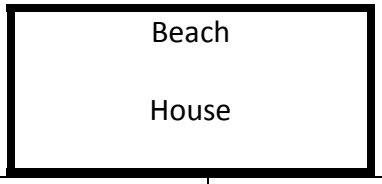
5) The expense of the effort can be offset by grants and donations. The fact that with vitex, the landowners received the service at no charge to them. We found that once municipal officials understood the problem, they were inclined to provide support or in-kind services to promote the effort. We also received in-kind support from developments with large infestations because we told them up front that we did not have the resources to do everything for them.

Appendix 1, Evaluation form for vitex infestations.

Vitex Lot Evaluation Location:	Date
Owner	
Mailing Address	
Phones	

GPS location:

Vitex seaward of beach house?	
Beach house on all-weather road?	
Enough area to park truck and chipper?	
Wide pathway in side yard?	
Access to street under beach house?	
Inground irrigation system?	
Amount of other species in Vitex?	
Is the beach house a permanent residence?	



Do adjacent lots have BV?	
Washing water access?	

Notes

10.76 square feet = 1 meter square

Appendix 2, template for permission letter

April 27, 2007
«Title» «HisName» «Last_Name»
«MailAddress»
«City», «State» «ZIP_Code»

Dear «Title» «Last_Name»:

As we discussed earlier, Clemson University has a grant for the selective eradication of beach vitex from 50 beachfront lots north of Charleston Harbor. Your property at «PropLoc» on «Beach» meets the criteria of the grant.

During the fall of 2006 or early spring of 2007 we will inject a powerful herbicide in the larger stems of beach vitex located seaward of the house. Stems too small to inject will be sprayed. The vitex will take up the herbicide and be killed during the next few months. Vitex stems injected in the fall 2006 will be dead by early spring 2007 and will be cut at ground line, carefully transported to a debris chipper parked in your driveway and chipped. The chips will be blown into the bed of a pickup truck. Soon after a soaking rain, we will plant the cleared area on an 18" grid with 70% sea oats and 30% bitter panicum, both native dune species and proven dune builders. A slow release fertilizer will be added to each planting location. Finally we will provide a report of what we did on your property and include recommendations on how to handle any re-sprouting and landscape maintenance. As the workload and grant duration permit, we will spot check our work. Vitex injected or sprayed in the spring of 2007 will be removed in mid summer 2007 and the area planted soon thereafter.

To accomplish this work we need to park the pickup truck and chipper in your driveway and haul the cut debris either through your side yard or under the house. Also we need a supply of potable water as a safety shower. If we are working on your neighbor's yard, we may stay set up on your property if your neighbor does not have easy access to the vitex. We will have to use a very powerful, relatively non-selective herbicide to kill vitex. The herbicide will be applied directly to a wound in the plant, thus application on a non-target plant is unlikely. However, in an effort to survive, the vitex may exude some herbicide from its roots or leaves and this exudate may damage nearby plants. As much as I do not want to spray the herbicide, this is the only practical way to eradicate the smaller vitex stems. Trained applicators will spray early in the morning before the wind increases and we will use a cone-shaped windshield to minimize herbicide drift. Again, there is a possibility that some herbicide will contact a non-target plant and damage or kill it. Our efforts will be confined to the vitex seaward of the front of your house only. All of this will be done at no cost to you; all we ask is your cooperation and permission to show this work to others who may be interested.

Please confirm your cooperation by signing and returning one copy of this letter. Call (843 546-6314) or email (cgrshm@Clemson.edu) me if you have questions regarding this project.

Charles A. Gresham
Associate Professor

«HisName» «Last_Name»
Landowner

Invasive Species Regulations: Does *Carex kobomugi* qualify as an Aquatic Nuisance Species?

Susan D. Halsey, Ph.D. Admiral Coastal Consulting, Pine Beach, New Jersey

Abstract

A variety of regulations govern the definition of invasive species and the permitted methods for their control. This presentation will provide an overview of those regulations in the context of the invasive Asiatic sand sedge, *Carex kobomugi*. The species clearly qualifies as a non-indigenous nuisance species with invasive properties, although its status as an aquatic species is debatable. The duties and responsibilities of federal agencies in light of this information will be outlined and discussed in the context of other better known invasive species.

My real interest in this dune plant, *Carex kobomugi* began more than 30 years ago now. After the significant northeast storms of early 1984, NJ received a Presidential disaster declaration. That triggered FEMA to enter the equation, and the new regulations required us to write the first 406 Plan (now the 409 Plan, named after the statute number), which was a hazard mitigation plan. There were two parts to it, one for the northern Passaic flooding, and the other was for the counties listed in the coastal areas. It was the first coastal hazard mitigation plan ever done for FEMA, and they were very eager for a good one to use as a model. My director certainly didn't love the amount of time I spent on it, but I used the opportunity to put a lot of research results in it as well as future proposals for research, and we even got to revise it after the 1987 disaster declaration. As a result of this Plan, we found out that then Senator Bradley arranged for a $2 million grant for a dune restoration and enhancement program to be passed through directly to us to implement the Dune Rehabilitation Projects we had included in the plan. Of course, we affectionately called this our "Bradley money."

When I left DEP and went to NJ Sea Grant in 2001, my interest in *Carex* was quickly resurrected when I read a small blurb in the National Park's magazine (Gateway) on eradication efforts for invasive species at Gateway National Park. They indicated that "at the North Pond area, Japanese curly grass (which is one common name for *Carex*) will be removed and American Beach Grass planted in its place." Questions came into my head: Who branded *Carex*, my favorite plant, an invasive species? On what scientific basis did they have for determination of that? Exactly how are they planning on eradicating the acres upon acres of *Carex* I knew to be on the Hook alone? Phone calls determined that not wanting to use chemical means, they were planning on bulldozing the back dune swale areas. Now even dumb geologists like myself knows that if you break up plants like that with deep rhizomes, they only succeed in spreading more. So, I called Louise and learned that the State DEP was already busy in eradicating their *Carex* with "Round-Up" on their back dune area. This knowledge sent me to the literature as

well as the federal regulations to determine its standing now that this was a species or genus that seemed to be “non-grata.”

I originally knew of this plant because it had obtained a legendary status in New Jersey. It was reported that the Governor’s summer house, part of the old Phipps Estate, had been one of only a few structures left standing in the area after the March, 1962 storm. What we now know as Island Beach State Park, was originally part of the old Phipps Estate before the 1962 storm. This area was going to be a Long Beach Island of its day. The developers and planners had street signs installed, and they had it all demarcated out into blocks, and they were ready to go and sell lots. It was going to be an elegant development, with an arboretum, lovely mansions and beautiful settings. Then came the ‘62 storm and everything here and further south and especially on Long Beach Island was relegated to toothpicks. But standing like a sentinel was the Governor’s Mansion, because it had a high, whole horseshoe of dunes around it on the seaward side with *Carex* on it. Post storm it looked untouched, like nothing had happened to it. The water had swirled around into the parking lot on the road side, and maybe got the yard a little wet, but that house stood untouched. Thus, it attained this legendary status because the *Carex* dune protected the Mansion when everything else was destroyed, or heavily damaged.

Unless you’ve seen the photos in the National Geographic magazine, you have no idea what destruction was wrought on that island. My father flew over Long Beach Island in a Navy helicopter to try and rescue anyone that was there. Houses were half floating in the bay, amid rafts of debris. There was little or no topography left, and a lot of water remained. The only way he could figure out were land had been, was to follow the telephone poles going down the main drag of Long Beach Island, even though they were all skewed, bent over to the west. That was the only way he could get himself oriented to a place that he knew very well. It was a bad day in Blackrock there.

As dune manager at DEP at the time, we were always trying to figure out ways to keep and enhance dunes along the New Jersey coast. Of course this was, and still is a difficult job, since dunes are considered a “four letter word “along our coast…especially when they get big enough to block the view! Plus, every beachfront home wanted a quick and easy path to the ocean, which led to many private footpaths across the dunes. Add to these, municipalities made much wider paths to the beach through the dunes at the end of every street, and you had lots of bare sand pathways to the beaches. My thinking at the time was that since *Carex* seemed to be so tough, it might just be more tolerant to tramping than regular beach grass, *Ammophila breviligulata*. If we could plant *Carex* in these footpaths where *Ammophila* cannot grow due to rhizome breakage, we could possibly keep dune paths from lowering in elevation from all that food traffic. If we could make it easier for people to walk to the beach, such as on a carpet of *Carex* instead of trudging through deep, loose sand It would be an improvement all around.

Thus, it was important for us to find out more about this plant to see if it could be of use to us. One of the most important characteristic of *Carex* would be to determine how tolerant it would be to burial from overwash sand. If we were to plant it in pathways, which are lower than the tops of the dunes, undoubtedly it would be washed over during major storms. Would the sand smother it? How deeply could it be covered and still live? Or would it grow through the sand, no matter how deeply, like *Ammophila* happily does? To this end, using money from the Bradley/NOAA grant, we commissioned a study on *Carex* from Rutgers with Joe Schisler, and Dave Sherrett [ditch: was] the graduate student on the project. We wanted to know: where was it located, how much of it was along the Jersey coast, and whether we could grow it easily. The study was published in 1987.

The most important thing they found was that they couldn't propagate it from seed at all. Even though the Plant Material guys down in Cape May were growing it and selling it, Schisler and Sherrett couldn't get it grow in the greenhouse at all. Thus, one of the most eagerly awaited pieces of information we needed, the data on depth of sand burial, couldn't be determined because it wouldn't grow! However, they did get the information on where it was, and how much of it was out there, and this report became the baseline against which Louise and her students now compare their acreage studies. I must say, with all the talk about *Carex* at this conference, I'm feeling very maternal.

As you know now, *Carex* was identified just north of Island Beach State Park in the Seaside Park area in 1929. J.A. Small writing in Ecology in 1954 speculated that *Carex* was accidentally discarded or escaped from the bowels of passing ships, most likely in solid ballast. Since then the debate about how it got there has continued. Louise disagrees with me, but I still hold out for a scenario in which *Carex* was introduced to shore from shipwrecks. I learned from the Museum of Modern Art that there was often plant material packaged in crates or barrels with porcelains coming in from the Orient. Soft plant material was used as packing material as we use foam peanuts today. This "export china" was a favorite cargo item of the day. Some ships went into Philadelphia, others came up to New York, and also, of all places, Tuckerton, NJ was a point of entry through the Great Egg Inlet, which is right below Long Beach Island. In fact, until a few years ago, it was still listed as an official port of entry into the US, complete with its own Customs House. This was an active place for ships and when we had storms, ships could make their way into Tuckerton to lay up if they could find the inlet. Many could not, and wrecked on Island Beach and Long Beach Island.

I understand from Louise that she has done some research to see whether our eastern *Carex* is genetically more like Asian *Carex* than the west coast version of *Carex*. This might help us understand where our *Carex* came from, and whether or not my shipwreck scenario could be possible. We know we had many shipwrecks back in the day and I might add that quite

frequently, these shipwrecks were aided and abetted by unscrupulous residents who moonlighted as their "night job" luring ships ashore. They'd hold the lights up, to try and lure the ships off course, luring them closer to the coast, only to crash on the sand bars. They'd do this during storms too. They were more than willing to help salvage any cargo that just happened to spill out where it was wrecked. If you go on the tours down at Barnegat Light Historical Society, they will tell you about it. No doubt these guys were the precursors to the Sopranos of our day!

So, what is *Carex*? At the time, we didn't know what it was. *Carex* was determined to be a non-native plant. Originally these species were termed exotics, a term still used today. Not much was done with these plants or invasive animals until zebra mussels were first detected in the Great Lakes in 1988 and it has caused a huge environmental and economic problem ever since. Dan Terlizzi of Maryland Sea Grant called the zebra mussels "the darkest cloud yet in the invasive biology of North America." So we looked, and the first thing we could find was the definitions in the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990. There were some phrases that were helpful:

"Aquatic Nuisance Species"

> Means a nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters.

"Nonindigenous Species"

> Means any species or other viable biological material that enters an ecosystem beyond its historic range, including any such organism transferred from one country to another.

"Unintentional Introduction"

> Means an introduction of nonindigenous species that occurs as a result of activities other than the purposeful or intentional introduction of the species involved, such as the transport of nonindigenous species in ballast or in water used to transport fish, mollusks or crustaceans for aquaculture or other purposes.

We looked at that carefully. The Act also provided for, and launched, the whole new area of study. As well as encouraging studies and as monitoring, it provided authority to control these species was given. Now, there is little debate that *Carex kobomugi* is a non-indigenous species. We know that. It was unintentionally introduced, whether it came from ballast or shipwrecks or whatever means, it got here. However, we were not yet certain this plant actually met the

criteria for aquatic nuisance species like the plant, Purple Loosestrife or our perennial "bad plant", *Phragmites*.

Let's look at the definition of an "Aquatic Nuisance Species" by itself. In some places *Carex* grows very close to the ocean's edge. But does this species meet the definition of an ***AQUATIC*** nuisance species? It's not completely clear!

Does it threaten the diversity or abundance of native species? We know that *Ammophila* usually is one of very few native species that thrives in the foredunes, and often dies off in the back dune area where other species are more abundant and diversity increases. Thus, the presence of *Carex* can actually increase diversity at least early in the invasion when both species coexist, though later on there is a real decline in diversity in invaded areas. So its effect on diversity is mixed. So, does *Carex* threaten the abundance of *Ammophila*? Moreover, in some places where *Ammophila* doesn't do too well, like the back dune area, inner dune swales, and very steep slopes, *Carex* grows very well. So today we know that the answer to that question is a definitive "yes". However, back then we didn't know that.

So I'd be interested in your opinions on this, and whether any of you have had any experience vetting a species based on definitions like this.

This is all we had until 1999 when then President Clinton signed Executive Order 13112 on invasive species. Some of the new definitions that Order 13112 produced were these:

- "Alien Species" means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.
- "Introduction" means the intentional or unintentional escape, release, dissemination or placement of a species into an ecosystem as a result of human activity.
- "Invasive species" means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Now it appears that the Nonindigenous Species has been simplified to just "Alien." The Unintentional Introduction is simplified into "Introduction." However, the real phrase of interest here is 'environmental harm.' We see nothing there about the spread rates, specific data on killing off of native species, or lists of bad actors like the Asian Long-horned Beetles that eat up our hardwood trees. Nor are there listed other scientific criteria for invasiveness beyond "environmental harm" which, alas, is not defined anywhere. However, if we go back to the 1990 aquatic nuisance species definitions, we a hint of what is meant by 'environmental harm'.

The purposes of the nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 were listed as being

- To prevent unintentional introduction and dispersal of nonindigenous species into waters of the United States through ballast water management and other requirements.

- To develop and carry out environmentally sound control methods to prevent, monitor and control unintentional introductions of nonindigenous species from pathways other than ballast water exchange.

- To understand and minimize economic and ecological impacts of nonindigenous aquatic nuisance species that become established, including the zebra mussel.

In addition, the 1999 Executive Order charged the federal agency to do a whole host of things including:

- prevent the introduction of invasive species;
- detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner;
- monitor invasive species populations accurately and reliably;
- provide for restoration of native species and habitat conditions in ecosystems that have been involved;
- conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species; and
- promote public education on invasive species and the mean to address them.

Under the Aquatic Nuisance Species Prevention and Control Act of 1990 “Environmentally Sound” methods, efforts, actions or program are defined as “Methods, efforts, actions or programs to prevent introductions or control infestations of aquatic nuisance species that minimize adverse impacts to the structure and function of an ecosystem and adverse effects on non-target organisms and ecosystems and emphasize integrated pest management techniques and nonchemical measures”.

Table 1: Qualification of *Carex* as an invasive species under the 1990 and 1999 definitions.

Definitions		Does *Carex* sp. Meet?		
		Yes	Maybe	No
1990	Non-Indigenous Species (NIS)	X		
Unintentional Introduction		X		
Aquatic Nuisance Species (ANS)			? Too Dry?	
1999	Alien Species	X		
Introduction		X		
Invasive Species		2009 Definitely	2002	

1990: Public Law 101-646 as amended

1999: E.O. 13112

Clearly *Carex* meets all of the definitions of an invasive species, even if its status as an <u>*Aquatic*</u> Nuisance Species is less clear. I am crushed, because that means we now have to get rid of it! My former darling dune plant turns out to be "species non-grata." Instead of being something useful, it has to be killed! Certainly, there is no doubt that *Carex* is in love with the Jersey Shore. As we know, it has spread rampantly in our area and beyond. And, unless we start work on dealing with it soon, that spread threatens to overwhelm our ability to deal with it.

Post-Conference Update

During the discussion period after the talk, someone asked if any new regulations have added to our understanding of *Carex's* status. The initial 1990 law was reauthorized, and renamed the National Aquatic Invasive Species Act, or NAISA. It was expanded slightly in 1996, but most of the other changes dealt with ballast water: all ships arriving from outside the 200-mile U.S. Exclusive Economic Zone were encouraged to exchange their ballast water, but required to report whether they had. NAISA also authorized important research and linked its results to decisions about whether further ballast water regulation was needed.

The NAISA expired in September 2002, and has yet to be reauthorized. The National Invasive Species Council (NSIC) (www.nationalspeciesinfo.gov) website opines:

Despite its successes, NAISA has considerable room for improvement. Federal agencies have ignored important provisions; the law neglects important pathways of introduction other than ballast water; all the nation's waters deserve protection equal to the Great Lakes; and reliance on ballast water exchange to reduce organisms in ballast water doesn't work—even in the Great Lakes where exchange is mandatory.

In 2005, the NAISA was re-introduced into the U.S. Senate, with complementary legislation being introduced in the House. These new bills strengthen the older legislation by extending protection to include not only ballast water introductions, but also to other pathways. They also authorize funds for rapid response and education / outreach programs, as well as for research. Passage of this legislation would be an important tool for managers working to manage *Carex* and other aquatic invasive species. However, currently both versions of the bill appear to be stalled. We encourage all our readers to visit http://www.necis.net/intro-to-invasive-species/invasive-species-solutions/federal/naisa/ to learn more.

The final update of note is that *Carex* is not listed on the Federal Noxious Weed List published on December 10, 2010. Section 403 of the Plant Protection Act (PPA) defines a Noxious Weed as:

"*any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment.*"

Unfortunately, since the environmental impacts of this species have been clearly demonstrated, *Carex kobomugi* should be added to this list at the next revision.

Looking through a different lens. Aquatic invasive species public education. Douglas A. Jensen. Aquatic Invasive Species Program Coordinator, University of Minnesota Sea Grant Program. 144 Chester Park, 31 West College Street, Duluth, MN 55812-1198.

Abstract
Invasive species management is about people management. Effective public education is a critical component of aquatic invasive species (AIS) prevention and control. Recognizing the need to move "beyond brochures," natural resource managers, policy makers and educators are drawing upon what has been learned about AIS management and merging it with contemporary social sciences to improve outreach. Minnesota Sea Grant works with federal, state, and local partners to blend and extend "lessons learned" to encourage changes in behavior through AIS public outreach. Results of Sea Grant-sponsored surveys show that effective AIS public outreach taps into audience values and motivations, stresses why preventing the spread is important, and delivers strong, concise, consistent messages. Sea Grant found that public willingness to change can increase over time and that people are generally willing to take action if they know what to do. Building individual responsibility, social norms, and community responsibility are concepts at the heart of bringing about sustained behavior change (e.g., removal of aquatic plants from boats/trailers; not releasing unwanted aquarium fish and plants from aquaria). This presentation will highlight two national campaigns that embody these concepts. Stop Aquatic HitchhikersTM, (www.protectyourwaters.net) and HabitattittudeTM (www.habitattitude.net) can help you build awareness and capacity to stop the spread of AIS to coastal dunes and maritime forests and beyond.

Greetings from Minnesota – the land of 10,000 lakes and 6,564 natural rivers and streams! Clearly, our state has a tremendous amount of water resources to lose if we fail to aggressively address aquatic invasive species (AIS). Minnesota has a strong heritage in recreating on those lakes and rivers. Our economy depends upon those natural resources, including tourism. Our state is tied for first with Alaska in that 19% of the population fish annually. Currently, there are about 29 million people that visit Minnesota. Of those visitors, 36% participate in fishing. This emphasizes the point that we need to not only educate our residents, but also educate visitors about AIS to prevent and slow the spread of AIS.

Minnesota has much to lose and that is why our state has made addressing AIS a priority. Since 1991, the Minnesota State Legislature has given the Minnesota Department of Natural Resources (MnDNR) the authority to manage AIS. A major element of this effort is a prevention program focusing on public education. Minnesota Sea Grant has partnered with the MnDNR on dozens of projects over the years. We feel that those efforts have been very successful, considering the extent of pathways for potential spread. Importantly, we have evidence that those efforts have been successful at preventing and slowing the spread of AIS.

Besides working within Minnesota, I have been actively engaged at regional and national levels to help "pass the baton of lessons learned" it seems like to every corner of the United States in an effort to raise awareness and build capacity to more effectively deal with the AIS challenge.

In doing so, one of my messages has been that public education does work and it can work for you.

The purpose of this paper is to identify the elements for effective education, highlight two national campaigns, *Stop Aquatic Hitchhikers!* and *Habitattitude* as two very successful approaches, describe more about approaches used and identify resources by these campaigns and share couple of success stories with you all. I hope that there are some insights that you can use based upon what we have learned. We do not claim to have all of the answers, but I am confident that there are some "take-home" messages that will help you address invasive species to protect dune areas and maritime forests here in New Jersey and elsewhere.

In our experience, it all starts with behavior. Our challenge is to educate guys like these, who say [quote], "So I figure dig a moat, plant some milfoil and voila! Lower our property tax!!" While this may seem like a good solution, what he is not considering is that invaders such as Eurasian watermilfoil, an invasive aquatic plant, can lower lakefront property values by 15%.

For communities that depend upon the value of lakefront property for taxes that provide funding for local services, it is the best interest of everyone in those communities to work together to prevent and slow the spread of Eurasian watermilfoil as well as other AIS in their communities.

Since the early 1990s, entities across the Great Lakes responded to and have learned a great deal about how to design and implement effective AIS public education efforts targeting audiences. As this conference has identified, it is about addressing pathways for spread in a comprehensive manner. Effective public education is key to preventing and slowing the overland spread of AIS.

Evidence shows that strategic public education can work to raise awareness and change behavior to prevent the spread of AIS. Results of Sea Grant-sponsored surveys show that education can significantly change public behavior regarding AIS, thus protecting water resources. Common elements for effective programs are to: make public education a priority, use the best strategies or methods, adapt or adopt proven approaches or tools, and use consistent guidelines to promote behavior change. Using consistent guidelines and messages in an educational approach doesn't necessarily require a hammer.

Two audiences that we have had success in forming partnerships and addressing AIS through public education are recreational boaters and anglers, and aquarists and water gardeners. Both audiences are challenges in that there are not natural conduits for flow of information from any one entity using any one source of information. It's widely known for over two decades that recreational boaters pose great risks for overland spread of AIS. After all, there are over 13 million registered boats in the United States, which move frequently between waterbodies. In the Great Lakes region, there are about 4 million registered boats within the U.S. and another 2 million in Canada – a large pathway to deal with. Another thing that is known, is that *without* proper information, recreationists will not clean their watercraft of AIS. Aquarists and water

gardeners pose risks because release or escape of unwanted fish, plants, snails, crayfish, and turtles are becoming an increasing problem. There are over 13 million households in the U.S. that maintain aquaria with another 2 million plus with water gardens or ponds. With the increasing popularity of ponds and water gardens, without understanding the consequences of their own actions, consumer releases will continue to grow as an issue. Both of these situations provide an opportunity to protect water resources through public education by targeting education and raising awareness aimed at bringing about behavior change.

Stop Aquatic Hitchhikers! is a successful national education campaign to educate boaters, anglers and other recreationists about how to prevent the spread of aquatic invaders. Launched by the U.S. Fish and Wildlife Service in 2002, the campaign builds upon the successes in Minnesota and beyond, where Minnesota Sea Grant-sponsored surveys have shown that not only are boaters and anglers more aware of AIS, they are willing to change their behavior to prevent the spread. To this end, it is a nationally branded campaign using a recognizable logo, word mark, tagline, Website and guidelines, which I'll return to in a moment. It uses internet marketing strategies, the most effective media and a campaign Website, which provides resources for campaign partners and recreationists. It was created to be 'stepped-down' so businesses, agencies, academia, and non-governmental organizations can adapt or adopt resource materials. Today, over 700 groups have joined the partnership nationally, with at least 50 in Minnesota alone.

As mentioned earlier, a cornerstone of the *Stop Aquatic Hitchhikers!* campaign is the guidelines. In the mid-1990s, I served as the National Sea Grant Program on the Recreational Activities Committee of the ANSTF (RAC). The mission of the RAC was to review the guidelines originally promoted in Minnesota and through the Great Lakes Panel on Aquatic Nuisance Species and adapt those guidelines for application by various recreationists for use anywhere in the country. Six sets of guidelines were developed for boaters and anglers, waterfowl hunters, scuba divers, recreational baitfish harvesters, sailors, and personal watercraft users. Guidelines were tailored specific to those audiences taking into account the types of equipment they use, the life histories of AIS that could be spread via that pathway, and promoting specific actions that those audiences need to take to prevent the spread of AIS. Each guideline begins with a positive action oriented verb that describes exactly what to do and where. For example, guidelines specific to boaters and anglers are:

BEFORE launching…**BEFORE** leaving:

- ✓ ***Remove*** aquatic plants and animals from boat, motor, and trailer.
- ✓ ***Drain*** lake or river water from livewell, motor, and bilge.
- ✓ ***Dispose*** of leftover live bait, worms and fish parts in the trash.
- ✓ ***Rinse*** boat and equipment with high pressure, hot water, especially if moored for more than a day.
- ✓ ***Dry*** everything for at least five days.

Note that many of the products shown throughout this presentation serve as models so that any organization can adapt or adopt them by inserting their group's logo, producing and

distributing them, to help extend consistent messages through the campaign to recreationists in their communities.

Beginning in 2006, Minnesota Sea Grant collaborated with Minnesota, Wisconsin, and Iowa Departments of Natural Resources, Wisconsin Sea Grant, and many others to extend and promote the *Stop Aquatic Hitchhikers!* campaign along key invasion corridors targeting resident and non-resident boaters and anglers in three states. Through this two-year special initiative funded by NOAA-Sea Grant, we developed and implemented a strategic multi-media effort using existing and new products, many based on what we knew work to reach recreationists across the Midwest. Objectives of the initiative were to: 1) raise awareness among boaters and anglers, 2) expand ownership of lakes and rivers and AIS threats, 3) empower to actively prevent AIS spread, 4) build, empower, and leverage community-based support to extend the campaign locally in communities, and 5) evaluate outcomes to determine effectiveness. Importantly, two key goals of the initiative were to: a) evaluate outcomes to determine campaign effectiveness, and b) assess whether this type of social marketing-based campaign can build upon previous AIS outreach efforts and justify resources.

In 2006, the *Stop Aquatic Hitchhikers!* campaign effectively merged with Wildlife Forever's *Threats Campaign* to coordinate regional AIS mass communications and outreach efforts, leverage expertise, and avoid duplication of efforts. A planning committee consisting of campaign partners in the three states devised a multi-media campaign in an effort to reach recreationists using 25 types of media. Those identified below with asterisks were shown to be effective as best sources for information based on Minnesota Sea Grant-sponsored surveys. Also tested through this initiative were other methods that had not been evaluated before including: highway billboards, traveler information systems, and outside advertisements on gas pumps. Select multi-media used included:

1. Highway radio messages (TISs)
2. Billboards
3. TV, radio, and newspaper PSAs*
4. Displays at rest areas
5. Kiosks at retail and other outlets
6. Outside ads on gas pumps (toppers)
7. Lawn banners
8. Regulations booklets*
9. Watercraft inspectors*
10. Signs along roadways
11. Signs at water accesses*
12. Windshield flyers
13. Displays at airports (dioramas)
14. Brochures*
15. AIS cards*
16. Stickers
17. Other media

Through combined efforts of campaign partners, the campaign reached a tremendous number of people across Minnesota, Wisconsin and Iowa. Wildlife Forever estimates there were 262 million exposures (impressions) created in 2006-2007. The campaign was promoted through a variety of organizations including businesses and industries, agencies and organizations to extend messages to recreationists.

With over 5 million people in Minnesota, it is obvious that the campaign reached many people multiple times and that is exactly where we want to be. Like other successful commercial branding efforts, for example Nike, it is the intent of campaign communication and education efforts to position the S*top Aquatic Hitchhikers!-Threats* campaign in as many of the most effective media as possible, and as many times as possible.

Two surveys were developed to assess the effectiveness of the campaign, a face-to-face and a self-administered survey. Surveys were administered in 2006-2007 at water accesses by watercraft inspectors and interns. More surveys were administered in Minnesota than the other two states at almost 2 to 1. Also, more locations were surveyed in Minnesota (45), then Iowa (5), and Wisconsin (10). This was because Minnesota has more watercraft inspectors than Iowa and Wisconsin.

A key element of the initiative's evaluation was to learn what are the most effective sources for information to reach boaters and anglers with *Stop Aquatic Hitchhikers!-Threats* messages. For Minnesota, Wisconsin, and Iowa, the top five sources for information were quite consistent: signs at water accesses, watercraft inspectors, regulation booklets, billboards, and television and radio advertisements. Other important methods were also identified.

Another key element of the initiative's evaluation was to learn how exposure to the *Stop Aquatic Hitchhikers!-Threats* campaign influenced boater's awareness. Results show that the campaign raised the highest level of awareness among Minnesota boaters and anglers, followed by Iowa and Wisconsin. It is important to recognize that Minnesota more broadly implemented many of the campaign methods used, while IA and WI used select methods in a more limited manner. Nonetheless, results for IA and WI are very encouraging! Overall, 86% of respondents indicated that their awareness was raised a large to moderate amount based on their exposure to the campaign. Similar results were shown regarding boater knowledge and understanding of AIS.

Understanding if behavior was changed based on that awareness is critically important. When asked "how likely is it that YOU WILL take special actions in the FUTURE to prevent the spread of AIS?" the survey showed that: 99% of Minnesota boaters reported that they will likely take action, compared to 84% of boaters in Iowa, and 88% of boaters in Wisconsin. Averaged for all three states, at least 97% of responding boaters in all three states indicated that they *will be influenced a large to moderate amount to take action to prevent the spread of AIS!* These results show that awareness based on the *Stop Aquatic Hitchhikers!-Threats* campaign can translate into behavior change aimed at protecting water resources from AIS.

Previous Minnesota Sea Grant-sponsored surveys show that public education can not only raise awareness but can change behavior of boaters and anglers. A 2000 survey conducted in Minnesota, Vermont, Ohio, Kansas, and California showed that Minnesota and Vermont boaters had changed their behavior (90% and 82%, respectively) to a greater extent than in other states surveyed. Minnesota boaters who took action increased to over 90% compared to a similar Sea Grant survey in 1994, which showed that 70% took action. Differences among states relate to emphasis placed on AIS public outreach and the variety of best methods used to reach boaters. As it turns out, Minnesota and Vermont had placed more emphasis and used the best variety of methods to reach boaters compared to the other states.

Overall, results demonstrate that AIS public education can significantly change boater behavior to prevent and slow the spread of AIS. Results also suggest that boaters regardless of region of the country can be influenced in terms of their awareness and behavior change with regard to preventing the spread of AIS.

Critically important is knowing <u>why</u> boaters didn't take action so that efforts can be implemented to strategically attempt to overcome barriers for future behavior change. Concern was that there might be attitudes that prevent boaters and anglers from considering taking action. Based on the 2000 survey, results showed that only 1-3% of the boaters surveyed in all five states indicated that they didn't take action because: 1) they didn't have time, 2) it wouldn't help prevent the spread or 3) AIS were not a problem. The main reason why they didn't take action was because they didn't know what to do. Outcomes revealed insights that concern among boaters is high once the threats are of AIS are known (survey data not discussed here). Results also revealed that apathy and complacency is very low. Therefore, the challenge for AIS management is the need to effectively communicate and educate boaters as well as other recreationists on *what to do*, which will help overcome the barriers for inaction, build the necessary skills for those actions, and promote personal and social norms reflecting effective preventive actions at water accesses.

Based on evidence of over a decade of social science research conducted by Minnesota Sea Grant, we believe that AIS public education can work to prevent and slow the spread of AIS. As a case study, evidence from Minnesota provides a compelling story. Based on the *Stop Aquatic Hitchhikers!-Threats* campaign survey, evidence showed that it works in Iowa and Wisconsin, and likely elsewhere. Boater awareness and behavior is influenced by education. Furthermore, watercraft inspections in Minnesota show that frequency of aquatic vegetation on boats inspected at water accesses is decreasing each year. AIS spread has been prevented or slowed. Since 1993, the number of Eurasian watermilfoil lakes found each year has remained flat – at about half the rate of spread compared to the early 1990s. Zebra mussels were nearly held at the doorstep for over a decade, despite the fact that the number of registered watercraft increases annually with more and more boaters moving between waterbodies increasing the risk for spread. As other examples, the Eurasian ruffe (introduced in 1986) and round goby (introduced in 1995), two invasive fish, have infested the Duluth-Superior Harbor for over a decade. Anecdotal evidence from many conversations with anglers for years at boat shows

suggest that they know that these fish are undesirable, they are not putting them in the bait buckets, transporting or releasing them in inland waters–otherwise there would be inland lake infestation—but there are none.

Based on a comprehensive effort in Minnesota that focuses on prevention through public education, watercraft inspection, research, monitoring and early detection, as well as policy and enforcement– these five elements have worked to almost "close the door" preventing the spread of zebra mussels. Consider the comparison of infestations in Minnesota to Wisconsin, and Michigan, where support to inform boaters and other recreationists was less than Minnesota during the 1990s. In those two states, zebra mussels spread to more inland waterbodies than in Minnesota. However, it should be mentioned that Wisconsin has impressively emphasized a comprehensive program over the past five years. Results show that Wisconsin has been able to slow the spread of not only zebra mussels but Eurasian watermilfoil as well. Unfortunately, zebra mussel spread continues at a more rapid rate in Michigan.

In Minnesota, there is further evidence that the spread of AIS can be slowed. Using Eurasian watermilfoil as another benchmark, the spread would have been much faster in the absence of comprehensive efforts. Soon after this invasive plant was discovered in Minnesota the cumulative number of waterbodies found to be infested was nearly exponential. Currently (2009), there are 215 Eurasian watermilfoil infested lakes. Comparing the potential to observed infestations over time, if this invader would not have been addressed, there would likely be between 1,200-1,500 infested lakes across the state. First found in Minnesota in 1987, Lake Minnetonka last year spent over $200,000 to control the infestation, maintain navigable access through mechanical harvest and herbicide treatments. Depending upon lake size and severity of infestation, every Minnesota lake that remains uninfested is a cost savings at least between $100,000 to $200,000 per year.

In summary, *Stop Aquatic Hitchhikers!* builds upon previous efforts to help protect water resources, jobs and economic viability of the communities that depend upon those resources. The campaign promotes simple and consistent messages and actions that invite boaters and other recreationists to be part of the solution. It unifies business, tourism, industry, government and academia with boaters and others in a common cause. Successes justify expending more resources on AIS outreach because of demonstrated return on this investment by being proactive, which is much more cost effective than being reactive. The campaign will continue to build partnerships in 2009 and beyond.

Switching gears now to another pathway for spread. What do pacu, water lettuce, water hyacinth, purple loosestrife, lima shovelnose catfish, yellow iris, cayman, koi and northern snakehead have in common? They have been released by aquarium and water gardeners in the Great Lakes region and elsewhere across the United States!

Launched in 2004, another national education campaign *Habitattitude* was created by a unique partnership of industry, academia, and government. It focuses on raising public awareness, engaging consumers, and promoting environmental messages with corresponding beneficial

actions. It provides an opportunity for business, industry, agencies, non-governmental organizations and associations to join in partnership to address the release and escape of pets and plants by aquarists and water gardeners.

All segments of the pet industry are involved with the campaign from wholesalers to retailers, trans-shippers to producers, manufacturers to trade and consumer publication media. It is likely that the industry have contributed than $1.1 million as a part of a grant from NOAA-Sea Grant, which jump-started the national campaign effort.

To evaluate the *Habitattitude* campaign, Minnesota Sea Grant led a pre-campaign mail survey in two communities in two states, Pennsylvania and Minnesota. An advisory committee with survey expertise developed the survey. Among the four communities, 600-800 surveys were administered. Response rate between cities ranged from 30-46%, with an average of 40%. Key highlights of the survey demonstrated that the campaign is well-positioned to have long-term impacts.

Survey results showed that the best sources for information for consumers were: pet store personnel, in-store signs, brochures, Internet, books/libraries, followed by newsletters, television, and magazines. Results suggest that a small but significant number of consumers are releasing pet and plants into the environment, likely reflective of not knowing the unintended consequences of their actions.

For the first time, survey data was gathered concerning consumer attitudes toward release of fish and aquatic plants. At very high levels, 80-90% of consumers surveyed felt that: release is preventable, that they should never release unwanted fish, etc. into the environment, and release is an environmental problem.

About 1/3 of respondents indicated that they owned unwanted fish, plants, snails, crayfish, or turtles during the three years before the survey. Of concern is that about 1/5 of those with unwanted pets and plants released them into local waters. Importantly, survey results confirmed that over that three year period, at least 50 release events by consumers had occurred in the communities surveyed. If the frequency of those release events is extrapolated to the statewide population of aquarists and water gardeners, there are likely hundreds if not thousands of releases occurring in those states, as well as other states and provinces across United States and Canada. This behavior is likely reflective of a small but significant proportion of consumers not knowing the unintended consequences of their actions.

A key element we wanted to gauge was consumer reactions to the campaign's logo and messages. Results showed that an overwhelming majority liked the brand on a variety of levels. They largely felt that the: logo was acceptable to them, easy to understand, attractive, has a positive impression, has a clear message, and encourages the support and purchase of hobby supplies. Overall, these results show that the campaign's logo and messages relate well to consumers.

Most importantly, the survey revealed that the campaign can increase awareness leading to potential sustained behavior change. Consumers indicated that the campaign will be very or somewhat likely to: increase public awareness, increase knowledge, change their attitudes, change the behaviors of others, and *change their behavior* (84%). Results suggest that the campaign is well positioned to achieve the goal of influencing behavior aimed at preventing release, thereby resulting in natural resource protection.

Results of this study established the first link between AIS, conservation and consumer attitudes toward their hobby. The *Habitattitude* campaign is well positioned as a communication platform to address releases by affecting behavior change resulting in environmental protection. Currently, there are over 70 partners in the United States and the partnership is expanding. In 2006, the Pet Industry Advisory Council in Canada launched the campaign. Other countries are considering joining the campaign as well.

Joining either campaign is free and there are no obligations. Simply go the *Stop Aquatic Hitchhikers!* campaign Website (www.protectyourwaters.net) or *Habitattitude* (www.habitattitude.net) and click on become a campaign partner. Fill in the contact information and you will receive via regular mail a compact disc containing campaign logos in various orientations and camera ready artwork that can be easily integrated into new and existing outreach and promotional materials. By joining the campaign, organizations have access to resources and expertise to help them effectively extend prevention messages based on these campaigns to recreationists or consumers in your community.

Partners can choose either in-kind or low cost outreach options or more cost, leveraged resources. As in-kind or low cost outreach options, your organization can link to the national campaign Website (address above), use your communication networks (e.g., newsletters, Web, magazines, water awareness events, mass media), or integrate prevention messages into existing outreach media. As more cost, leverage resources, partners can use model media already created by other campaign partners or create their own, encourage other local organizations to join, or implement the campaign by leveraging local expertise, funding and generate resources to extend prevention messages based on the campaign in their region.

Both of these campaigns embody the building of individual responsibility – concepts at the heart of bringing about sustained behavior change. These are key elements that will make implementation of the campaign successful in reaching the audiences we all wish to seek and influence.

Turning now to how we can take what we've learned from these two successful campaigns. I suggest targeting each audience using principles based on environmental education. Use the national guidelines for AIS developed for specific audiences and designed to promote sustained behavior change. Use the best media or strategies based on human dimensions research. Promote messages that: stress why prevention is important, tap values, motivation and promote a positive self-image, avoid myths or fallacies concerning spread, which will be discussed later, and reinforce compliance with laws and regulations at local, state, and federal

levels. Use social science models and evaluate based on behavior determinants including individual empowerment and development of social norms.

Recognizing that aquatic and terrestrial invasive species pose threats to New Jersey's dunes and maritime forests, it is important to identify and target each audience that represents a pathway for spread and establishment of invasive species. Those audiences listed below in segments represent: recreational, management, and private audience pathways for aquatic and terrestrial invasive species:

Aquatic	Terrestrial
Recreational boaters	Campers (e.g. firewood)
Live bait use by anglers	Hunters and Trappers
Sailors	Off road vehicles motorized vehicles
Personal watercraft users	Off road vehicles non-motorized vehicles
Aquarists	Hikers
Water gardeners	Backyard ornaments gardeners
Scuba divers	Land management operations
Waterfowl hunters	Foresters
Seaplane operators	Urban, Land and Forest management
Fish stocking operators	Enforcement officers
Management agencies	Research/consultants
Enforcement officers	Right of way highway construction
Researchers/consultants	Roads and highway construction
Commercial boat haulers	Landscaping/mowing operations
Aquiculture	Farmers (e.g. hay)
Nursery industries	Commercial equipment haulers
Biological supply houses	Horticulture operations
Barge operators	Nursery Industries
Commercial shipping	Shipping materials (e.g. pallets)

As mentioned earlier, AIS management needs to apply long-standing principles of environmental education in AIS education. AIS education should teach toward traditional performance measures used in environmental education including: awareness, attitudes, knowledge, understanding, and behavior. Efforts should consider age and gender using place-based pedogy. It is also suggested that efforts include in evaluation a variety of assessment instruments to measure outcomes and impacts. Logic models help provide a framework for compiling and measuring outputs, outcomes and impacts.

As another tip to help make AIS communication and education effective, it is strongly recommended that fallacies be avoided. This is because promoting fallacies can undermine successes in bringing about behavior change among targeted audiences. Some may recall Comedian Flip Wilson on his television show when he dressed up as character, Geraldine. Her famous line was, "what you say is what you get!" Well, this statement holds true for AIS outreach. Communicating fallacies such as "it's only a matter of time", "it only takes one

mistake", or "invasive species are going to spread everywhere anyway," undermine successes in motivating target audiences to assume personal responsibility that can promote social norms. Promoting fallacies is a missed opportunity to provide a meaningful educational message. Once social norms are established, the frequency and magnitude of AIS introductions can significantly reduce the probability that they will become established and spread.

Dozens of research papers indentify that most environmental education fails to meet goals. There are many reasons for this, but one reason is summed up best by Iozzi (1989): "increasing knowledge alone will not significantly change attitudes and values." Taking this statement one step further, it obvious that if values and attitudes do not change, neither will behavior.

During the 1940s, the "one-way transmission model of communication" emerged to describe how a message is linearly transferred as a signal along a continuum through a receiver to its destination. Unfortunately, it was adopted as a model for learning and behavior within public education. While seemingly still in vogue today, it has been showed to be inadequate in learning and behavior. More integrative models have evolved to better characterize learning and teaching based on advances in human dimensions research. Those studies have shown that learning is much more complex, non-linear, and often based on interactions of intrinsic and extrinsic situational variables.

Most education efforts used by natural resource professionals have been based on classical education techniques, which assume that information alone will lead to desired behavior change. There is plenty of evidence showing that this approach is not very effective in bringing about the behavior for environmental protection.

Community-based social marketing (CBSM) is a mature science-based spin off of marketing. With a proven track record for nearly 40 years, CBSM uses marketing techniques that encourage change in behaviors. There are eight components of CBSM. What is important to remember concerns removing barriers to behavior change. For application to AIS outreach and communication, it is important to produce media tools that link barriers to solutions.

As an example, if motivation is an issue, try forms of commitment, norms, incentives or disincentives such as laws or fines. Forgetting is usually a key barrier to behavior change. What sort of prompts could be located for place-based exposure? Establishing personal and social norms are important. If knowledge is the barrier, then more information is needed focusing on using the most effective communication and education materials. If convenience is the issue, communicate where infrastructure such as access to nearby carwashes or boat wash stations are located to make it easier to foster long-term behavior change. If pet release is the issue, identify specific businesses that will take back unwanted pet and plants.

Another suggestion is to integrate the theory of planned behavior as a model to be in a better position to know what variables control the behaviors for which a campaign aims to influence. AIS communication and education can then be more strategically designed to target those

variables that actually do predict the likelihood that people in the target audience will engage in the pro-environmental behavior.

Briefly, human behavior is largely driven by these inherent characteristics:

1. Beliefs about the likely consequences of the behavior and the evaluation of behavior beliefs.
2. Beliefs about the normative expectations of others and motivation to comply with these expectations are called normative beliefs.
3. Beliefs about the presence of factors that may control, facilitate or impede performance of the behavior and perceived importance of these factors.
4. Attitudes are a set of beliefs about what would be the likelihood of an individual to engage in the behavior together with the consequences.
5. Social norms are what an individual believes is expected of them by others whose advise or opinions they value together with how motivated they are to comply.
6. Perceived behavior control is the extent that external factors including their own ability or capacity are such that they actually could do the behavior if they wanted to. In this case, I would also add that the likelihood of effectiveness also interplay here.

Together, these modulate into behavior intention, then behavior. This conceptual framework is very useful to consider when designing more effective outreach programs and campaigns aimed at changing behaviors of boaters, anglers, or consumers.
In summary, this brings us to a place that creates opportunities to help improved AIS management by integrating social science. This opportunity allows the use of new approaches that integrate: environmental education, social marketing, psychology, sociology, and evaluation, and empower individual action, social norms and responsibility. It allows creation of communication platforms for partners, including businesses, industries, agencies, academia, and non-government organizations – to all work together toward an end goal. Through the partnership, those groups can extend messages to their members and clients, and leverages other partners to join in their communities.

Hopefully, this discussion has provided you with some examples of effective AIS communication and outreach campaigns, and that there were insights that you can use to build upon what we have learned so that you can more effectively address invasive species in an effort to protect dune areas and maritime forests here in New Jersey and beyond.

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Health and vigor of seaside goldenrod (*Solidago sempervirens*) in *Ammophila breviligulata* relative to that in *Carex kobomugi*-dominated dune systems at Sandy Hook, New Jersey.

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Abstract

The invasive Asiatic sand sedge, *Carex kobomugi,* grows at much higher stem densities than does the native American beach grass, *Ammophila breviligulata* and tends to outcompete native vegetation, resulting in a monoculture of the sedge on the longer term. It was thus hypothesized that *Solidago sempervirens* plants growing in proximity to invasive *C. kobomugi* dunes would grow smaller and be less healthy than those growing in native *A. breviligulata* dunes on Sandy Hook, New Jersey. Plant health was quantified by measuring height, diameter, and stem number. Six field sites were selected; three sites within native dunes and three within invasive dunes. Six *S. sempervirens* specimens were selected at each site. Specimens' height, diameter, and stem number were measured and recorded from June 2008 through October 2009. Significant differences were found between number of stems per *S. sempervirens* plant between the two communities (repeated measures ANOVA, $p < 0.01$), with that number being significantly higher in plants growing on native *A. breviligulata* dunes. Basal diameters of the goldenrod plants growing in infested areas also appeared lower, but we were unable to show a significant difference with the number of replicates used in this study. There was no significant difference in height of the tallest shoot for plants growing in infested areas relative to plants growing on dunes dominated by native vegetation.

Introduction

Coastal sand dunes are a transitional environment which links a marine ecosystem to an inland ecosystem (Bird, 2008). In addition, a healthy dune system provides protection to inland areas from violent marine conditions. Coastal dunes form as sediments, carried by winds, collect on beaches (Martinez et al., 2004). Dune grasses provide an important role in stablilizing this sand, and allowing dune systems to form and persist. One of the most important species of sand-stabilizing plants on American North East Coastal dunes is *Ammophila breviligulata*, or American beach grass (USDA, NRCS, 2008). It is a member of the Poaceae family and can grow to nearly a meter in height (USDA, NRCS, 2008). In New Jersey, *A*. *breviligulata* is the key stabilizer of the primary dune system. It grows with great success throughout New Jersey's dune systems and forms the basis of the native dune ecosystem. American beach grass can be identified by its dense, green/brown stems and rounded leaf edges (Robichaud, 1973).

In recent years the invasive Asiatic sand sedge ,*Carex kobomugi* Ohwi, has been invading coastal dunes throughout North East Coast of the US as well as in Oregon (United States Department of Agriculture, NRCS, 2008). *Carex kobomugi* grows naturally in Central/Eastern Asia. It was probably first introduced to New Jersey beaches through the disposal of solid ballast in the early twentieth century. It was later intentionally introduced to dunes as a dune stabilizer in the 1970s and 80s (Wootton, 2003). Since that time *C*. *kobomugi* has grown from having a foothold to controlling a large amount of New Jersey's dune systems. A recent survey

showed that *C. kobomugi* populations in New Jersey have increased in size by 300 to 700 percent between 1985 and 2002 (Wootton et al. 2005). *Carex kobomugi* generally grows from 10 centimeters to 25 centimeters tall and forms dense patches (Bennett, 2001), referred to as infestations. It appears to outcompete native plants, resulting in significantly lower abundances of native plants, as well as reduced native plant diversity in infested areas (Wootton et al. 2005).

Solidago sempervirens (seaside goldenrod) is native to coastal areas throughout the entire Eastern United States and most of Northeast Canada (USDA, NRCS, 2008). It has bright green leaves and a long flower stem. It blooms in late September to early October when it can be easily recognized by its bright golden-yellow flower clusters. In New Jersey, seaside goldenrod is a primary host plant for several species of Checkerspot Butterflies. It also is a key source of nectar available to coastal-migrating Monarch butterflies on their journey south (Walton et al. 2006).

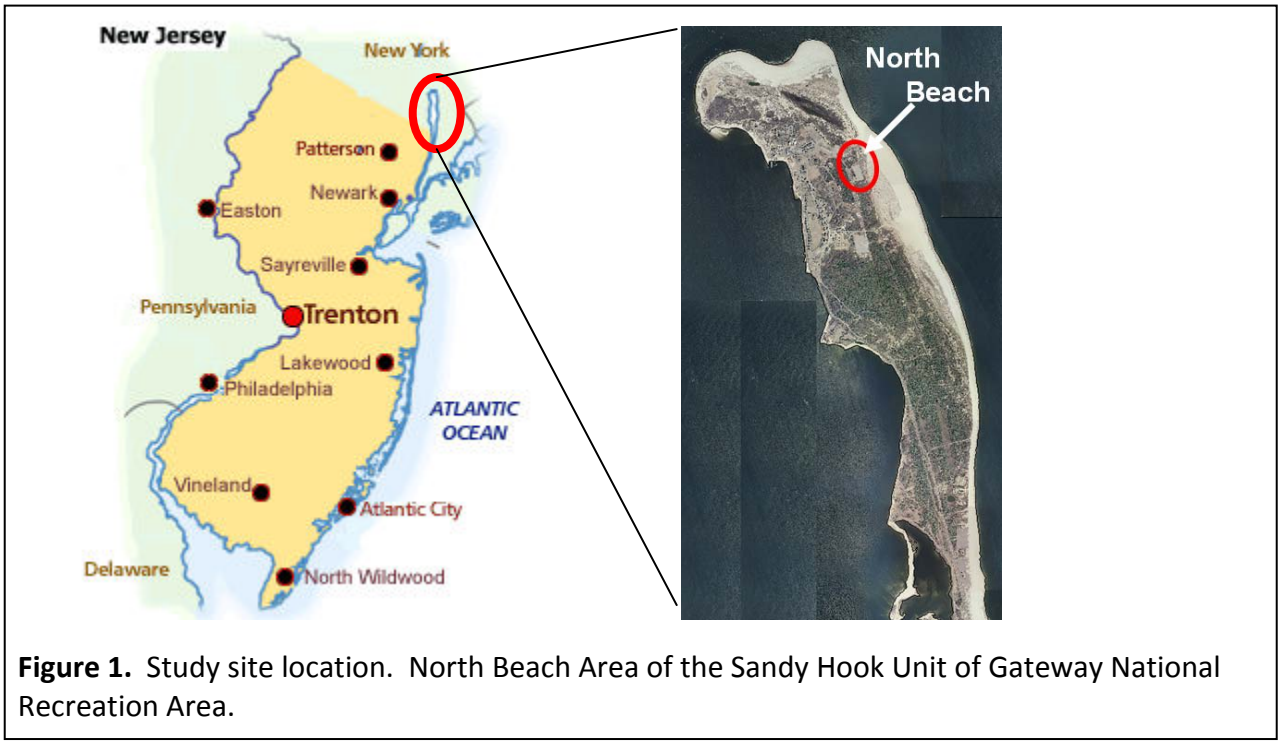

Figure 1. Study site location. North Beach Area of the Sandy Hook Unit of Gateway National Recreation Area.

The purpose of this study was to determine the effect of the invasive sand sedge on the growth and vigor of seaside goldenrod *(Solidago sempervirens*). To do this my study assessed several indicators health and vigor of *S. sempervirens* plants growing in proximity to *C. kobomugi* infestations, as well as in plants growing in proximity to the native *Ammophila breviligulata*.

Materials and Methods

Study Site and Sample Locations: The study was conducted at North Beach, which is located in the Sandy Hook Unit of Gateway National Park in New Jersey (Figure 1). Six study plots were established, three of which contained *S. sempervirens* and native *A. breviligulata* species, and

the remaining three contained *S*. *sempervirens* and *C*. *kobomugi* populations. The sites were paired with one another, such that each study site affected by the invasive sedge had a native population in relatively close proximity. All sites were located on back dunes with generally similar physical conditions (aspect, wind exposure etc.).

Monitoring Methodology: At each study site, six *S*. *sempervirens* specimens were chosen at random and marked with pink ribbon, resulting in a total of 36 plants being monitored, 18 within *C. kobomugi* infested areas and 18 on dunes with native vegetation. Each of the marked plants was then surveyed for its diameter, height and number of stems. To determine the plant diameter, each specimen was measured across its widest point. To determine plant height the tallest stem of each specimen was measured from tip to base. The number of stems per specimen was also counted, as were the number of blooms. Data were collected monthly from June through October 2008.

Data Analysis: In order to determine if a difference existed between the *S*. *sempervirens* specimens in the two different plant communities, a repeated measures ANOVA was performed using Statistical Product and Service Solutions (SPSS, version 16.0; SPSS Inc., Chicago, IL, USA).

Results

The number of stems present per plant was significantly lower in *S. sempervirens* plants growing on dunes infested with *C. kobomugi* relative to those growing on dunes dominated by native vegetation throughout the growing season (Figure 2a; Repeated measures ANOVA, $n = 6$, $F = 7.625$, $p = 0.009$). Basal diameters of the goldenrod plants growing in infested areas also appeared lower, but we were unable to show a significant difference with the number of replicates used in this study (Figure 2b. Repeated measures ANOVA, $n = 6$, $F = 2.501$, $p = 0.123$). There was no significant difference in height of the tallest shoot for plants growing in infested areas relative to plants growing on dunes dominated by native vegetation (Figure 2c; Repeated measures ANOVA, $n = 6$, $F = 0.009$, $p = 0.926$).

The average number of blooms on plants growing among *Carex* ($n = 18$) at the end of the growing season (October 2008) was 6.7 ± 4.7, while that on plants growing on dunes dominated by the native *Ammophila* ($n = 18$) was 10.2 ± 7.5. Although suggestive of a decreased bloom count in plants growing on infested dunes, the high degree of variability in these data meant that no significant difference between these two populations could be detected (two sample independent t test, $t = -1.656$, 34 df, $p = 0.107$).

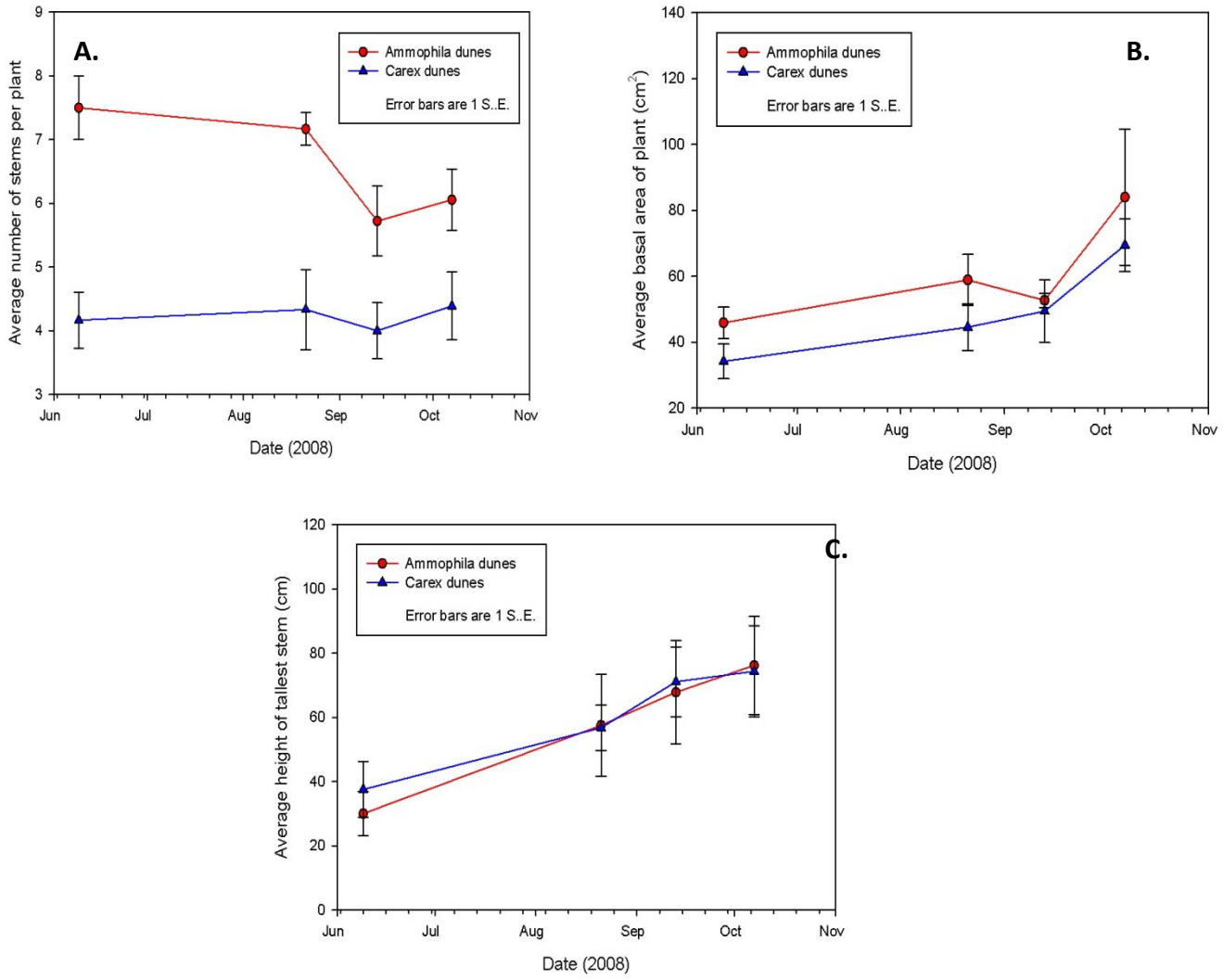

Figure 2. Comparison of various measures of health and vigor of *Solidago sempervirens* growing in areas infested by Asiatic Sand Sedge (*Carex kobomugi*) relative to those growing on dunes dominated by the native American Beach Grass (*Ammophila breviligulata*). (A) Average number of stems per plant. (B) Average basal area of plant (C) Average height of tallest shoot.

Discussion

Generally, it seems safe to assume that a larger plant, especially in terms of basal diameter, is a healthier one, since the diameter is largely defined by the size and spread of the plants' leaves. Similarly, the number of stems helps determine how productive the specimen will be, since a specimen with more stems can produce more blooms. Finally, bloom volume is expected to be a proxy for the reproductive potential of the plant, since larger blooming heads support more flowers, and thus have the potential to form more seeds. The results of this study point to a strong connection between the presence of the invasive sand sedge and the overall health of native seaside goldenrod plants, particularly in terms of the number of stems produced by each plant. Interestingly, the study did not indicate any effect of the sedge on *S. sempervirens*

height, suggesting that competition with the sedge has less effect on this parameter, but rather acts more to prevent the outward spread of the plant.

The results of this study point to the overall health of *S*. *sempervirens* decreasing when growing in proximity to *C*. *kobomugi* infestations. Because of the rapid rate at which this invasive species is spreading in New Jersey's coastal dunes (Wootton et al. 2005) this study supports the hypothesis that that the sedge may pose a serious problem to the ecology of these fragile and valuable ecosystems. Similar results were found by Wootton and her colleagues (2005), who showed significant declines in abundance of native plants in areas infested by this sedge, including *S*. *sempervirens*.

This study also tends to confirm the results of other findings (Zedler et al., 2004) that invasive species can negatively affect the biodiversity of an area. Invaders tend to create a "monotype" (Lugo, 2004) ecosystem, in which only the invasive species exists.

If the sedge really is outcompeting the plant either by physical root competition, or perhaps even allelopathy, one would expect that the vigor of the native plants growing in areas infested by the sedge to decline over time. Unfortunately, since this study was conducted over the course of only one growing season, it does not provide a sense of whether or not such trends exist. In the future the sites could be surveyed over a longer period of time. It would also be possible for a future study to use more specimens per site, or to use more sites. Similar studies could also be conducted on other native dune plants which grow in areas affected by the invasive sedge, such as *Ammophila* or wormwood.

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A Modest Proposal to Control and Eradicate *Carex kobomugi* (Asiatic sand sedge) from Habitat for Rare, Threatened and Endangered Species in New Jersey's Coastal Dunes.

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Abstract

Coastal dunes form the "first line of protection" for the land behind them by reducing the energy of storm waves. Coastal dunes play a vital role in protecting coastal areas from erosion, coastal flooding and storm damage, as well as providing habitat for specially adapted plants and animals. One plant species that is invasive in coastal dunes in the United States is Asiatic sand sedge (*Carex kobomugi*), a perennial sedge native to eastern Asia. In recent years, populations of *C. kobomugi* among the dunes of the New Jersey coast have been rapidly increasing in size and number. To reduce the threat that spreading *C. kobomugi* imposes upon rare species, we propose the eradication of the plant from the dunes of Island Beach State Park, NJ and the Sandy Hook Unit of the Gateway National Recreation Area, NJ through herbicide application. We propose using a three-tiered replanting effort with foredunes being planted with *Ammophila breviligulata* (beach grass), hind dunes being planted with a mix of grasses and forbs, and secondary and tertiary dunes being planted with grasses, forbs and shrubs. At some locations, open sandy areas will be maintained as habitat for rare species, such as piping plover (*Charadrius melodus*).

Introduction

Carex kobomugi is a perennial sedge from Asia that has become an invasive plant on the eastern coast of the U.S. Island Beach State Park, NJ and the Sandy Hook Unit of the Gateway National Recreation Area, NJ are suffering from particularly high levels of infestation by this species. For example, the area of dunes occupied by *C. kobomugi* at Island Beach State Park, NJ, doubled between 2002 and 2008 through natural propagation alone (Wootton 2003 using unpublished 2008 survey data). As a result of its rapid expansion and its negative impacts on native plant species (Wootton et al. 2005, Burkitt 2007), *C. kobomugi* has moved from being considered an endangered species in the 1970s (Fairbrothers and Hough 1973) to being one of the ten most unwanted plant species in New Jersey today (Bennett-Chase 2001).

The dune community of the New Jersey coast is habitat for a number of rare, threatened or endangered species including, but not limited to, piping plover (*Charadrius melodus*), least tern (*Sterna antillarum*), black skimmer (*Rynchops niger*), northeastern beach tiger beetle (*Cicindela d. dorsalis*), seabeach amaranth (*Amaranthus pumilus*), seaside knotweed (*Polygonum glaucum*), sea sandwort (*Honckenya peploides*), slender seapurslane (*Sesuvium maritimum*) and seabeach evening primrose (*Oenothera humifusa*) (NJDEP 2008a-e, NJDEP ND). Expansion of *C. kobomugi* on the coastal dunes of NJ threatens rare plants directly through competition and threatens endangered animals through habitat elimination. Species that thrive in the high beach habitat in New Jersey, including nesting shorebirds, such as the piping plover, and plants like sea beach amaranth and seaside knotweed, are already threatened by the reduction of available open sandy habitat for nesting as a result of coastal development. With the increasing

recognition of the reality of global warming and the increase in sea level that is expected to occur as a result in upcoming years, the amount of high beach habitat that is available for these species is likely to decline in upcoming years regardless of the vegetation type in the dunes. The *C. kobomugi* invasion may further exacerbate the problems experienced by these species, since the sedge appears to grow further down into the previously unvegetated regions of the high beach shore than does the native *Ammophila breviligulata*, thereby reducing yet further the area of open sandy habitat between the high tide line and the vegetated high shore (Lea and McLaughlin 2006). The diminished height of *C. kobomugi*-stabilized dunes means that they are less able to protect the communities behind them and are believed to be more vulnerable to blowouts and erosion than those stabilized by native *Ammophila breviligulata*. Thus, invaded dunes are likely to be less resilient to future environmental changes or other challenges.

Goals

The goals of the proposed eradication and restoration project area as follows:

- Removal of invasive *Carex kobomugi* on coastal dunes at Island Beach State Park and Sandy Hook Unit of Gateway National Recreation Area
- Restoring treated dunes with native dune plants
- Habitat enhancement for high beach plants and shorebirds
- Monitoring of effectiveness of spray treatments and habitat enhancement efforts
- Assessment of changes in dune profile (geomorphology)

Methods

1. Application of glyphosphate-based herbicides. Manual removal can be used in areas with small beds.
2. Long-term monitoring, coupled with repeated spot applications.
3. Foredune areas will be replanted with American beachgrass (*Ammophila breviligulata*) culms in late winter to early spring.
4. Hind dune areas, secondary dunes will be replanted with mix of grass and forb root stocks: *A. breviligulata*, *Spartina patens*, *Panicum amarum* var. *amarulum*, *Schizachyrium littorale*, *Solidago sempervirens*, *Lathyrus japonicus* – to be supplemented with local seed mix.
5. Randomly distributed shrub (*Morella pensylvanica* and *Prunus maritima*) clusters in appropriate habitats.
6. Application of fertilizer and arbuscular mycorrhizal fungi (AMF) spores.
7. Long-term monitoring – stem counts and photo plots.
8. Assess dune profiles at selected sites pre- and post- treatment using Emery dune profiling method.

Based on the results of previous attempts to remove *Carex* spp. from coastal dunes (McGough et al. 2003, test plots at SHU; Wootton unpublished data), when herbicides are directly applied to individual plants, which is the preferred method in this ecosystem because of the high porosity and low organic content of dune soils, long term monitoring coupled with repeated spot applications will be needed to completely eradicate this species. To date, no population

has been completely eradicated through herbicide application, largely as a result of a lack of consistent follow up monitoring and retreatment (McGough et al. 2003).

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IPANE (Invasive Plant Atlas of New England): Connecting Citizens to Science to Create an Early Detection Network for New England. Leslie J. Mehrhoff, Invasive Plant Atlas of New England, Box U-43, University of Connecticut, Storrs, CT 06269-3043.

Abstract

Most conservationists agree that the early detection of an invasive plant incursion, followed by a rapid and strategic response, is cost-effective, potentially less disruptive to the environment, and most likely to succeed. The overarching goal of the Invasive Plant Atlas of New England (IPANE) is to develop tools for early detection and establish a network of stakeholders to use them. IPANE trains concerned citizens to recognize and report incursions of invasive plants and to gather some basic ecological information about each occurrence. These trained volunteers comprise the IPANE early detection network. Data gathered, in part, by these program-trained volunteers are used to generate maps and databases and are used to construct ecological models of predicted ranges within the region. These models can be used to focus volunteer field work and for setting training priorities. Conversely, the volunteer network can be used to "ground truth" the predictive models. A big part of the IPANE initiative is to increase public awareness of invasive plants and the efficacy of early detection as a strategy for invasive plant control by making data, including those gathered by the volunteers available on the IPANE interactive website (http://ipane.org). This presentation discusses IPANE's early detection efforts, the tools available on the IPANE website, IPANE's "Localized Early Detection Site" network, how the program's extensive volunteer network works across New England, and IPANE's involvement in building a national and international early detection network.

Editor's note: Because Les passed away before he was able to complete his white paper for this conference, a full transcript of his presentation is included here:

Thank you Louise for having me and to those of you who stayed to the end of the conference for your interest. One of the things about coming late in a program is the tendency to want to change your talk. If I had the opportunity to do over, I'd try to address a lot of different things that have been said over the last two days. But since I can't do that from memory, I'm going to go ahead and give a talk that's about IPANE, specifically the early detection part of IPANE, which is the part that I'm working most closely with now. First, little bit of background information about me: I have a mixed background in everything. I was a native of NJ and moved to New England. I started out in graduate school as a plant taxonomist and ended up as a plant ecologist with a dissertation that was on biodiversity. After teaching a little college, I worked for years for the Department of Environmental Protection running their Geological and Natural History survey and biology program and then I went to the university to be the curator of the herbarium. One of the things that surprised me in getting there was that I couldn't go out and collect plants. How could I be a curator and not collect plants? The truth is, the original basis for the IPANE idea was purely an excuse to get me out in the field to collect plants! Of course, since then, it has grown into something totally different; something, much bigger than any of us had ever imagined.

Quickly, some of the partners in IPANE are: the USGS, National Biological Information Infrastructure (NBII), and the Invasive Plant Control Company. These are people that support a lot of the work I do with IPANE.

We've been talking about invasive species for days, so I don't need to talk to about that the fact that it's real. There are species invading our landscape. Darwin is one of my heroes and this is the 200th anniversary of his birthday. The first sentence of the last paragraph of Origin of Species (1859) says, "It is interesting to contemplate an entangled bank…". I don't think this (picture of a bank of entangled plants) is what old CD was thinking about! This is a place right near the University of CT and almost everything in that picture is on our state's list of invasive plants. This is not what it's supposed to look like and that's a part of the whole issue.

New England, where we chose to do IPANE, is like NJ and many other places. The landscape is a mixture of different habitats, different landforms, species that are both native and nonnative, and most people don't notice any of this when they drive through. They might notice the pretty foliage, but in general, they are not going "Is that a native species? Is that a nonnative species?" So it falls to us to try and bring these educational issues to the forefront. Like NJ, our landscapes go from urban areas to places like White Mountain National Forest, where as far as the eye can see, it's pretty much wild country. The Crawford Path is arguably the oldest hiking trail in the nation and there are no invasive species on it. So you have this continuum from areas that are highly populated and highly perturbed to others being less perturbed or less recently perturbed and with relatively few invasive species. But for the most part, the landscape is a mixture of native and nonnative patchiness, houses, urban areas. I took this picture while landing in Bradley Airport in April a few years ago. Notice the trees all throughout here- the yellowish looking ones – they are all Norway Maples. Their flowers come out really early. The nursery industry is telling us in CT they are non-invasive. So, if you are looking at the landscape and you are in tune with things like this, you can see some of the issues.

We chose New England for IMAP because it's relatively small in size, with slightly less square miles than the state of Washington (71,992mi^2 total). But interestingly enough, in that relatively small area, we have almost 5% of the population in the United States. You have the same thing here in NJ. Maine is fairly rural. CT and MA fairly populated. But the point that we are concerned with is that it is all an invaded landscape, just to different degrees and with different species. Whether it's Japanese barberry or Oriental bittersweet, the landscape has its problems. This is *Carex kobomugi* in Rhode Island. It was first reported from there back in 1982. I wish I had the slides I took when I saw it first in 1984 out there. It was nowhere near extensive as it is now. This is at East Beach and looking to the west. We also have lakes and ponds that are choked with things like Eurasian water milfoil or variable-leaf water milfoil or Combamba and other things that are nonnative. Our woodlands, if you drive through, and this is another thing they are in total denial about, are full of burning bush. They say "No, no no, it doesn't produce seeds, so it's not a problem." The cultivar problem is a serious one in CT but our woodlands are now full of this species.

Glen had some figures that were more astronomical the other day, but some of our students at one site calculated an average of 37 stems – and these are centimeter size stems - per square meter of burning bush in this place. The nursery industry says they don't produce seeds. But we also have other places like this, and you do too here in NJ, I know. This picture was taken at a state park up in northeast CT. As you can see, there are no invasive species present. This is where early detection comes in because, within a kilometer of that site, a number of invasive species are present. It's just as matter of time before the wind blows something in or a bird carries something in. The harder part of the equation is to figure out things like this: A port down in Miami, or an airport in Beijing or even a bike trail in CT lined with Japanese stilt grass. You don't know what's going to show up next or from where. And that's the part of it. You can train people to look for Japanese barberry, but you can't predict what's likely to come into these areas. In the old days, it was relatively easy. We knew where things were coming from and how they were going to get there and where they derived.

APHIS has done an admirable job protecting our boundaries. They knew where to be and how to check for these things. If they found something they could take care of it. That was fine. Nowadays, it just isn't like that anymore. With containerized shipping, containers move everywhere. You cannot have an APHIS official by every container to open it up and see what's inside it. This is just one of the things we are faced with. We are worried. I think, relatively, we have it easier with plants than the entomologist does. If you open up a container and there's an insect in there, it's going to fly out. None the less, you still never know what is going to show up in that kind of site. That is why we are trying to get volunteers and increase our search capabilities. Right after lunch is not the greatest time to show this picture but we hear a lot about early detection in medicine. We've heard it for a long time. That's a precancerous polyp. How many of you in the audience know someone that is around today because of early detection of some medical thing? That's the whole thing. If the concept didn't work we wouldn't be hearing about it. The concept is good because it does work. You've seen a lot of these s- or g-shaped curves. You see something show up down here and by the time the public react to it its way up there and the damage ecologically and the costs, monetarily, are going to be way off the board.

What IPANE is all about is trying to shift so the action is down here. When something is first discovered and we say that's a potential problem, let's not mess around with it; let's get it off, that's what EDRR is all about. That right there. If we can get that message around, we'd be much better off.

So, I would suggest that there are seven burning early detection questions:

1. Is this species going to get here?
2. Where will it first show up?
3. Will it become naturalized?
4. Who will discover it?
5. Will they report it?
6. Will we identify it correctly?
7. Will it become invasive?

Wavy leaf basket grass (*Oplismenus undulatifolius*) is a great example. I took this picture back in 2005 in Japan. I actually saw this plant a year before in China and when I saw it. I said "Whoa. If that ever gets into the nursery trade, we are going to have a serious problem!" It's cool, it has these wavy leaves. And here are the kinds of questions you would ask of stuff like that…So I asked a Japanese botanist who was with us on that trip (Takashi Enomoto, Laboratory of Wild Plant Science, Okayama University) "What is it?" and he said, "This is weedy, it could be invasive in your country."

Prevention is the ideal way to deal with invasives. Ideally we would stop potentially invasive species from entering region in the first place. For the most part, though, most of us cannot do an awful lot about prevention. We can't keep those ships from landing. We can't keep the stuff off. That is something someone else has to do for us with regulations and stuff like that.

The next tool is early detection: Locate and identify the invader before it becomes well established and spreads. What we can do is get out and look for these things. This is what early detection is all about. Find these things early, when the populations are small, when removal won't cost as much, and there will not be as much environmental damage from the actual removal. This is why we created IPANE. We had species strangling New England, like Oriental bittersweet. We wanted to figure out what we can do because, like someone said earlier this morning, when IPANE started in 1999, there was nobody in New England, whether state government or federal agency, who was tasked with the responsibility of working on invasive species and that was one of the things in our initial grant. We put two people on the ground, working on invasive species throughout the region.

So, why early detection? Mostly, it seemed like a logical place to start. It allowed us to make good use of science and citizens and it was practical and doable. We also found there were lots of people in New England who are savvy and interested enough to get involved and who believe they can make a difference.

The next question might then be "Why New England?" As we saw earlier, it has an understandable geography. When you say New England, most people know what you are talking about. People have asked why didn't we include New York? New York added a whole spectrum of different issues: Different habitat types way out west. Just the logistics of getting around and do the museum surveys and everything else. So New England was a reasonable landscape just to look at. There's another reason and that's the people. This is where our volunteers come from: Off the streets. We have some professionals, we have amateurs, we have students, we have retired people… all different kinds of people.

One of our big problems, and you have the same one down here, birds can't read lists. We can make all the lists of invasive species we want but once something gets on to the landscape, birds, whether it's a mocking bird or any other species, are going to pick these things up and move them around. Wind only moves things so far. Mammals have a closer home range. Water is a dispersal vector for every invasive species. It may not move things very far. It's not

just the aquatic plants. If you have a stream you are managing, things can come in on that stream and things can go out because these seeds don't drop to the ground and stay there, they travel. Birds just fly so much further. And then humans are another big variable. There is nothing stopping me from getting on an airplane this afternoon, after I've walked all through here and picked up Japanese stilt grass seeds, getting on a plane and flying to California and go hiking in the foot hills around San Francisco and taking those seeds with me, or going to China or coming from China. We are the ones who move things the most of all.

The other big problem is the loss of "old-time" field botanists who were New England's former "Early Detectors" like Merritt Lyndon Fernald, Albion Hodgdon (NH), George Rossbach (ME), Bill Linke (CT), Harry Ahles (MA), Bill Countryman (VT) and Richard Champlin (RI). Richard Champlin was the first person to collect *Carex kobomugi* in New England. These were people in my lifetime that I've worked with who are all gone. They knew the flora. They knew when something was different. We needed to come up with a mechanism because schools were not training people. These were the ideas behind IPANE. IPANE volunteers became the "Front Line of Defense".

The next thing is, if an invasive species gets here, we can't let it become established! Invasive species go through a predictable cycle, starting with introduction and establishment and moving to reproduction and spread. A species goes through this cycle "X" number of times before, at some point, it crosses the threshold where it becomes invasive. This is what we want to stop. We want to stop it before it gets to this threshold. That is the whole idea behind what I want to talk about.

Some of the questions that IPANE can answer include

- What IAS are already on the landscape?
- Where are they?
- How abundant they are?
- Understanding their biology in order to control them

We also need to find new incursions before…

- They become well established and spread
- The cost of environmental damage of their eradication is prohibitive

If we can't understand something, we can't manage it effectively.

The Invasive Plant Atlas of New England's (IPANE) mission is to create a comprehensive web-accessible database of invasive and potentially invasive plants in New England that will be continually updated by a network of professionals and trained volunteers. The database will facilitate education and research that will lead to a greater understanding of invasive plant ecology and support informed conservation management. An important focus of the project is the early detection of, and rapid response to, new invasions. (September 2001)

The IPANE Equation for Invasives is essentially this: Early Detection + Rapid Reporting + Reliable Data + Good Science = Effective Strategic Response

As you can see, then, IPANE is actually a multi-faceted program that does lots of different things but today we are going to focus on early detection.

Randy Westbrooks and I were up at a Weeds Across Borders meeting last year with people from Mexico and Canada talking about the exchange of these species across borders. Randy has been involved with the thinking about IPANE almost since its inception. He wanted me to tell this story yesterday about when I first met him because he walked up to me at a meeting we had in New England and he was introduced and he said "I've got to talk to you." He hasn't stopped talking since!

This FICMNEW Early Warning and Rapid Response Workshop, June 2000 meeting is where the real basis for IPANE came from. That meeting took place at USGS Research Center, in Ft. Collins, CO, sponsored by USDA & USGS. With broad stakeholder participation, five working groups formed working on Early Detection, Rapid Assessment, Rapid Response, Outreach and Education and Operational Framework. The proceedings and action plan were published the following spring.

Right after that, Randy and his boss, Bill Craig, invited me to go out and Bill and I co-chaired a section of that meeting on the science end and we looked at different aspects of early detection and what we now call early warning. That's the precursor to what Randy showed in his talk yesterday about the national plan put together by FICMNEW. We had applied for our IPANE grant at that point, but didn't get it though I didn't know that at the time. After we learned we didn't get it, we decided to go back in and resubmit and change some of the things that I had learned at that meeting about early detection and put that in the grant and it sailed right through. That's the result of that meeting.

What Randy and I are working on now is the US National Early Detection and Rapid Response System for Invasive Plant. The idea is to bring in all sorts of partners to develop a national network of early detection programs. They can be different. They don't have to use the same databases. There are several out there. For example, another very good one is IMAPS, which is doing work in the Mid-Atlantic States. The important thing is to get the data, get the people on a landscape and get the information in so it can be used.

At IPANE we use four different approaches to early detection:

1. Spontaneous Reports
2. Localized Early detection Network
3. Trained Volunteers
4. Research-based tools
    a. Pathways and vector research
    b. Predictive modeling

These approaches will work equally well elsewhere. Number one came right out of the Fort Collins meeting. What we are looking for are things we CAN teach people and we CAN teach them to be observant.

Through IPANE, people can make spontaneous and unsolicited reports of invasive species. Anybody can make a report. You don't have to be IPANE trained volunteer. If you find something that you don't recognize, you can send it in. People report their "sightings" via a button on website homepage, where they can also attach digital images. These sightings are then verified by IPANE staff, in consultation with regional herbaria, BONAP distribution maps (John Cortez's program) and Florida North America (FNA) project authors. If necessary, a rapid assessment process will be initiated and a response is sent to submitter, explaining what the species they submitted turned out to be.

The second thing is something we call a "Localized Early Detection Network". We started realizing IPANE includes over 100 species and we are about to add some more on our website. We tried, and this was "Stupid Idea Number 572", two day training sessions to teach some of our volunteers to recognize these 100+ species. It was bad! They walked out, and even I was bleary eyed by the end of the first day! So what we do now is to take smaller parcels of land, with fewer species that people need to recognize and then trained either the staff or the public coming through. We piloted these Local Early Detection Network Sites in the White Mountain National Forest (NH) where the trainees came from the Forest Service and the Appalachian Mountain Club and the Arnold Arboretum (Boston, MA) where the trainees were Arboretum Staff

This is one of the training sessions we had up in White Mountain National Forest (WMNF). The Appalachian Mountain Club let us use their facilities for the day. We got all the people together, ran a training session teaching people how to identify the 8 or 9 species of plants and 4 insects that were likely to be present, so they can be on the lookout for them. It was all low key. We also put together a brochure to show people some things that can be easily identified from photos. What's on the list of things in the brochures was decided on with the partners at each site. It's not easy to tell Japanese stilt grass from a single photograph, but get people to look, that's the part we are trying to do. They can tear off a section of the brochure, fill it in drop it off at designated locations. Then the local partners, in this case the forest service, will go and check on these things for us. I've been doing this now with some fish and wildlife refuges and some of the national parks in the northeast, as well as the Arnold Arboretum.

In the case of the Arnold Arboretum we created a list of Early Detection Species. There are a couple of things that are not there that are highly invasive which we have reason to expect soon will be (e.g. Mile-a-minute vine (*Polygovum perfoliotum*) and Japanese stilt grass (*Microstegium vimineum*)). There are places where Japanese stilt grass (e.g. Morristown National Historic Park) and Mile-a-minute are found really close (within 10 miles) to where the arboretum is. One area has a trail where people go birding and the other is in a sort of botanical garden situation. The kinds of people that visit those two sites are likely to also visit the arboretum. Thus, you have a mechanism, you have a vector, and you have a pathway.

Then there were the invasives already present in low numbers (Kudzu (P*ueraria montana subsp. Lobata*), Thunberg's geranium (*Geranium thunbergia*)). We are working with them to get those off. We think that the Kudzu is gone now, for example. But we are learning about other things we are seeing escaping (e.g. planted ornamentals like *Kalopanux semtenlobus, Phellodendron spp.* and probably others)

With the volunteer network, we originally aimed at having 25 people per state per year training. Some states were higher than that and some states ended up lower. We currently have over 700 volunteers trained. They are not all active, though I wish they were. We run all different kinds of training sessions, from introductory to advanced, for both terrestrial and aquatic species. We usually do the introductory ones where we bring people inside to learn to enter data into the website in the spring, before the field season. Each volunteer is then assigned a quadrant and we now have the capability on our website to allow you to go see the status of any quadrangle to see if it's been done or if people are still working on it. Each one of those colors represents one of these 4 categories. So you can look at a state like CT. The reds are completed; we have enough information. The greens are in progress. Yellow means we have gotten no data for them. This came about during the gas crunch when people were saying "I don't want to drive this far". We say "Look and see the status". If it's an area where something is not done, we will put you in contact. As you can see, some areas are much more intensely surveyed than others. Our coverage is uneven. I admit that. Where there are big blanks we plan to use graduate students or some blockbusting weekend, go up there, and see if we can gather some information.

We offer some of the specialized things where we cover different groups, for example, just trees. We get the volunteers out in the field and try to train them and try to make it fun. That's a big thing for me. I don't want this to become arduous because if it does, we aren't going to keep the volunteers. We have a lot of fun out there. Getting that many pairs of eyes trained really helps. One of the great things about our volunteers, this is what I love about them, this is at a different workshop where we are doing grasses and we went by a state park and there was a small little patch of Japanese stilt grass and they could not stop themselves. They started ripping it out and putting it plastic bags. They can make a difference.

The fourth part in this is research-based tools. A big part of the IPANE project run out of the University of CT in the ecology, evolution and biology department is using research to understand the science part. One focus is looking at the pathways and vectors. For example, I just learned something before from talking to Chris (Miller) that got me really excited about the possible origin of the *Carex kobomugi* populations reported from MA.

We look at things and try to figure out how it got into this country or where it showed up? For example for Stilt grass, if you look at the USDA plants database, they say the distribution is a certain way. On those maps it is shown as absent from ME, NH, and VT. It does occur in RI and we know that. I bet it is unfortunately in Me, NH and VT but it hasn't been found yet. In fact, I can count on it. This is George Ainslie (1886-1930). I love this picture of a ton of different

reasons. George Ainslie was the first person to discover Japanese stilt grass in this country. He found it in Knoxville, TN. He was an entomologist. He studied insects that bore into the stems of grasses. I got this picture of him going out in to the field from his granddaughter. What people get most excited about in this picture is the 1914 Indian Motorcycle. Bu this is where he found the plant on the banks of the 3rd river and this is one of the things that is kind of cool. This is the information on the label from the Smithsonian (*Pollinia imberbie* Nees., River bank near 3rd Creek, Knox. Tenn., Oct. 9, 1919, G.G. Ainslee). We know that Ainslie did not identify this plant because Ainslie's name is misspelled on the label. . He sent it to somebody but we don't know who. Anyway, that is where he found the plant. And this is what 3rd Creek looks like today: The Japanese stilt grass is still there!

Here is another one, Japanese honeysuckle. This plant is a big problem around here as well as in New England. Its name is *Lonicera morrowii* for James Morrow (1820-1865). James Morrow was a medical doctor who was assigned to Perry's Expedition to Japan (1853-1855) but he wasn't part of the expedition. He was part of the state department. He was sent by the state department to introduce them to agriculture. He sent back specimens of things that went to Professor Gray and I love this cover letter because it shows that, even back then, the government wasn't any different:

U.S. Patent Office
March 3, 1855

Dr. Morrow
Sir:

Please deliver to Professor Gray of Boston the dry specimens in Botany procured by you in Japan with a request that he will examine and classify the same if he can do so without expense to the government. This last condition is rendered necessary by the fact that there is no appropriation for this purpose.

The specimens are to be returned to this office after the classification by Prof. Gray.

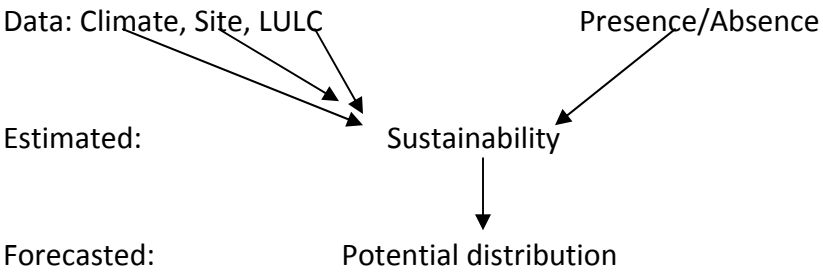
Yours truly,
Charles Mason

What's really interesting is that the Arnold Arboretum had this old card catalogue in which somebody put in some salmon colored index cards that said, "First cultivated in the United State by Arnold Arboretum." They say "Morris Honeysuckle", but the type specimen was in flower not in fruit. The fruit was maintained by the patent office and distributed elsewhere.

The other kind of research that we do is using those data that the volunteers gather to develop predictive models about where we might look for some of these things. In the old days of early detection, if we look at a map where the filled area is shaded in, finding any member of the species outside of that area is an early detection thing. What we are trying to do now is to plug in some science with that. In looking at one of the species we have been working with, Oriental bittersweet, the locations known from herbarium records were fairly limited, but the locations that are now known volunteer reports are way more extensive. Randy mentioned this

yesterday. He gets all fired up about this map! It shows what volunteers have added to the whole system. What we are tying to do is bring in some basic information on climate and site in order to come up with a way of predicting what the potential distribution of the species can be.

The Hierarchical Bayesian (HB) Model for Potential Distribution



John Sciander, a professor at the University doing research on this, went and got Japanese data on the species' home range. Plugging that information into the model makes for a better model. So we can say that there are certain areas in the northern part of ME that are not vulnerable and there are other areas that might be. This was a big surprise. For example, the model suggests that the NE portion of ME is probably vulnerable for Oriental bittersweet. Now, we don't have volunteers up there and there are not a lot of data from up in that part of ME. So maybe it hasn't gotten there yet, or maybe it's really well established, but now we know we need to look for it. With these models, this is what we are trying to do. We can take what the models predict are high risk areas and use that information to focus our volunteers. We hope to develop other ones as well. We don't know how far north it is going to go. We don't know how high in elevation. That is what we want to try and figure out. If you want to get some more information, go to our website. We are tying to get the model stuff we are doing on the website. It gives us different models for different species. We can use these to try and convince the nurseries that these are a problem.

In closing I'd like to talk about how all this fits into a national network. The key roles of a national network are to support the scientific research and make the results available and to maintain databases of current distribution of known or suspected invasive species. There are a number of options for making this happen including the IMAPS interface, and Bud Wood (down in Georgia)'s EdMaps among others. There are lots of different ways to do this, but to me it doesn't matter which you use. The important thing is for these programs to work together and collect the data.

You also need to know what's in the neighborhood and what's around the corner. Years ago, some of you may know Peter Raven from the Missouri Botanical Garden, he was up in CT talking with us. He asked "How would you put together a watch list for New England?" I said, "I'd go to PA!" I was joking about it but that's the way we used to have to do it.

If we work with Local Early Detection Networks to build practical Early Detection lists, we can get a lot of area covered and we can have alert systems. That way those of us New England can

learn what to expect from what's happening in PA and NJ, as well as what's coming down from the Canadian Maritimes through ME and MA. It goes both ways. We are now working with the Maritime Provinces in Canada to expand this whole network on the east coast

We also need to help train volunteers (especially on ID) within the national network. For example, we can say this is a species that is fairly common in PA and it really seems to be increasing, so we should be training people to look for it in New England.

Volunteers, scientists, and land managers all have something to contribute to this process: The volunteers collect data. The scientists do research and the land managers not only work on early detection and rapid response, but also test management tools, what works and what doesn't. Getting that mechanism back is really crucial. People try something on their preserve or where ever they are working, is just as important to communicate if it didn't work as if it did work, so that other people don't waste time trying.

As I mentioned, all of this really does work. Just I'm going to close with just a couple stories. This is jokingly what I call IPANE's fire drill. This was an unknown mustard that showed up in CT where I found it. A week after this, a weed scientist from MA called up and said I've got this yellow mustard that's extensive all around here. Can you tell me what it is? I said "Oh yeah, is this it?" But this one has little orbicular fruits, whereas the one he was describing had fruits that are sausage shaped. I asked him to send me a picture of the fruits. Turns out they are both in the genus *Rorippa,* but two different species. To sort that out, I had to go to Harvard to look at their specimens because we didn't have any. I also sent them out to the FNA author out in Missouri that works with mustard for confirmation. We were able to sort out misidentifications in herbaria, resulting in new records for the two states and we are now watching both species.

This is a Kudzu population that was reported by a volunteer in CT. We took that information and went to a great guy that worked for the CT Highway Department and talked to him about it. He sent out his contract sprayers and they whacked the site. They really hammered it. One of the interesting things is… speaking about funding…. You know who lives on the other side of that wooden sound barrier? Diana Ross! I can't get in there. I've talked to the guy at the gate. He sends me pictures of plants he thinks are invasive, but I cannot get in to talk to Diana Ross. I'm sure the Kudzu got into Diana Ross's place but I can't get in there. Maybe I could get some money out of her to help fund some of this so we can get the Kudzu out of there?!

Here is another case. One of our volunteers was riding down the road, and I will never forget this. She called up all ecstatic. She found at that time what was the new northern-most locality for Mile-a-minute. Saw it on the side of the road in northern CT and she got in gear. We worked with her and the same guy from the highway department and went out and sprayed. Between the two of them, they decided just spraying the highway wasn't enough. He got permission from his boss and she got permission from the local land owners and they sprayed the entire population in the area around the highway. That was just in one year. But she didn't stop. She started organizing volunteers. She got together with a friend from the Conservation

Commission of that town and, one morning, they went out there. They had maybe 14 volunteers or so and spent the morning going through pulling Mile-a-minute. The result was 55 bags big heavy duty sacks of plant material. The town agreed to haul them away and incinerate them. That was not a small contribution, it was fairly big. They provided the bags for them. They got involved, but the volunteers did the work and we also got a lot of press out of this. We've learned about a lot of new sites because of it and we are now actively involved in working with that species out there.

Let me ask you a question. What if we don't respond rapidly? All of this we have talked about does take time. What if we don't do it? Let me show you what happens. This is Jockey Hollow, in Morristown National Historic Park, NJ. It didn't look like this when I was here. This is now all thick Japanese stilt grass. There is a little tiny salamander called a Red Salamander (*Pseudotriton ruber*) that used to be found there. We are not sure if it's still in there, but if it is, think about the amount of herbicides they'd have to use in there and what that would do to a salamander that absorbs things through its skin. So there are issues with biodiversity and things like that that we really need to think about.

Remember when I showed you the picture with the wiggly leaf grass? Well unbeknownst to me when I was over in Japan, somebody found it in MD in 1996. By the time it got into the scientific literature, a little article in 1999 talked about the two populations that this guy had found. I got these pictures from the MD Department of Conservation Resources. One of the two sites where this guy found that plant is 1.6 by 2.7 meters. You could have put all of it in a black plastic bag if we had known. We didn't and it's spread like crazy since then. And while it looks like Japanese stilt grass, its worse since it is a perennial and Japanese stilt grass is an annual. This is what happens if we don't do early detection and we don't come up with a rapid response mechanism. Moreover, this is in a MD state park. There is nothing preventing people walking through there and coming up and then walking through any of the state parks up here.

I want to leave you with that. There are things out there on the landscape that we don't know about yet and working with the public and volunteers and all the different contacts we have, there are ways we can marshal this energy in trying to find these things early and get them reported to the right people so as to get them out BEFORE they become a problem.

Cape May Point State Park-A Case Study for Improving the Maritime Forest Community.

Christopher F. Miller * (USDA-NRCS Cape May Plant Materials Center) and Matt Pelligrine (Division of Parks and Forestry-Cape May Point State Park)

In 2004, the Cape May Point State Park received a WHIP (Wildlife Habitat Incentives Program) contract from the USDA-Natural Resources Incentive Program for permanent restoration and enhancement of its maritime forest and transitional habitat. Practices are planned to remove invasive shrubs, vines and *Phragmites* and to establish native trees and shrubs to improve native wildlife and migratory bird habitat. The Cape May Point State Park encompasses 190 acres of freshwater wetland, scrub-shrub, and maritime forest at the southern tip of New Jersey. Wetland and transitional areas are almost completely dominated by common reed (*Phragmites*). Pockets of maritime forest are scattered throughout the Park. Most of the forest has been stressed by salt water flooding. Mortality of the vegetation due to flooding and windfall has allowed too much light into the forest promoting invasive species invasion. The most invasive species is virgin's bower clematis (*Clematis flammula*) and introduced species from southern Europe. Other invasives include: Japanese honeysuckle (*Lonicera japonica*), English ivy (*Hendera helix*), porcelain berry (*Ampelopsis brevipedunculata*) and multiflora rose (*Rosa multiflora*). This presentation will focus on the restoration plan and the successes and failures of the 5 year project. Most of the work was concentrated in a 20 acre "target" control area using both mechanical and chemical control methods.

INTRODUCTION

In 2004, the Cape May Point State Park received a 5 year WHIP (Wildlife Habitat Incentives Program) contract from the USDA-Natural Resources Conservation Service for permanent restoration and enhancement of its maritime forest and transitional habitat. USDA-NRCS Practices planned and implemented included: brush management, (Practice Code 314) tree/shrub establishment (612), and Early Successional Habitat Development/Management (647). These practices are intended to remove invasive shrubs, vines and phragmites and to re-establish native trees and shrubs to improve native wildlife and migratory bird habitat.

Early 2000 surveys of the State Park by the Army Corps of Engineers discovered several rare plants. Most we wetland species unaffected by the invasive vines, however a Species of Concern, blue boneset (*Eupatorium coelestinum*), grows in the transitional areas often smothered in vines. It is believed that the reduction in density of the vines would prove beneficial to this species.

ECOLOGICAL DESCRIPTION

The Cape May Point State Park encompasses 190 acres of freshwater wetland, scrub-shrub, and maritime forest at the southern tip of New Jersey. Wetland and transitional areas are almost completely dominated by common reed (*Phragmites*). Pockets of maritime forest are scattered throughout the Park. Common trees within the forest include post oak (*Quercus stelata*), white oak (*Quercus alba*), black oak (*Quercus velutina*), southern red oak (*Quercus falcata*), chestnut

oak (*Quercus prinus*), black gum (*Nyssa sylvatica*), sassafras (*Sassafras albidum*) persimmon (*Diospyros virginiana*), mockernut hickory (*Carya tomentosa*), white mulberry (*Morus alba*), black cherry (*Prunus serotina*), pitch pine (*Pinus rigida*) and eastern red cedar (*Juniperus virginiana*). Less common species include serviceberry (*Amelanchier arborea*), sweetbay magnolia (*Magnolia virginiana*), and hackberry (*Celtis occidentalis*). Major native understory shrubs include arrowwood viburnum (*Viburnum dentatum*), bayberry *(Morella pensylvanica*), wax myrtle (*Morella cerifera*), high bush blueberry (*Vaccinium corymbosum*), elderberry (*Sambucus canadensis*), and winged sumac (*Rhus copallinium*).

PROBLEM IDENTIFICATION

Most of the forest has been stressed by the harsh seashore conditions i.e. salt water flooding and windfall. Average height of the trees is only 40 feet with a diameter of 10 inches. Mortality of the vegetation due to flooding and windfall has allowed too much light into the forest, promoting the invasion of invasive species. Some common invasives include: Japanese honeysuckle (*Lonicera japonica*), English ivy (*Hendera helix*), porcelain berry (*Ampelopsis brevipedunculata*) multiflora rose (*Rosa multiflora*), European privet (*Ligustrum vulgare*) and autumn olive (*Elaeagnus umbellata*).

This project targeted the invasive porcelainberry, Japanese honeysuckle, multiflora rose and the most tenacious, virgin's bower clematis (*Clematis flammula*), an introduced species from southern Europe. This plant most aggressively contributes to windfall by smothering the trees, pulling down limbs, and draping the forest floor thereby inhibiting the succession of native species. When cut, it exudes a noxious gas that burns the eyes, so protection is needed. Mowing alone to control this plant is not very effective. Also, it takes approximately 3 weeks to show injury from a glyphosate treatment. It's a very tough plant and there is not much information in the literature on the extent of its range and effective control methods. The porcelainberry is fairly easily controlled by repeated mowing and multiflora rose is starting to be affected by the rosa rosette disease that is moving in from the Midwest.

Native vines include trumper creeper (*Campsis radicans*), greenbrier (Smilax rotundifolia), fox grape (*Parthenocissus quinquefolia*), and poison ivy (*Toxicondendron radicans*). These plants also climb trees, but most have useful attributes. For example, Virginia creeper berry is highly desired by birds and being in a major flyway, this fruit is a good energy source for migrating birds. In addition, the trumpet creeper flower is a good hummingbird attractant. Unfortunately, in the process of controlling the undesirables, especially the first year, some of these native vines were destroyed also. However, it appears that some of these native vines are volunteering back on their own. Future treatments will be more selective as to minimize the harm to the natives.

RESTORATION PLAN

Treatment of the entire 44 acres of forest did not seem feasible from a financial or labor standpoint. It was decided to concentrate in a 20 acre "target" control area visible from the

main nature trail through the park. The methods used would be both mechanical and chemical control. Approximately 5 acres a year would be treated.

Year 1-2004

The first year control would be the most aggressive year as large equipment such as drum choppers (Gyrotrac 18XP) were brought in to shred large areas of aggressive vines. Smaller sections around native trees and shrubs were cut and mowed by Park personnel with smaller equipment. This operation was done in May just as the vines leafed out and had very little root reserves to resprout. In late fall of 2004, new growth of the invasives were sprayed with Rodeo (Glyphosate). This is an effective time to spray for greater translocation of the chemical to the roots as the plant prepares to shut down for the winter. Also, a revegetation plan was developed the first year in anticipation of needing healthy and available native plant species by the third year of the project.

Year 2-2005

This season required follow-up treatments in areas that saw additional regrowth. Most of the mechanical work, however, was done with weed whackers, mowers, etc. by Park seasonal labor. Some additional spraying was done again in the fall. No nursery grown plants have been installed yet.

Year 3 – 2006

Planting was started in the spring in large areas where good invasive control was accomplished in the previous two years. Most of the plants installed were those tree species native to the Park. Most of the containerized species were purchased through a large restoration nursery in southern New Jersey, Pinelands Nursery, and through the State of NJ, Forest Tree Nursery for the smaller, bare root stock. Three species that were desired, but difficult to obtain commercially were Post oak (*Quercus stellata*), American holly (*Ilex opaca*), and eastern red cedar (*Juniperus virginiana*).

To allow for easier maintenance in the larger, more open areas, the trees were installed in a plantation style planting. By planting in rows, it would be easier to mow and/or spray between the rows for future invasive weed control. In smaller sections, the new plants were scattered throughout. Because of deer and rabbit predation, most all of the newly planted seedlings had tree guards installed around them. These guards also helped protect and identify them as desirable plants as maintenance occurred.

Years 4 and 5, 2007-2008

Early spring mechanical weed control, fall chemical treatment and planting/replanting seedlings that died throughout the year, continued using seasonal labor if possible.

RESULTS

Invasive species control was achieved, at least in the short term, in target areas of the park (i.e. along nature trails, viewing platforms, etc.) Although only about ½ the maritime forest was improved with this project, Park personnel were getting good reception from the public because improvements were targeted to highly visible areas.

LESSONS LEARNED

1. You're never really done. Repeated mowing/chemical treatment will need to be done periodically as maintenance in previously treated areas and where new outbreaks occur.
2. Need a consistent workforce dedicated solely to new invasives control and retreatment.
3. Using volunteer labor is inexpensive however , contracting out the work would have been more beneficial for long term control.
4. Nuisance fauna like deer, rabbits, and geese can damage new seedlings and must be controlled also.

The Maritime Forest in New Jersey, A Fragmented Plant Community. Terry O'Leary. New Jersey Forest Service. Forest Resource Education Center, Jackson NJ 08527.

Abstract
The maritime forest in New Jersey is characterized by a slightly more luxuriant and taller climax forest than that of pine-oak and oak-pine forest communities which are found further inland. Contributing factors to the evolution of the maritime forest include slightly increased soil fertility and moisture, and less frequent forest fires than encountered in the heart of the Pine Barrens. From colonial times, because of these conditions and proximity to the coast, substantial areas of maritime forest were cleared for farms and homesteads, as well as for the demand for lumber. After 250 years of a mostly resource based culture, farming activity and sawmill operations began to decline by the 1950s and 1960s. The succession of the tilled fields and pastures of these once active farms back into mature Maritime Forests has occurred in a relatively short period of time (50-70 years). However, due to intense development pressure during this period, much of the maritime forest has become fragmented. The remnant forested areas, even tracts that have been purchased for conservation purposes, have been degraded by the introduction of a number of non-native invasive species.

Today I'm first going to talk about forest communities in general and then get a little more specific about maritime forests in NJ. My first example comes from Cattus Island County Park, which is a county park in Ocean County, located about 6 or 7 miles from Georgian Court. Cattus Island is an island of trees in a marsh- basically a giant hummock separated by marsh and water from the uplands. Until recently, much of the marsh area was dominated by *Phragmites*. Then, in collaboration with Rutgers University and the Ocean County Mosquito Commission, Ocean County Parks implemented an Open Water Marsh Management Plan. What they did was to dig radial ditches which created tidal circulation with a three-fold purpose, (1) to introduce fish that would eat mosquito larvae, (2) to change the hydrology to make it less favorable for phragmites, and (3) to enhance the marsh for wildlife habitat. The project was very successful in eliminating the invasive *Phragmites* and in restoring native vegetation.

A plant community typically encountered in the southern part of NJ is an association of trees, shrubs and herbaceous plant species. That association changes as a function of elevation, soils, hydrology and climate

I'm not a geologist, but I'm going to try to provide a very brief description of the geology of NJ here for background. Basically, only the areas north of the Raritan River were glaciated in the last ice age. When the glaciers melted, all of the areas to the south were inundated. What we know today as the Pine Barrens was at the bottom of the sea. As a result this region has very sandy, infertile soils. In fact that's why the early settlers called it "barrens" - because there wasn't much they could grow there. When they settled the land, they chose to live along the coast in the maritime forest. If you were a mariner, you were out to sea most of the time, and when you came home you did not want to live right by the ocean, where you would be in danger of a storm. You would most likely wish to live in the upland, and the first upland

encountered was the maritime forest. Add to this that water was the main means of transportation and the area in proximity to the present US 9. The continued development of this area up to the present day is why this habitat type has been so badly fragmented.

Two types of soils that are often found in the pinelands are dry sandy soil or gravel. Gravel basically came when the icebergs from the melting glaciers floated south and as they melted came to a grinding halt, releasing the rock fragments from within the ice. The gravel mixed with iron in the soil, and under extreme pressure, created concretions, typically known as Jersey Sandstone that forms Atlantic Highlands, Cherry Hill, Mount Holly, and the Forked River Mountains of South Jersey, which are about 200 feet high. When this rock erodes the iron gets dissolved in ground and surface water, and the precipitate that forms is called bog iron (Limonite). Bog iron was actually mined and forged to make the cannonballs that were used in the Revolutionary War. The forges and furnaces were fueled by charcoal made from thousands of acres of trees cut from the pine barrens. So we've had disturbances in this habitat all the way through.

Hydrology has everything to do with plant community structure. Nearly everything in South Jersey is slowly sloping downward toward the coast. If you dig a well in the middle of the pine barrens, you may only have to go a short distance to hit the aquifer. As you go toward the coast, the wells have to be deeper to get through to the second formation. The first water bearing formation is right near the surface, then there's a clay lens, followed by a second, deeper aquifer formation.

Climate is also a key in plant community structure. The pine barrens area actually receives more rainfall than any other area in NJ. We have prevailing westerly winds and then, every day, as the land and sea warm and cool at different rates, an onshore breeze picks up. As a result, as the wind switches direction, the area changes from wet to dry and back again. If you keep licking your lips, they get wet then dry, and you end up with chapped lips. This is how the Pinelands can dry out soon after a rainfall. The center of the Pinelands is the second most flammable area in the United States and the vegetation found there continues to be formed in a regime of fire.

To maintain this type of community, fires must occur, but much of the time fire is suppressed because of the risk to life and property. To offset this, the Bureau of Forest Management, NJ Forest Fire Service conducts prescribed burns when weather conditions and manpower permit. When ecological prescribed burning is undertaken, we try not to burn with the wind, rather we burn into the wind. We also only burn in the winter because the sap isn't flowing upwards in the dormant trees, so the fire doesn't harm the trees –prescribed burning season is from November until March. What we try to do is to remove the understory and the shrub zone to reduce the fuel load to help lessen the danger of wildfire. In New Jersey, our fires typically spread from west to east, and everyone that lives in the maritime forest is at risk for a devastating fire. Before we had motorized pumps around the 1890s, when a forest fire started, it could burn all the way until it hit the Barnegat Bay. There was one fire that burned 137,000 acres in one day. The entire town of Jackson burned down and it burned all the way from Whitesbog to Bricktown in three days for a total of 163,000 acres. Only a few weeks after the

fires, though, the pine trees re-sprout. The most well adapted species at resprouting is pitch pine. It has thick alligator-like bark, and also has the ability to sprout epicormically along the charred bark and branches. Most oaks are killed from to the base in a severe fire because of their thinner bark. If we didn't have fires for a long duration, we might actually have oak barrens.

Other impacts, especially in the maritime forest are resource extraction (gravel pits) and, because the soil is a little more fertile, farming, with vineyards and horse farming being particularly common in this area. Another impact in maritime forests that add to fragmentation is logging. Before the 1960s there was almost unabated logging in this region. In fact, NJ Forest Services was formed 101 years ago as a reaction to over-logging. When settlers first came here, they thought of the forest as an inexhaustible resource. They kept cutting and cutting, never replanting, cutting down 20 square miles of forest at a time to run one of those furnaces to make the bog-iron and not replanting. As a result, having no separation between the canopy and the ground cover, frequent devastating wildfires occurred that they could not put out. Now we are at a place where more and more people want to live here and they want to have a house. The builders may leave 3 or 4 trees and then they run over the area with the bulldozer to grade the ground and after 2 or 3 years of soil compaction, the trees are dead.

In the uplands, we have mostly oaks with some pines, as we go down slope we have pines with some oaks. As we go further down, in this area seen here, we have a wetlands forest or seasonal wetland called pitch pine lowlands. It has hydric plants. It is also the most flammable area because there is no separation between the ground cover, the shrub level and the tree level. This is where many of the senior citizen developments have been built, especially around Whiting. When they move here they have no clue what it's like to be in or fight a forest fire.

In our lowest elevations, we originally had stream corridors consisting of Atlantic white cedar swamps, but now a lot of these wetlands are transitioning to hardwood swamps. Typical tree species in this habitat are Atlantic white cedar, pitch pine, sour gum, red maple, swamp magnolia, gray birch, and American holly. Many of the streams that drain from the Pine Barrens into this habitat have very dark water from the iron and also from tannic acid. People may call it "cedar water", but a lot of it the color is actually from oak tannins. In many cases, the cedar swamps are in fresh water areas with no tidal influence. Most of trees in these areas are Atlantic white cedars which grow in tall stands, although occasionally you get a gum tree or a maple tree along the edge. The problem is that cedar is one of the most valuable timbers we have in NJ. It's straight grained and light weight and doesn't split, so it is used extensively for timber. We can grow cedar and sell cedar but we have to keep the deer off of it. Young white cedars are one of the favorite foods of the white tailed deer and if you just harvest and don't do anything controlling deer browse, the area will just transition into a hardwood swamp. And once the other hardwoods start growing the cedars, which are shade intolerant, won't come back without the full sun to regenerate. There are only four foresters in the central and southern regions to manage the area of New Jersey that contains most of the pinelands all the way down to Cape May, so we rely on private land owners to take care of their land. If a landowner wants to harvest cedar from the Pinelands National Reserve, a permit is required, which includes submitting a management plan showing how they will harvest and replant as

well as the seed source. When we collect seeds or cuttings, we actually GPS the locations so they can be used to plant close to the seed source.

Some of the characteristic shrubs that grow in cedar swamps or hardwood swamps include greenbriar, highbush blueberry, swamp azalea, fetterbush, sweet pepperbush, leatherleaf, sheep laurel, chokeberry, inkberry holly, winterberry holly and buttonbush. Cedar swamps provide habitat for pine barren tree frogs and also timber rattlesnakes. Researchers have found that timber rattlesnakes will hibernate under the stumps and roots of Atlantic white cedars. Timber rattlesnakes are a listed species here in NJ.

Another pineland habitat is the pitch pine lowland. Typical trees here are pitch pine, red maple, sour gum and blackjack oak and the shrub community includes scrub oak, greenbriar, highbush blueberry, lowbush blueberry, pine barrens heather, fetterbush, staggerbush, sweet pepperbush, black huckleberry, sheep laurel, sand myrtle, chokeberry, sweet fern and inkberry holly. When fires occur in the pitch pine lowlands, it may burn through the roots and turf right down to bare mineral soil. A hot burned are like this is referred to locally as a "bald". The trees, especially the pines can eventually resprout, but it may take a while for the shrub layer to recover.

As you go further upland, a lot of these communities can transition into pine-oak forest. Here the pines are dominant tree with oaks being co-dominant. But as fires are controlled, you can have more oaks and fewer pines. Typical tree species are pitch pine, shortleaf pine, Virginia pine, blackjack oak, post oak, scarlet oak, sassafras and black cherry, and typical shrubs are lowbush blueberry, mountain laurel, black huckleberry, scrub oak, pine barrens heather, greenbriar, trailing arbutus, bayberry, sweet fern and bearberry. All three of the oaks in this habitat are thin bark oaks which don't react well to fire. 99% of the fires in New Jersey are human caused; about 1% are a result of lightning. Many of the blackjack oaks encountered may have a "zipper" scar from being struck by lightning, especially if they are in iron-rich soil, like Lakewood Sand, which is a reddish soil interspersed with Jersey Sandstone.

From the pine-oak forest a transition further upland usually results in an oak-pine forest, which is dominated by oaks. Typical trees here are chestnut oak, scarlet oak, black oak, white oak and post oak(which have persistent winter leaves), pitch pine, shortleaf pine, loblolly pine, sassafras and black cherry. Typical shrubs are mountain laurel, greenbriar, lowbush blueberry, black huckleberry, bayberry, trailing arbutus and sweet fern.

Finally, let's explore the maritime forest itself. The maritime forest is characterized by decreased forest fires and slightly greater soil fertility, which allow development of a more luxuriant and taller forest. In NJ, the maritime forest one of the dominant trees is sweet gum typically with an understory of shade tolerant American holly. If you went back a couple hundred years, this is the forest you might have encountered all along the coast- with enormous hollies. Unfortunately, holly-wood is prized for its lumber: Its wood was used to make inlaid furniture and piano keys. Today, there are only a few places around that have stands of holly, and these may be in decline because there really isn't any current forest management. They really need management and we've recommended it. One ancient holly

forest is at Sandy Hook, and there are others in Sea Girt, at the Lighthouse Center in Waretown, and down in Avalon near Cape May.

A very important part of the maritime forest is the ecotone (edge). This is the place where the invasive *Phragmites* wants to grow. This narrow transition zone is also the habitat for several rare plants that may in decline because the critical transitional edge habitat is being lost to *Phragmites* invasion.

The maritime forest is a habitat characterized by plants with high salt and wind tolerance. As I mentioned earlier, it was one of the first areas that was cleared for farms and homesteads. Early on, the main roads through the maritime forest were called landing roads because water was really the main means of transportation. One of the challenges for those early settlers was finding building materials. You could have plenty of wood to build your house but what were you going to put it on? You couldn't buy cinder blocks so Jersey Sandstone or bricks from the ballast of sailing ships were the foundations of the oldest houses.

In addition, early settlers used soil amendments such as clam and oyster shells, eelgrass and fish heads to increased soil fertility and moisture. Those soil amendments made long term changes to the habitat. One time I was out in the field alongside an archeologist looking for Native American artifacts at a site in Tuckerton. He was looking around and digging holes but not finding anything, and I said "Why don't you dig over here by this plant?" He said "Why would I do that?" and I explained that the plant was ebony spleenwort (ebony because it's black, wart is the old English word for weed, and it was thought that this small evergreen fern cured ailments of the spleen; but it did not). We know that in the Pinelands, where the soil is normally acidic, this plant will not grow. However, when the soil is amended with clam shells it may be encountered. Wherever you go in the pinelands and find an old village, you might find Ebony spleenwort. The guy said "Oh really?" and then we saw, in the next month edition of an archaeologist's journal, that he discovered this phenomenon!

The maritime forest is highly valuable for wildlife, providing both food and cover in a number of different habitats including forest edges, clearings, streams, snags (standing dead trees) and vernal pools. Characteristic oaks in this habitat are southern red or Spanish oak (this example is a wolf tree), white oak (which has 183 species of wildlife known to use it), willow oak, black oak and pin oak. Characteristic pines are pitch pine, white pine, Virginia pine, shortleaf pine and loblolly pine.

Within maritime forest swamps, the typical trees include American holly, black gum, red maple, swamp magnolia, sweet gum and Atlantic white cedar. Typical upland trees in the maritime forest are black cherry, sassafras, shadbush (most salt-tolerant/first to bloom/first to produce fruit), red cedar (ultimate wildlife tree), hackberry (very salt tolerant), gray birch (phototropic) and persimmon (distinctive bark).

Characteristic shrubs include bayberry (Nitrogen-fixing, salt tolerant), inkberry holly, winged sumac, highbush blueberry (watch out for mocking birds!), swamp azalea, sweet pepperbush, marsh elder (highly salt tolerant), groundsel, spicebush (beavers love), toothed arrowood, smooth alder (right against water), winterberry holly, mountain laurel and beach plum.

Characteristic vines are greenbriar, Japanese honeysuckle (invasive), poison ivy, Virginia creeper and fox grape and typical ground cover is club moss.

In summary, there are numerous reasons why these forests are in decline including forest fragmentation, insufficient buffers, housing developments, loss of habitat, invasive species (*Phragmites*, tree of heaven) and habitat degradation.

So where can you encounter a maritime forest? The Forsythe Refuge is the largest land owner of maritime forest in NJ with over 47,000 acres. They have targeted land that was in peril of being developed or had habitat variety and they have a really nice trail near the Visitor Center (James F. Akers Woodland Trail). The Manahawkin Swamp is the largest intact maritime forest in New Jersey, stretching from Barnegat to Manahawkin. The Lighthouse Center for Natural Resource Education in Waretown and the Tuckerton Seaport both have maritime forest interpretive trails worth exploring.

A Community Response: Asiatic Sand Sedge (*Carex kobomugi*) Management at Sachuest Beach, Middletown, Rhode Island. Scott P. Rabideau, Leland Mello, Kristin Travis, Natural Resource Services, Inc. P.O. Box 311 Harrisville, Rhode Island 02380

Abstract
There are approximately 4,200 non-native plant species in the Unites States that have escaped cultivation. Approximately, half of these plant species are considered invasive and present many ecological and economic consequences. In order to reduce the impact of invasive species through early detection and action, the United States Geological Survey developed the Early Detection and Rapid Response (EDRR) program which relies on interagency cooperation to detect and monitor new threats. One species the EDRR program monitors, the Asiatic Sand Sedge (*Carex kobomugi*), threatens the dunes of the Northeastern United States coastline and the native beach grasses that traditionally grow there. This paper examines the case of Asiatic Sand Sedge infestation in Sachuest Beach in Middletown, Rhode Island in the context of the EDRR program and offers an example of successful interagency, as well as public and private sector, collaboration.

Introduction
Scientists estimate that 50,000 non-native plant and animal species have been introduced to North America since the beginning of colonization (Westbrooks& Babson, 2005). Although many of these introduced species are beneficial and can be utilized for food, pest control, landscape restoration, and food processing, others have been identified as being invasive and causing significant economic, environmental, and human health harm. In addition, non-native invasive plant and animal species have been found to impact approximately 42% of the species listed as being threatened and/or endangered (Wilcove et al., 1998). Overall, it is estimated that annual damages and control costs associated with invasive species total $120 billion dollars in the United States, with invasive plant species being directly responsible for approximately one-third of this cost (Pimental et al., 2004; Westbrooks & Babson, 2010).

It is estimated that at least 50% of the 4,200 introduced plant species which have escaped cultivation in the United States are invasive. Rhode Island currently lists 45 invasive plant species that are well-established and have the potential to cause significant ecological and economic impacts. However, newly discovered species, such as the Asiatic Sand Sedge (*Carex kobomugi*), further threaten native plant communities and disrupt natural ecosystem processes.

Asiatic Sand Sedge
Widely introduced in New Jersey by intentional planting because of its potential ability to stabilize dunes, the Asiatic Sand Sedge most likely spread to New England by intentional planting, ocean currents dispersing plant and seed fragments, or anthropogenic transport (Swearingen, 2009). Asiatic Sand Sedge has historically been seen in the coastal beaches and dunes of Massachusetts and Rhode Island. Asiatic Sand Sedge is a perrenial sedge indigenous to Japan, China, and Korea, that can out-compete native maritime grasses, resulting in a low, dense vegetative mat in dunes. Lea and McLaughlin (2005) suggest that dunes dominated by

Asiatic Sand Sedge are more vulnerable to wind blow outs and storm erosion. The presence of this species also tends to decreases vegetative biodiversity of an ecosystem because of the high density at which it becomes established. Currently, this plant is listed as a noxious weed in Massachusetts and Connecticut, but no such designation exists in Rhode Island at this time.

In order to detect and monitor new species that are considered potentially invasive, the United States Geological Survey is leading an effort to develop a U.S. National Early Detection and Rapid Response System (EDRR) for invasive plants. The EDRR plan includes interagency cooperation in order to increase the detection, reporting, identification, and archiving of new invaders and allow for rapid assessment of new records and rapid response to control new invaders (Westbrooks & Babson 2010). This white paper details an implementation of the EDRR plan on a local scale by examining the case of invasive Asiatic Sand Sedge at Sachuest Beach in Middletown, Rhode Island.

Methodology

1. Identification and documentation

In 2008 a volunteer for the Invasive Plant Atlas of New England (IPANE) observed a small stand of Asiatic Sand Sedge at Sachuest Beach along the access road to Sachuest National Wildlife Refuge (NWR) in Middletown, Rhode Island. IPANE reported the observation to Middletown officials who retained Natural Resource Services, Inc. (NRS) to identify the scope of the infestation and map the extent of the existing stands. NRS initiated mapping efforts in the summer of 2008 and identified approximately 84,210 square feet of Asiatic Sand Sedge located on property owned by the Town of Middletown as well as on the Sachuest NWR operated by the U.S. Fish and Wildlife Service (USFWS). The USFWS was contacted and informed of the presence of Asiatic Sand Sedge in the refuge. The USFWS expressed interest in establishing a cooperative agreement with the Town of Middletown for the purpose of developing and implementing a suitable management plan under their existing Comprehensive Conservation Plan (CCP) (2002).

2. Rapid Response

The magnitude and possible ecological consequences of the infestation prompted the Town of Middletown to authorize the Town Manager to secure the necessary permits from the proper regulatory agencies for the treatment and control of the identified Asiatic Sand Sedge. NRS, in conjunction with the USFWS and the assistance of Dr. Louise Wooten of Georgian Court University, developed a multi-year management plan. NRS submitted the plan to the Rhode Island Coastal Resources Management Council (CRMC) in September of 2008.

The proposed management protocol consisted of the following six measures:

1. Those areas mapped as being colonized by Asiatic Sand Sedge will be demarcated in the field prior to treatment.

2. A 2% solution of glyphosate and water will be applied to target plants during the spring growing season (April-May), as well as during the fall (post-Labor Day) when plants are

actively transporting nutrients from stems and leaves to root systems. A colorant will be added to the solution to help track applications and ensure adequate coverage. It is anticipated that several spring-fall treatments may be necessary to achieve adequate control of this species. In addition, any surviving plants will be spot-treated immediately upon detection to prevent re-colonization.

3. Herbicides will be applied by a licensed applicator in accordance with all applicable regulations and label instructions. Furthermore, measures will be taken to prevent impacts to non-target species.

4. All treated sand dunes will be replanted with native vegetation once successful control of the target species has been achieved. If necessary, any post-treatment area(s) that will be left void of vegetation for an extended period of time (e.g., > 2 years) during which the root systems could potentially degrade and predispose them to erosion will be stabilized using jute mesh and/or other applicable erosion control products.

> Foredune areas will be replanted with American Beachgrass (*Ammophila breviligulata*) culms. Dunes will be planted in late winter to early spring, following completion of all treatment activities, to maximize plant survivability and productivity. Culms will be planted in groups of three (3) in a random (i.e. staggered) pattern, approximately 24 inches apart, 7-9 inches deep, throughout designated planting area(s).
>
> Backdune areas will be planted in early spring with a seed mixture comprised of 17% Switch Grass (*Panicum virgatum*) and 83% Atlantic Coastal Panicgrass (*Panicum amarum*) at a seeding rate of approximately 12 lbs/acre. In addition, backdunes will be planted with randomly distributed shrub clusters planted 25 feet on center. Clusters will be comprised of 3-6 shrubs planted 5 feet on center, and will include species such as Northern Bayberry (*Myrica pensylvanica*) and Beach Plum (*Prunus maritima*).

5. Pre- and post-monitoring of treatment areas will be performed by a qualified professional for a period of three years following management. Monitoring will be performed using permanent photo plots systematically established along transects within each treatment area. Photographs of each plot will be taken prior to treatment and compared with subsequent photographs taken after treatment. Photo-interpretive techniques will be used determine changes in plot density and vegetative composition.

6. Due to public access within close proximity of treatment areas the public will be notified of when the application will occur to reduce any conflicts. Additionally, treatment areas may be closed to public access at the discretion of the Town and signs will be posted notifying people that an herbicide was applied in the area.

3. Implementation and Results

The Rhode Island CRMC granted the assent for the proposed management plan in October 2008 and the contract to oversee management activities was granted to NRS by the town of Middletown in April of 2009. Beginning in May of 2009, NRS implemented the proposed management plan on Sachuest Beach. NRS established four photo monitoring plots in randomly selected locations for pre-treatment and post-treatment monitoring of vegetative cover and species composition. Pre-treatment monitoring to establish baseline data revealed that all plots were comprised of nearly 100% cover of Asiatic Sand Sedge. The first herbicide treatment occurred on May 20, 2009, using a 2% solution of glyphosphate and water with an added colorant. A second herbicide treatment followed after Labor Day in 2009.

NRS evaluated the effects of the preliminary herbicide treatment over the months of May and June of 2009. These assessments found that there was a substantial kill rate observed three weeks after the initial herbicide treatment. After these assessments NRS recommended that a second treatment be performed in the fall of 2009 prior to revegetation of the dunes, which was coordinated with the town of Middletown in order to reduce conflicts with the beach's recreational use.

Inspections of the dune system took place over the winter months and after the historic flooding that occurred throughout Rhode Island in March of 2010. NRS found that the dune system was not compromised over the winter season and observed that sand replenishment appeared above average along the entire beach. The first spring inspection of the beach took place in April of 2010 in order to monitor the treated areas for signs of regrowth after the fall herbicide treatment. Regrowth was mapped using a Trimble GeoXT GPS unit and the data were compiled and compared to previously known locations of infestation. NRS found five areas in which Asiatic Sand Sedge had regrown, but that these patches were substantially smaller in area than the initial distribution mapped in May 2009.

Future monitoring plans include continued monitoring within the dune system in mid- and late-May 2010 to determine if additional regrowth has occurred. A final herbicide application is tentatively scheduled for early fall of 2010. Planting of the backdune will be performed in the fall, followed by the planting of the foredune in the spring of 2011.

Conclusion

The case of Asiatic Sand Sedge on Sachuest beach illustrates the potential effectiveness of a national Early Detection and Rapid Response system when applied at a local scale. Through the collaborative efforts of volunteers and regional and national authorities such as IPANE, USFWS, and the Rhode Island CRMC, as well as the consultation of Natural Resource Services and Dr. Louise Wootton of Georgian Court University, Asiatic Sand Sedge was effectively managed before the ecological damage became irreversible.

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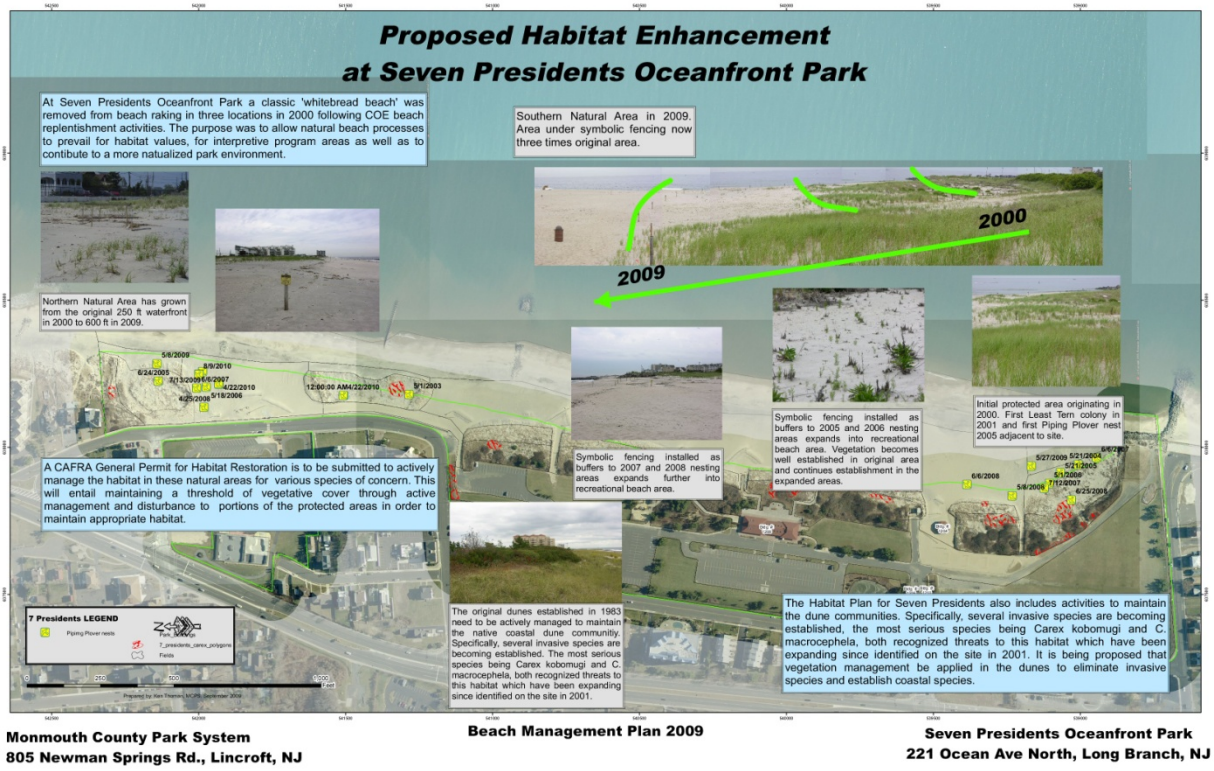
Beach Management Planning: Management for habitat and high recreation use. Kenneth P. Thoman and Anna Luiten. Monmouth County Park System. Lincroft, NJ 07738.

Abstract

A key management issue at Seven Presidents Oceanfront Park is the balance between providing a clean and safe public swimming beach for over 400,000 people annually and maintaining natural areas that provide storm protection, enhance site aesthetics, and maximize coastal habitat values for native plant and animal species. A management plan was initiated and implemented in 2000 which established portions of the 'whitebread' beach to be managed for natural coastal processes. The result has been suitable habitats for sustained and productive populations of endangered and threatened shore birds and coastal plants. Ongoing challenges include the management of invasive species and the preservation of specific habitats within the dynamic coastal zone.



To see this poster in full size, please click the image or navigate to
http://gcuonline.georgian.edu/wootton_l/SevenPresidentsposter.pdf

Status of the New Jersey Invasive Species Council and Regional Efforts to Prohibit Use of Invasive Species. Michael Van Clef, Ecological Solutions, LLC, Great Meadows, NJ 07838.

Abstract
The New Jersey Invasive Species Council was formed in 2004 and consists of 15 members representing various stakeholders. The Council is currently in the process of completing a statewide strategic management plan expected to be released in 2009. The plan will contain a comprehensive approach including outreach, prevention, control & restoration and recommended functions/structure for a permanent Council. Elements of the plan were discussed along with past and present efforts throughout New Jersey. One of the more obvious policy-related issues for any statewide effort is banning the propagation and distribution of invasive species. Efforts of nearby states (e.g., Connecticut, Massachusetts, New Hampshire, New York) were discussed to provide a summary of current regional efforts. The role of early detection & rapid response to maintaining up-to-date prohibited species lists was also presented.

Introduction
New Jersey currently has several existing policies related to invasive species. These policies include New Jersey Department of Environmental Protection (NJDEP) Policy Directive 2004-02 (http://www.state.nj.us/dep/commissioner/policy/pdir2004-02.htm), which prohibits the intentional release of 148 plant species on lands and waters administered by NJDEP. This comprehensive species list includes both widespread invaders and emerging or potential invaders. Although NJDEP lands still contain invasive species plantings, this Policy Directive is intended to make state land managers aware of the problem and prevent future use. The NJDEP Division of Fish & Wildlife have regulations that prohibit the possession or release of "potentially dangerous" wildlife that have the ability to cause agricultural or environmental damage or pose a threat to human safety. However, this list does not include many invasive or potentially invasive animal species.

The New Jersey Department of Agriculture (NJDA) administers plant shipment regulations through its Certification Program, which is intended to prevent the spread of economically important agricultural pests and pathogens (including those that impact forestry). NJDA also has seed regulations (prohibits five species including Canada Thistle and sets allowable quantities for eighteen other weedy plants). NJDA regulations are also aimed at preventing the spread of White Pine Blister Rust by restricting the possession or movement of European Black Currant and other currants and gooseberries (and their cultivars and hybrids). Shipment prohibitions to New Jersey can be found in commercial nursery catalogs.

In addition to existing policies, NJDA and NJDEP have several programs related to invasive species. These include the Gypsy Moth Suppression Program, Cooperative Agricultural Pest Survey, Federal and State cooperative efforts to eradicate Asian Longhorned Beetle, efforts to eradication Feral Hogs, and active searching for Emerald Ash Borer.

Despite these very positive programs, New Jersey lacks an organized/concerted/centralized effort to combat most invasive species in natural areas. In 2004, Governor McGreevey signed Executive Order #97. This order established the New Jersey Invasive Species Council (NJISC), which was charged with creating the New Jersey Strategic Management Plan for Invasive Species. The 15-member Council is co-chaired by the NJDEP Commissioner and the Secretary of Agriculture and consists of a diverse group of stakeholders including the Department of Transportation, conservation organizations, agriculture and nursery trade, academia and the general public. The required broad contents of the plan were also established through the Executive Order.

Since 2004, the NJISC has developed a vision statement and draft plan. The NJISC vision statement, "To reduce the impacts of invasive species on New Jersey's biodiversity, natural resources, agricultural resources and human health through prevention, control and restoration and to prevent new invasive species from becoming established", guided draft plan formulation. The Draft Plan contents include the following sections: 1) Introduction, 2) Stakeholder Conversations, 3) Prevention, 4) Control and Restoration, and 5) Structure of New Jersey's Invasive Species Program.

The Introduction explores what values are at risk, defines the scope of the invasive species problem in New Jersey, summarizes existing efforts, and outlines additional work that must be performed under the guiding principal that resources applied should be commensurate with the risks posed by invasive species. The Stakeholder Conversations section identifies stakeholders and outreach messages for a broad spectrum of private and public groups. The underlying principle is one of cooperative efforts that allow 'all boats to rise' rather than other less productive approaches. The Prevention section provides strategies for intentional and unintentional releases. It explores risks to New Jersey as a major port state, efforts of Federal partners and the need for improved Federal prevention regulations. The structure and development of a New Jersey early detection and rapid response program is detailed in this section based upon efforts of the US Geological Survey (Randy Westbrooks), Invasive Plant Atlas of New England (Leslie Mehrhoff), and international efforts (especially New Zealand). The Control & Restoration section provides a discussion of site susceptibility based upon edaphic conditions, past land use and overabundant white-tailed deer. Control methods and coordinated control programs are discussed along with a decision guide for site-based control efforts. Restoration, in the form of native plantings following control efforts, is briefly discussed. The Structure of New Jersey's Invasive Species Program section outlines the role of a permanent NJISC, resource requirements, potential funding sources and partnerships and regional cooperation. This section requests formation of a permanent Council that reports to the Governor, establishment of the Office of Invasive Species and the New Jersey Invasive Species Strike Team, and additional staff and funding for multiple state agencies. Specific goals are provided following each Draft Plan section. Short-term goals that are high leverage and budget neutral are expected to be completed within 2-3 years from acceptance of the final plan by the Governor. Long term goals are dependent upon financial input from the state (up to $2.4 million per year) and are hoped to be accomplished within 10 years of plan acceptance.

The conference presentation also included a discussion of the efforts of nearby states to prohibit use of invasive species - Connecticut, Massachusetts, New Hampshire, and New York were highlighted. In 2004, Connecticut determined a list through floristic analysis and 80 species were restricted (included species not yet present, but many important horticultural species were not listed). Massachusetts developed a structured decision tree analysis applied by a multi-stakeholder expert panel. Their final list included approximately 200 species (and their cultivars) that represent species not yet present and important horticultural species. New Hampshire utilized a simple five question decision process that resulted in the listing of 30 species (and their cultivars) including important horticultural species. New York is currently reviewing species to determine a list and is following the Massachusetts methodology, but is using a different species review process.

The conference presentation was capped with a discussion of efforts within New Jersey to establish an early detection & rapid response program (this goal is highlighted in the NJISC vision statement and emphasized in the Draft Plan). The Central Jersey Invasive Species Strike Team (CJISST) was initiated in 2008 by the Friends of Hopewell Valley Open Space (FoHVOS) and the Upper Raritan Watershed Association (URWA). Their goal was to create New Jersey's first private/public partnership based upon a cooperative approach to prevent the spread of newly emerging invasive species though early detection & rapid response (ED/RR).

CJISST has grown rapidly over the past year and now includes over 40 project partners from multiple sectors including government (Federal - US Fish & Wildlife Service, National Park Service/ Exotic Plant Management Team, Natural Resource Conservation Service, State, County, and Municipal), non-profit, corporate and private. As detailed in the CJISST Memorandum of Understanding, established in the spring of 2009, a representative from each project partner forms the Project Steering Committee, co-chaired by FoHVOS and URWA, and functions to guide the progress of CJISST. In addition to these formal partners, numerous volunteers, private landowners and natural resource professionals are also participating in CJISST. Stewardship and education/outreach activities occur throughout the project area which covers 1.3 million acres across 8 counties (Essex, Hudson, Hunterdon, Mercer, Middlesex, Morris, Somerset and Union). Since inception, CJISST has established a science-based protocol to identify target species, developed searching and reporting protocols, searched over 10,000 acres, detected nearly 1,000 populations, eradicated over 250 populations, provided over 20 educational presentations with over 600 total participants and trained over 150 partners and volunteers. The project has also created a project website to provide technical materials/data/reports and features a project area map depicting detections and eradications (www.cjisst.org).

Postcards from the Sedge: The Biology of the Invasive Asiatic Sand Sedge (*Carex kobomugi*) and its Spread in New Jersey's Coastal Dunes. Louise Wootton, Georgian Court University, Lakewood, NJ

Abstract

Coastal dunes and maritime forests have been particularly strongly impacted by development. In New Jersey, Only 31.2 of 130-miles of coast between Sandy Hook and Cape May Point have not yet been developed. Many species in these habitats are found no-where else. As a result, many dune-associated species are becoming increasingly rare. The additional threat posed by exotic and invasive species in these habitats is thus of particular concern. The invasive Asiatic sand sedge, *Carex kobomugi*, was first documented in New Jersey in 1929. Since then it has spread rapidly, and is now found from Massachusetts to the Carolinas, partially through natural propagation, and partially because it was deliberately planted as a dune stabilizer in the 1970s and 1980s. The species is currently spreading extremely rapidly in New Jersey, with the affected area doubling from 22 to 40 acres at Island Beach State Park, NJ between 2003 and 2008, and that at Sandy Hook tripling from 18 to 54 acres over the same time period. Expansion of *Carex kobomugi* negatively impacts native dune and high beach plant and wildlife species on the both directly through competition and indirectly through habitat elimination. Strong decreases in stem densities and species abundance of native plants have been observed in invaded dunes. Moreover, there is significant overlap in the ranges of several endangered species, including the piping plover (*Charadrius melodus)* and sea beach amaranth (*Amaranthus pumilus)* and the areas being invaded by this plant. As a result, the spread of this species should be prevented and current populations should be removed. Of the methods tried so far (tarpaulin, removal using sand removal and sifting, and application of herbicide) herbicide use appears to be the most effective. The closely related exotic plant, *Carex macrocephala*, has also been discovered recently on several New Jersey dunes. While this plant does not yet appear to be having the same negative ecological impacts as its sister species, there is concern that the two species could hybridize. Thus we suggest that this species also be removed from the dunes where it is currently growing as a preventative measure.

Introduction

In 2000, New Jersey had the highest population density among the 50 states (1,134.4 persons per square mile; City-data.com 2008). The desirability of scenic ocean views, combined with the high human population densities on the Atlantic Coast, mean that coastal dunes and their associated maritime forests have been particularly strongly impacted by development. Only 31.2 of the 130 miles of shoreline between Sandy Hook and Cape May Point remain undeveloped (NJBPN ND). Since many of the plant and animal species found in these habitats are found no-where else, many of the dune and “backdune” communities protected by coastal dunes are becoming increasingly rare at both a local and national scale. In a recent economic analysis of different ecosystems, dunes and coastal beaches were found to be “by far” the most valuable ecosystem in New Jersey on a per-acre basis (Costanza et al. 2006). As a result, the additional threat posed by exotic and invasive species in these habitats is of particular concern. The Asiatic sand sedge, *Carex kobomugi*, is one plant that’s invading these valuable coastal ecosystems. A perennial sedge in the Cyperaceae family, this plant is paradioecious, which

means that it forms separate male and female inflorescences on separate shoots of same clone. The species is wind pollinated, and distinctive, long cream-colored pollen tubes are produced on the anthers of the male flowering heads in the early spring. Later in the year, green-gold seeds are formed on the female inflorescences, each of which has a shallow notch at the tip of the falcate beak. The plant's distinctive serrated leaf edges distinguish it from similar native sedges.

Carex kobomugi is native to Japan, Korea, China and parts of eastern coastal Russia. The first documented population of this plant in the U.S. was at Island Beach State Park, New Jersey, in 1929 (Small 1954). It is not known how the plant arrived in North America, but a likely pathway for the introduction is transport of seeds in sand used as solid ballast in ships sailing empty from Asia in order to collect cargoes from New York. As ships entered the coastal waters near New York, this ballast would have been disposed of over the side of the ship, and propagules that had been included in the ballast might easily have floated on shore on New Jersey and taken up root in the dunes there. Alternately, a ship filled with solid ballast may have been wrecked on the Jersey shore and the propagules might have been released onto the dunes as the ship broke up.

Since its introduction, *C. kobomugi* has expanded its range from North Carolina to Massachusetts (Merhoff et al. 2003). Part of the reason for this rapid expansion is that this species was propagated at the Cape May Plant Materials Center (PMC) and distributed to multiple sites along the Atlantic Coast under the name 'Sea Isle' (plant # PI-433953) for use in coastal plantings, starting in 1970. By 1977, production of *C. kobomugi* at the PMC was up to 20,000 plants per year (Shisler et al. 1987).

Increased awareness of the ecological and economic problems caused by invasive species meant that *C. kobomugi* sales ceased in the mid-1980s. However, many areas of the eastern United States have since been invaded by *C. kobomugi* via natural propagation. For example, the area of dunes occupied by *C. kobomugi* at Island Beach State Park, NJ, doubled between 2002 and 2008 through natural propagation. *Carex kobomugi* populations at the Sandy Hook Unit of Gateway National Recreational Area tripled in area over the same period. Expansion of *C. kobomugi* in both areas has been roughly exponential (Figure 1).

Stem densities of many common native plants, including American beachgrass (*Ammophila breviligulata),* wormwood *(Artemisia* spp*.),* saltmeadow cordgrass (*Spartina patens)*, as well as species richness, are significantly lower within areas invaded by *C. kobomugi* than in the surrounding (uninvaded) dune areas (Wootton 2003). In addition, the dune community of the New Jersey coast is habitat for a number of rare, threatened or endangered species including, piping plover (*Charadrius melodus*), least tern (*Sterna antillarum*), black skimmer (*Rynchops niger*), northeastern beach tiger beetle (*Cicindela d. dorsalis*), seabeach amaranth (*Amaranthus pumilus*), seaside knotweed (*Polygonum glaucum*), sea sandwort (*Honckenya peploides*), slender seapurslane (*Sesuvium maritimum*) and seabeach evening primrose (*Oenothera humifusa*) (NJDEP 2008 a-f; NJDEP ND, Bowers-Altman 2003). Expansion of invasive *C. kobomugi* on the coastal dunes of New Jersey threatens plants like sea sandwort, slender seapurslane and seabeach evening primrose directly through competition. However, for most

threatened and endangered species, the greater impact of the invasive sedges comes from habitat elimination. Piping plover (federally threatened), least tern and black skimmer (state endangered) all nest in open sandy areas between the high tide mark and the vegetated portions of the dunes (Jenkins 2003, Liguori 2003, Liguori and Jenkins 2003, NJDEP a, b &e). These birds and others, such as oystercatchers, will not nest in highly vegetated areas. For instance, black skimmers are known to relocate colonies when dense vegetation takes over a previous nesting area (Liguori 2003). Invasion by *C. kobomugi* also negatively impacts seaside goldenrod (*Solidago sempervirens*), the nectar of which is an important food resource for migrating monarch butterflies, *Danaus plexippus* (Walton et al. 2005).

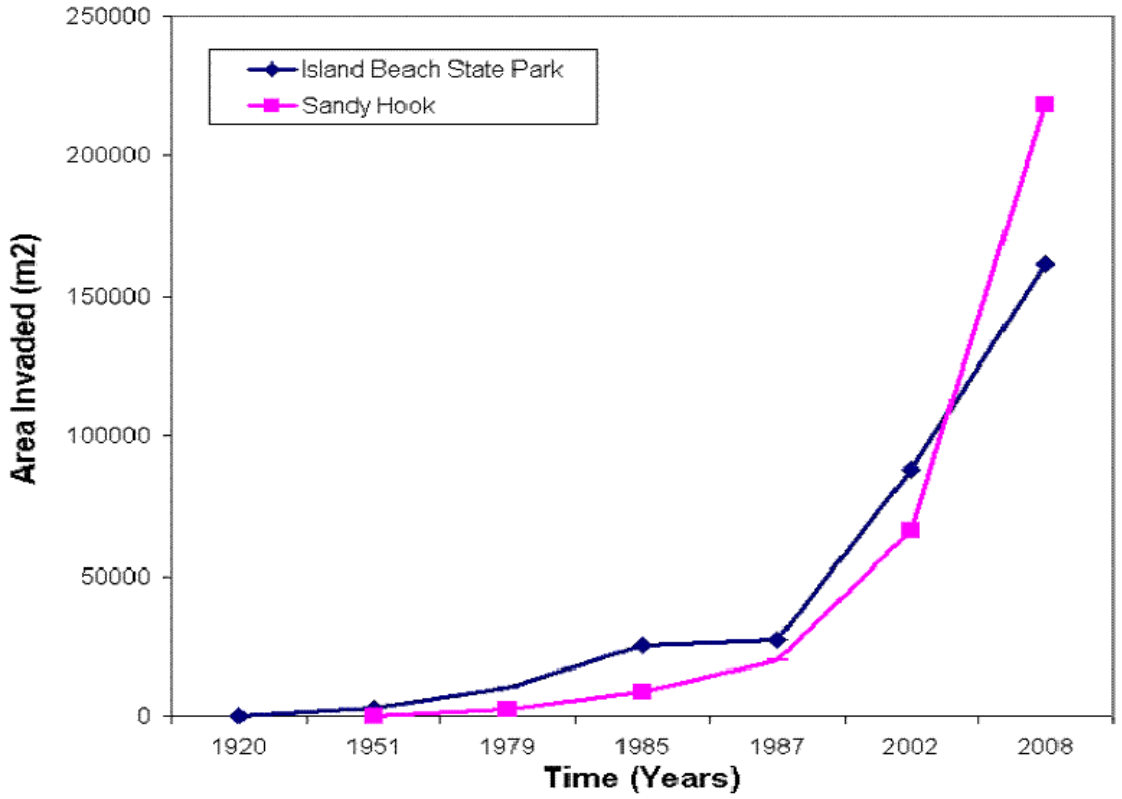


Figure 1. Increase in area invaded by *Carex kobomugi* at Island Beach State Park and Sandy Hook, New Jersey over time (Data from Small 1954, Shisler et al. 1987, Pronio 1989, Wootton 2003 and new (previously unpublished) survey data from 2008).

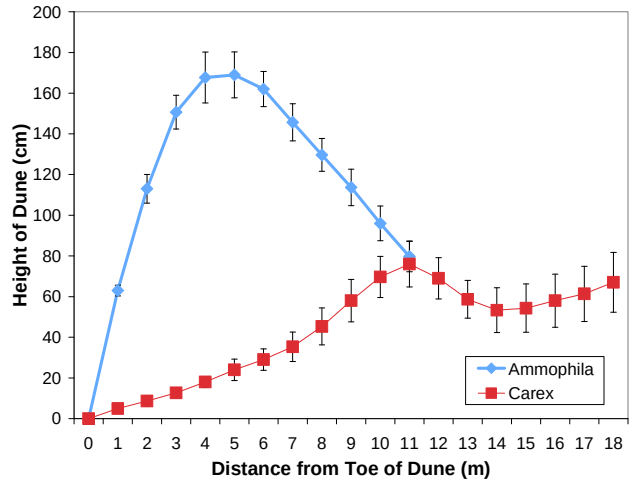
The northeastern beach tiger beetle (federally threatened, state endangered) is also typically found on wide, relatively undisturbed expanses of sandy beach (Bowers-Altman 2003, NJDEP d). It was reintroduced to the Sandy Hook Unit of Gateway National Recreation Area in 1997 (NJDEP d). Seabeach amaranth, another federally endangered plant, is found in the sparsely vegetated area of sandy beach between the toe of a dune and the high tide line (NJDEP ND). All of these species are already threatened by the reduction of available open sandy habitat for nesting as a result of coastal development. In addition, the increased sea levels that are expected to occur as a result of global warming in upcoming years (Beevers 2005) will further

reduce the amount of high beach habitat that is available for these species, regardless of the community composition of the vegetation on the dunes. *Carex kobomugi* may further exacerbate the problems experienced by these species, since the sedge appears to grow farther down into previously unvegetated regions of the high beach shore than does the native *Ammophila breviligulata*, thereby reducing yet further the area of open sandy habitat between the high tide line and the vegetated high shore (Lea and McLaughlin 2005). In addition, plover chicks are known to use open, sandy corridors between vegetated dunes as pathways to more interior habitat suitable for foraging (Loegering and Fraser 1995). If such pathways are lost to encroachment by *C. kobomugi*, plovers and other shorebirds may exhibit reduced survival.

In recent years, the importance of coastal dunes in protecting the mosaic of shrubland, grassland, and interdunal swale wetland habitats as well as the human coastal communities behind them from the effects of projected climate change has been increasingly recognized (e.g. Nordstrom 2000, Spence et al. 2007). Cooper et al. (2005) predict a relative sea level rise for the New Jersey coast between 1990 and 2100 of between 0.31 and 1.10 m, with a median expected value of about 0.71m. If sea level rise occurs within the median range of this estimate, the result would be that 100-year storms (storms creating the kind of flooding that used to happen only about one a century) will happen 3 or 4 times more often in the future. The resulting storm surges would inundate vast areas along the New Jersey coastline (Cooper et al. 2005, Lathrop and Love 2007). The presence of dunes has been shown to significantly reduce coastal flooding, even during extreme storm events (Houser et al. 2008). Thus, careful management of healthy dunes can reduce the need for expensive and time-consuming restoration in the future.

Dune vegetation plays an important role in maintaining healthy dunes. The friction caused by their leaves slows air movement, resulting in deposition of blowing sand and reducing future erosion, thus building the dune. They also stabilize sand within the dune by holding it in place with their roots and rhizomes. Because *C. kobomugi* is shorter in stature than native dune plants like *A. breviligulata,* it has been speculated that it scavenges less sand at the front of the dune (Shisler et al. 1987, Pronio 1989). If so on would expect *C. kobomugi* to support formation of lower, wider dunes than does the native *A. breviligulata*. If true, the diminished height of *C. kobomugi*-stabilized dunes would mean that they are less able to protect the communities behind them from the rising sea levels and increased frequency of storm surges associated with global warming. Until recently, though, no data existed to test this expectation.

A.



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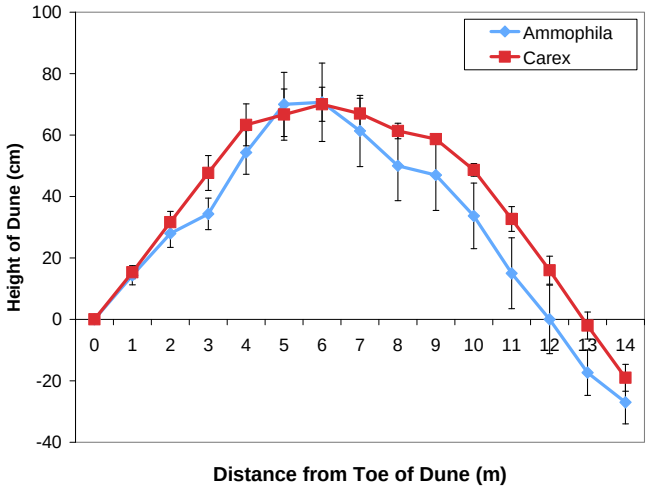


Figure 2. A. Comparison of profiles of dunes stabilized by *Carex kobomugi* and *Ammophila breviligulata* in a rapidly accreting dune. B. Comparison of profiles of dunes stabilized by *Carex kobomugi* and *Ammophila breviligulata* in a non-accreting habitat (Error bars represent 1 S.E. n = 3 sampling dates (August, November, 2007 and February 2008 of the same profile). Data from Max Kornek's senior research project at the Marine Academy of Science and Technology in Sandy Hook, New Jersey.

In 2008 we collected dune profiles from two areas within the Sandy Hook Unit of the Gateway Recreational Area. In the first area the dunes are accreting and are growing rapidly. In this area the *C. kobomugi* stabilized dunes have the predicted lower, wider profile relative to nearby dunes with the same aspect which are stabilized by the native *A. breviligulata* (Figure 2A). However, in the second area the dunes are relatively stable (neither accreting nor eroding). In this area the dunes currently stabilized by *C. kobomugi* have been invaded by the species

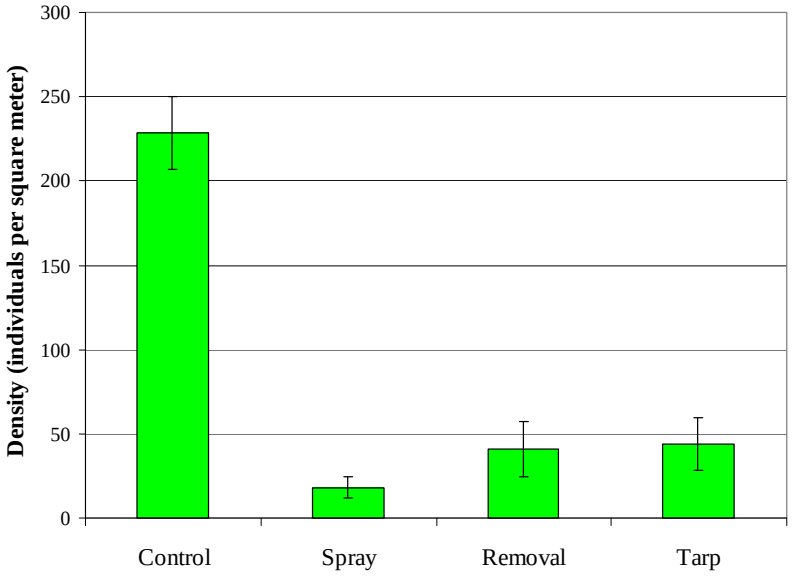
relatively recently (these areas were mapped as being native vegetation in 2002). In this case the profiles of the native and invaded dunes are more or less identical (Figure 2 B). This suggests that, when *C. kobomugi* overgrows pre-existing dune whose shape was created by native species, it simply stabilizes the dune in its original shape.

The numerous negative effects of *C. kobomugi* on the native dune communities, as well as the changes it can affect upon dune geomorphology, make it clear that removing this species from invaded dunes, and restoring native communities should be a high priority for coastal managers in the US. In 2003, McGough et al. reported on some of the first management attempts for this species. In that study, Roundup® was applied to the sedge at several sites at Island Beach State Park. Although a strong reduction in stem count in the sedge was observed in that study, the lack of sustained follow-up treatment meant that the sedge was not completely eradicated from any of the treated areas. In 2005, we chose a large population of the sedge at the Sandy Hook Unit of the Gateway National Recreational Area to assess alternative treatment strategies for this species. Triplicate 10 x 10 m plots of sedge were either covered with tarpaulins for 1 year (tarp), excavated to a depth of 6" using a backhoe and the vegetation removed using a sand-sifter (removal), or were treated with Roundup® (spray). Herbicide application was carried out following label instructions, and using a narrow nozzle and carrier dye. Our goal was to remove the sedge while sparing any native plants still present within the plots. One year after the herbicide application and excavation treatments were applied the tarpaulins were removed. Stem counts were then made in ten, $1m^2$ quadrats within each replicate treatment area.

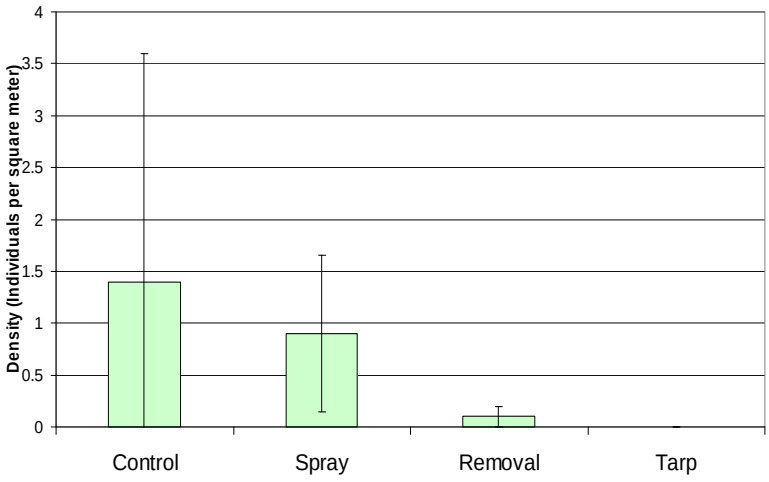
Compared with samples in triplicate control plots, all treatments significantly reduced *C. kobomugi* densities (Figure 3A). However, again, no treatment completely eliminated the plant from the study plots. High within- and between-plot variability resulted in us being unable to detect significant differences in stem counts of native plants between treatments (Figure 3 B, C and D). In general, though, it appeared that the spray application did spare at least some native plants. Removal and tarpaulins had much stronger effects on established native plants. However, the depressions left by excavation appeared to effectively scavenge seeds, resulting in high numbers of young goldenrod (*Solidago sempervirens*) seedlings being seen in these plots the year after treatment (Figure 3 C).

Despite being anchored by pegs every 15cm along their perimeters, the tarpaulins regularly blew away or tore during the numerous storms that occurred within the 1 year of their deployment. Covering large areas with such tarps and maintaining them for sufficient periods of time to kill the sedge would thus be highly impractical. Use of backhoe and sand sifter may also be problematic in that there is a risk of inadvertently spreading the sedge into new areas if propagules are not completely cleaned from backhoe and sand-sifters used in this way before they are returned to their usual use. The removal technique also results in large amounts of plant materials that need to be disposed of safely, as well as creating significant soil disturbance. Herbicide application allows managers to spare native vegetation, which is not possible with any of the other techniques that we tested. It also leaves the roots and rhizomes of treated plants in place, which helps maintain dune integrity while replanting takes place, and

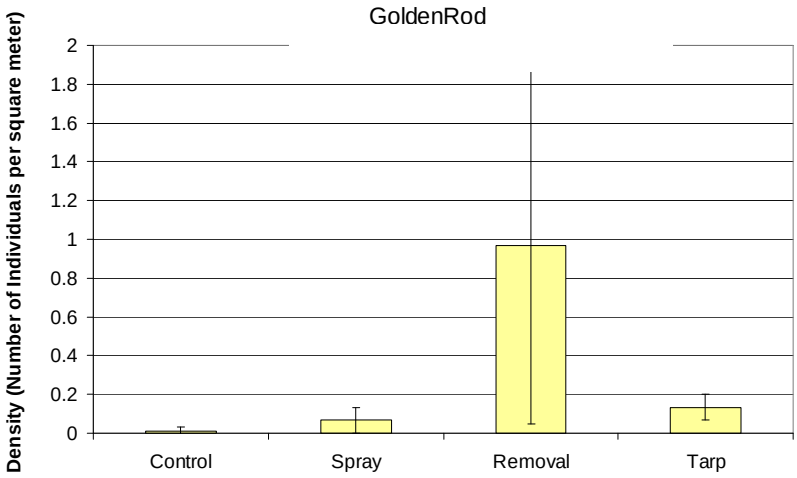
3A. *Carex kobomugi*



3B. *Ammophila breviligulata*



3C. *Solidago sempervirens*



3D. *Artemisia campestris caudata*

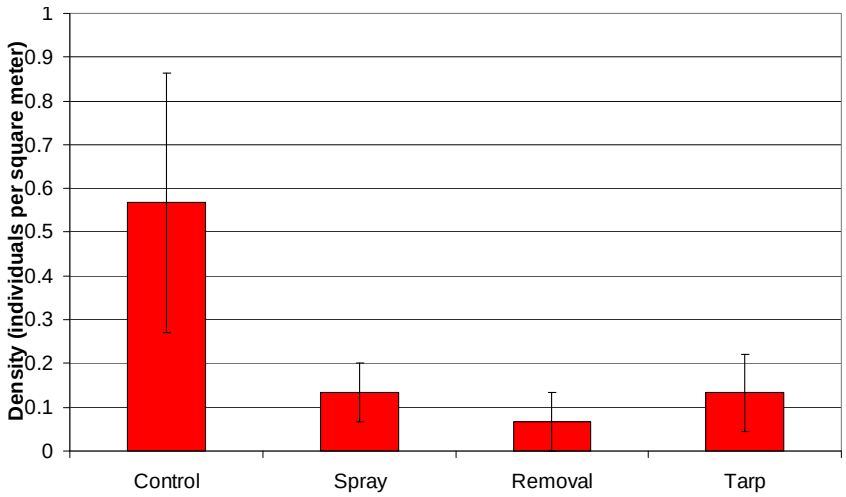


Figure 3. Response of A. *Carex kobomugi*, B. *Ammophila breviligulata*, C. *Solidago sempervirens*, D. *Artemisia campestris caudata* to various treatments. Error bars are 1 SE.

the new plants become established. As a result, localized application of herbicides such as Roundup® or Rodeo® is currently the best practice for treating this species. Again, though, the results of the 2005 study emphasize the need for multiple follow-up treatments in order to eliminate, rather than simply reduce, the densities of the sedge within treated areas.

Finally, it is worth noting that a sister species to *Carex kobomugi*, the large headed sedge, *C. macrocephala*, has also recently been found to be invading coastal dunes in New Jersey. Thus far, the area affected by this species is much less, and the plant seems to be growing at much lower densities than does *C. kobomugi* and to be having few if any discernable effects on native plant communities (Wootton 2007). But, because these plants are so closely related, and they do not naturally co-occur anywhere within their natural range, there is some concern that the close proximity of these sister species in New Jersey may pose a risk for hybridization between the two species (Wootton 2007). Since hybrids are often more invasive than either parent species, I am recommending speedy and aggressive removal of the *C. macrocephala* populations, since management of this species can be achieved more easily than can that of the more established *C. kobomugi*.

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Rapid Expansion of the Large-Headed Sedge, *Carex macrocephala,* at Seven Presidents Oceanfront Park, Monmouth County, New Jersey. Louise Wootton, Georgian Court University, Lakewood New Jersey 08701 woottonL@georgian.edu

ABSTRACT

The large headed sedge, *Carex macrocephala*, is native to Northern Japan, Russia and the northwest coast of North America. Several populations of this species have recently been discovered in New Jersey. To assess the potential of this species to become invasive in this area, we monitored one of these populations for two years. When we first discovered it in 2004, the *C. macrocephala* population at Seven Presidents Oceanfront Park in Monmouth County, New Jersey, consisted of several relatively small, fragmented patches. Since then, these populations have expanded landward at a rate of about 1 meter per year, and seaward and perpendicular to the shore at 2 - 3 meters per year. This has resulted in merger of several of the original patches, as well as invasion of dune areas previously occupied by native plant species. In addition, the species has expanded rapidly into the previously unvegetated high beach areas which are important habitats for a number of endangered species, including piping plover (*Charadrius melodus)*, beach tiger beetle (*Cicindela hirticollis*) and seabeach amaranth (*Amaranthus pumilus*). Rapid action to control or eliminate *C. macrocephala* from New Jersey's coastal dunes before it expands further would thus seem judicious.

The Plant

Carex macrocephala gets its common name from its distinctive, large reddish-brown flowering heads. It is distinguished from similar sedges by the presence of acutely angled culms. In addition, the proximal portions of the perigynia have distinctive, lacerate wings, while their distal tips show a characteristic, bidentate beak (Flora of North America Editorial Committee 2003).

Study objectives and methodology

Just because a species is not native to a region, does not automatically mean that it will exhibit invasive properties (e.g. rapid expansion, negative impact on native species). To assess the invasiveness of *C. macrocephala,* we used dGPS to delineate the boundaries of the population when it was first discovered in 2004 and again in 2006. We also carried out stem counts within each bed using a systematic sampling design in both years.

The Study Site

Part of the Monmouth County Park System, Seven Presidents Oceanfront Park is a 38-acre coastal park, located in Monmouth Beach, New Jersey (Figure 1). Much of the park is heavily used for recreation, and the entire park is bordered by roads and heavily developed suburban

areas. However, there are several dunes areas within the park that are home to populations of sea-beach amaranth (*A. pumilus)* and piping plover (*C. melodus)*, among other native species.

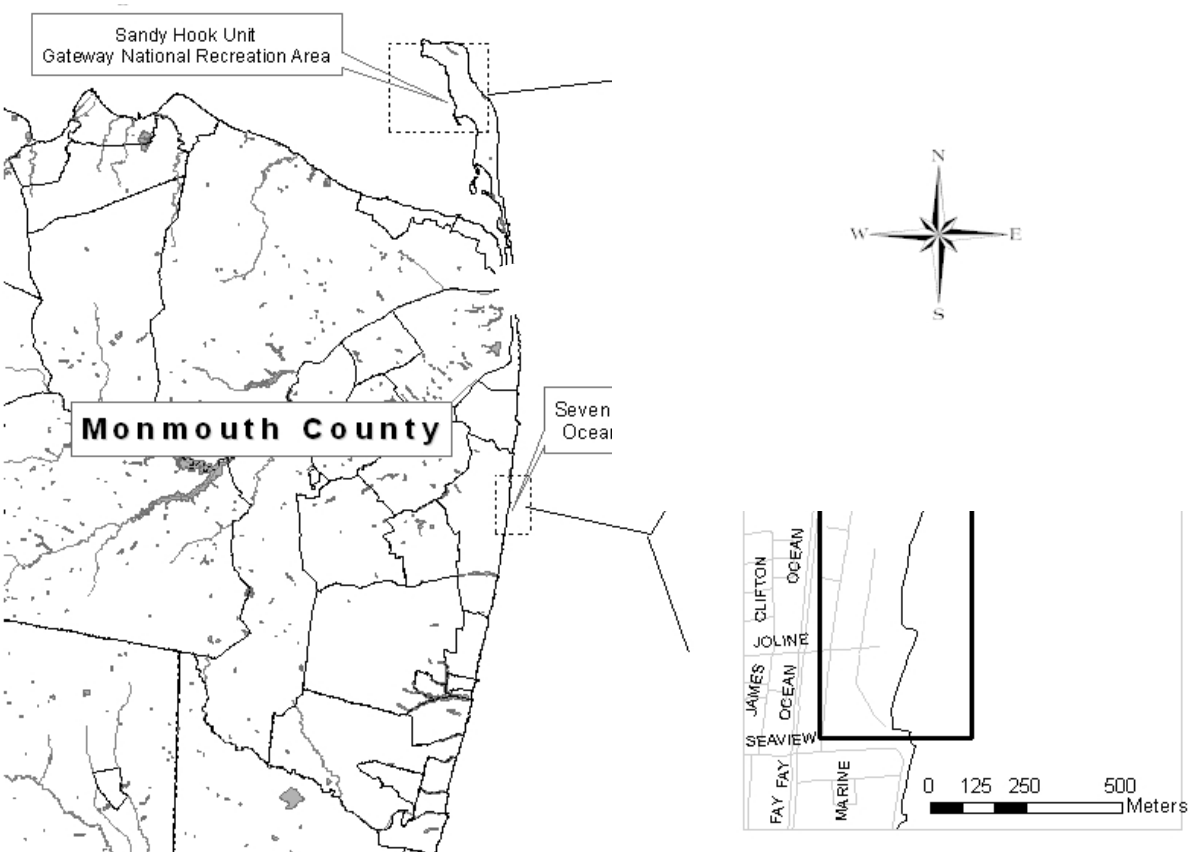

Figure 1. Location of study site in Monmouth County, New Jersey.

Results

All beds surveyed increased markedly in size between 2004 and 2006 (Figure 2). Landward expansion was relatively slow (ca. 1m per year). By contrast North → South expansion was much more rapid, averaging 2-3m per year, but with some areas expanding even faster than this. This expansion was largely into habitat previously dominated by American Beach Grass (*Ammophila breviligulata*). Seaward expansion into unvegetated, high beach areas, which are critical habitat for a number of endangered species, was also rapid (2 - 3m per year).

Average *C. macrocephala* stem densities increased slightly between 2004 and 2006, from 10.2 ± 11.7 to 12.7 ± 15.6 stems m^{-2}, but this difference was not statistically significant ($t = -1.707$, 341d.f., $p = 0.09$). Maximum stem densities also increased from 66 to 98 stems m^{-2}.

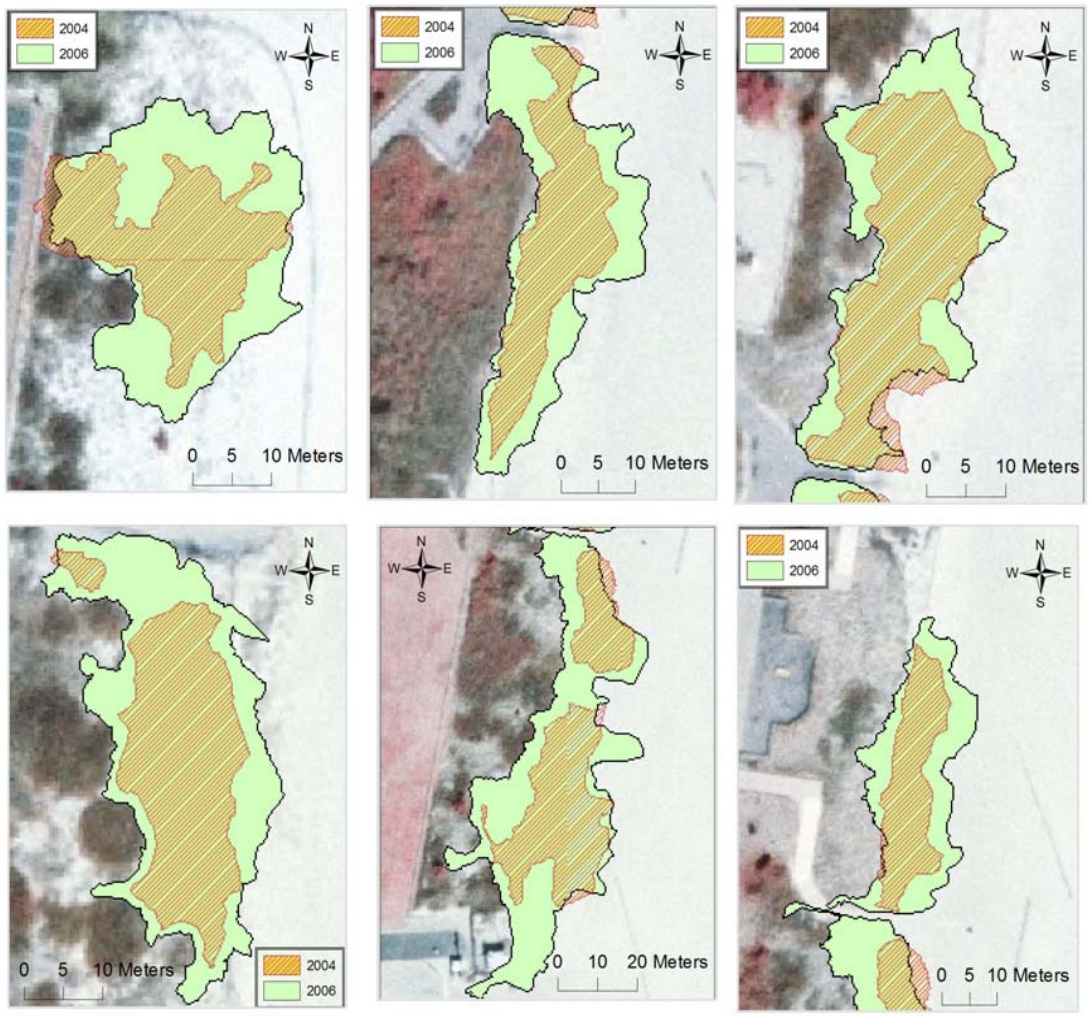

Figure 2. Relative size of populations of Carex macrocephala at Seven Presidents Park in Monmouth County New Jersey between 2004 and 2006.

Conclusions

Species native to high, unvegetated beach areas are being caught in a "pincer action" between rising sea-levels and rapidly expanding *Carex macrocephala* beds. Such habitat loss adds to the problems already faced by species living there, such as sea-beach amaranth, piping plover and tiger beach beetles. Since *C. macrocephala* populations in NJ are still small and localized, complete removal of the species in the state is still logistically and financially feasible, and should be carried out as soon as possible.

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Assessing Patterns in Spread Rate and Direction of *Carex kobomugi* Relative to Known Populations of Endangered Dune Species in Order to Prioritize Management Actions for this Species in New Jersey. Louise Wootton, Georgian Court University, Lakewood NJ 08701 and Jim Burkitt, Brookdale Community College, Lincroft, NJ 07738

Abstract

The invasive Asiatic sand sedge, *Carex kobomugi,* is spreading rapidly in New Jersey's coastal dunes, where it is having a strong, negative effect on the abundance and diversity of native flora. Currently there is no active management plan for the species, nor is one planned. Starting in 2002, we have been working to create a species inventory using dGPS mapping and GIS-based data processing. Comparison of polygons denoting population sizes at each sampling interval will be used to look for patterns in the rates and direction of spread of this species. For example, are certain populations in New Jersey spreading faster than others? If so, can those patterns be related to physical characteristics of sand dune habitats such as prevailing winds or long-shore ocean currents? We also plan to combine our data with existing databases of the locations of threatened and endangered species. This information will, in turn, be used to help direct future management efforts to areas where they will have maximum benefit. For example, areas predicted to be at high risk of future invasion should be subjected to intensive monitoring to allow for early detection. Similarly, new populations should be targeted for rapid response (manual removal, herbicide application, etc.). In addition, removal of populations presenting particularly strong threats to threatened and endangered species should be prioritized. Finally, the population inventory that we generate for *C. kobomugi* will provide a benchmark against which future expansion of the species, or the effectiveness of future management efforts, can be measured

Introduction

Asiatic sand sedge (*Carex kobomugi*) is a perennial sedge in the Cyperaceae family that is native to Japan, Korea, China and parts of eastern coastal Russia (Swearingen 2009). Since its accidental introduction to New Jersey about a century ago, this sedge has spread widely along the East Coast. While its range now extends from Massachusetts to the Carolinas, the species is particularly abundant in New Jersey, where it has expanded into many of the state's remaining coastal dune systems (Wootton et al. 2005). *C. kobomugi* is expanding rapidly in NJ, with most stands expanding by several meters in diameter every year.

Stem densities of many native plants, including American beachgrass (*Ammophila breviligulata*), wormwood (*Artemisia* spp.) and saltmeadow cordgrass (*Spartina patens*), as well as species richness are significantly lower within areas invaded by *C. kobomugi* than in the surrounding (uninvaded) dune areas (Wootton et al. 2005). In addition, there is a strong negative correlation between stem densities of *C. kobomugi* and those of native species within the invaded areas, again confirming the negative effects of this species on native plants.

Invasion by *C. kobomugi* also negatively impacts seaside goldenrod (*Solidago sempervirens*) (Wootton et al. 2005), the nectar of which is an important food resource for migrating monarch butterflies (*Danaus plexippus*). We also suspected that the rapid expansion of this sedge was moving it into habitats occupied by endangered species, such as sea-beach amaranth (*Amaranthus pumilus*), seaside knotweed (*Polygonum glaucum*), piping plover (*Charadrius melodius*), and beach tiger beetles (*Cicindela dorsalis dorsalis*), increasing the ecological pressures on these already embattled species. However, until the current study, the interactions between these species had not been documented.

Methods

Areas of New Jersey's coastal dunes that have been invaded by *Carex kobomugi* were mapped using Leica Geosystem GS5+ differential GPS receivers (accuracy ca. 1m) in both 2003 and 2008. The perimeter of each population was mapped twice: once by walking around it in a clockwise direction and then again in a counter-clockwise direction using a different dGPS unit. Once the perimeters were mapped, the data were merged using the geographic information system ArcGIS 9.3 (Environmental Systems Research Institute (ESRI). Redlands, CA), allowing us to detect and compensate for any operator and/or mechanical errors within the data set.

Data on locations of a variety of threatened and endangered plant and animal species were obtained from monitoring programs conducted by the National Park System at Sandy Hook Unit of Gateway National Recreation Area (Jeanne McArthur), the U.S. Fish and Wildlife Edwin B Forsythe National Wildlife Area (Kevin Hollister), the U.S. Fish and Wildlife New Jersey Field Office (Wendy Wallace) and the New Jersey Department of Natural Resources (Jay Kelly). All of these data were also entered into our GIS database in order to create the maps shown here.

We have not yet started quantitative data analysis on these data sets. Eventually we propose to assess rates of expansion seaward, landward, north and south to see if we see any patterns that we can relate to prevailing wind or current directions. Similarly we plan to look for patterns in locations of newly established populations relative to older ones. The results presented here represent a qualitative assessment of the data collected so far, based largely on visual inspection of maps made based on them.

Results and Discussion

Spread Rate and Spread Direction: Existing Stands: As might be expected, there is a clear trend for expansion of existing beds to be much faster when the plant is growing into open habitats (e.g. high beach) than when it is growing into areas with existing, native vegetation. No clear pattern was apparent in the spread rate on the North-South rather than East-West (usually Landward / Seaward) axis in this preliminary analysis (Figure 1), suggesting that prevailing wind / current directions are not playing a major role in shaping the spread rates or directions of existing populations.

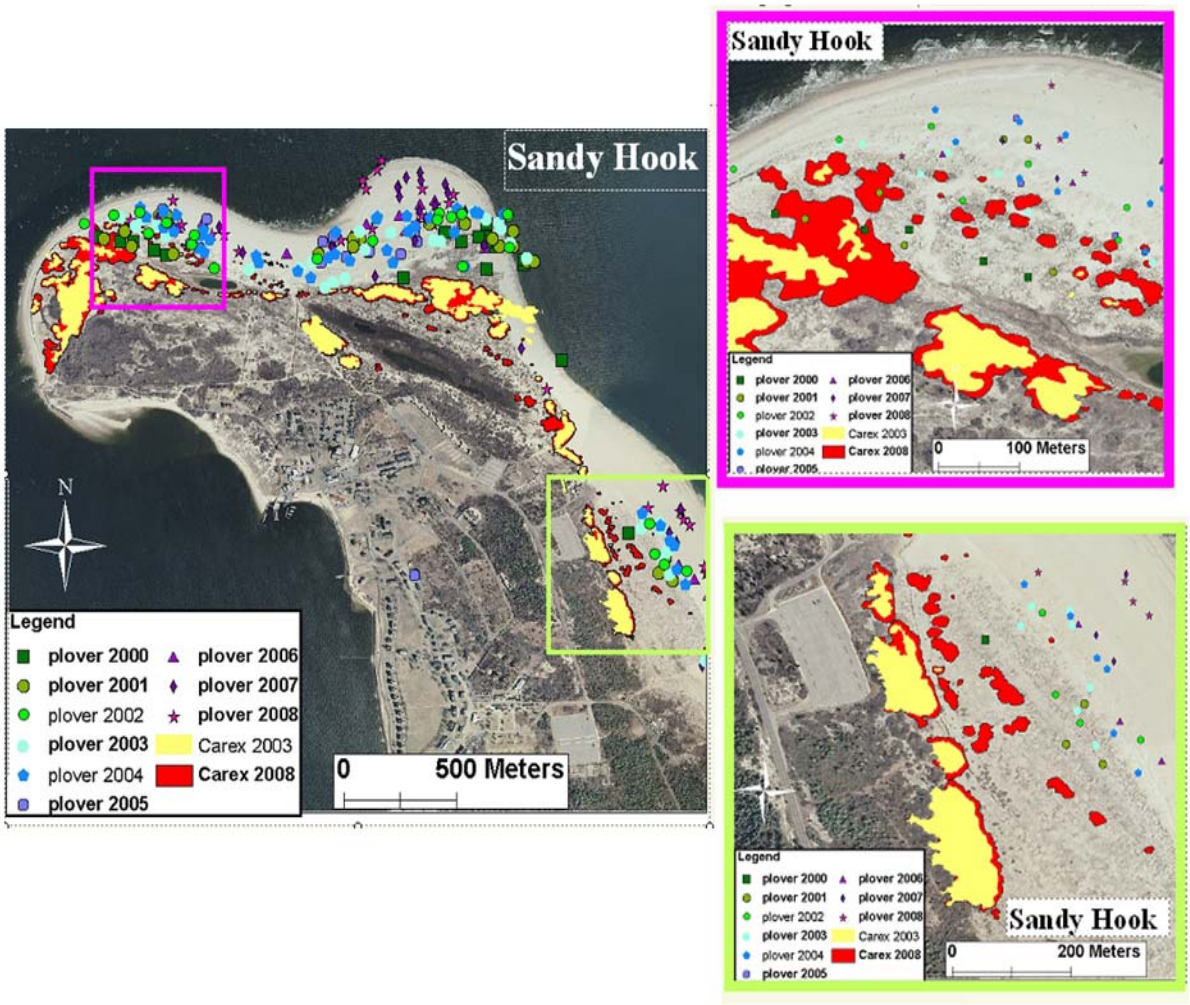

Figure 1. Relative positions of *Carex komomugi* populations relative to piping plover (*Charadrius melodius*) nesting sites at Sandy Hook NJ. Red areas represent those into which *C. komomugi* has expanded between 2003 and 2008

Spread Rate and Spread Direction: Location of New Stands: As with established populations, the vast majority of populations established between 2003 and 2008 have grown up in habitats that were previously unvegetated (i.e. in high beach habitats). While the majority of new populations are near previously established ones, there are also a number of new populations that are more than a mile from the nearest population mapped in 2003, suggesting that long distance transport is playing an important role in dispersing this species into new habitats. In these cases, the new populations tend to be south of the most likely source population, which is in keeping with the net southerly current direction seen during major storm events in NJ.

Threats to Threatened and Endangered (T&E) Species: The high beach is home to a number of T&E species, including piping plover, seabeach amaranth and seaside knotweed. The rapid expansion of invasive sedge into this habitat, discussed above, is pushing the habitat available

to species seaward at a time when sea-level rise is pushing mean high-tide levels landward. In many places, *C. kobomugi* is now growing on or near sites that previously harbored piping plover nests (Figure 1), sea-beach amaranth or seaside knotweed (Figure 2), among other T&E species. There is also a clear trend within the piping plover data of nest locations being pushed progressively seaward over the years for which we have data (Figure 1).

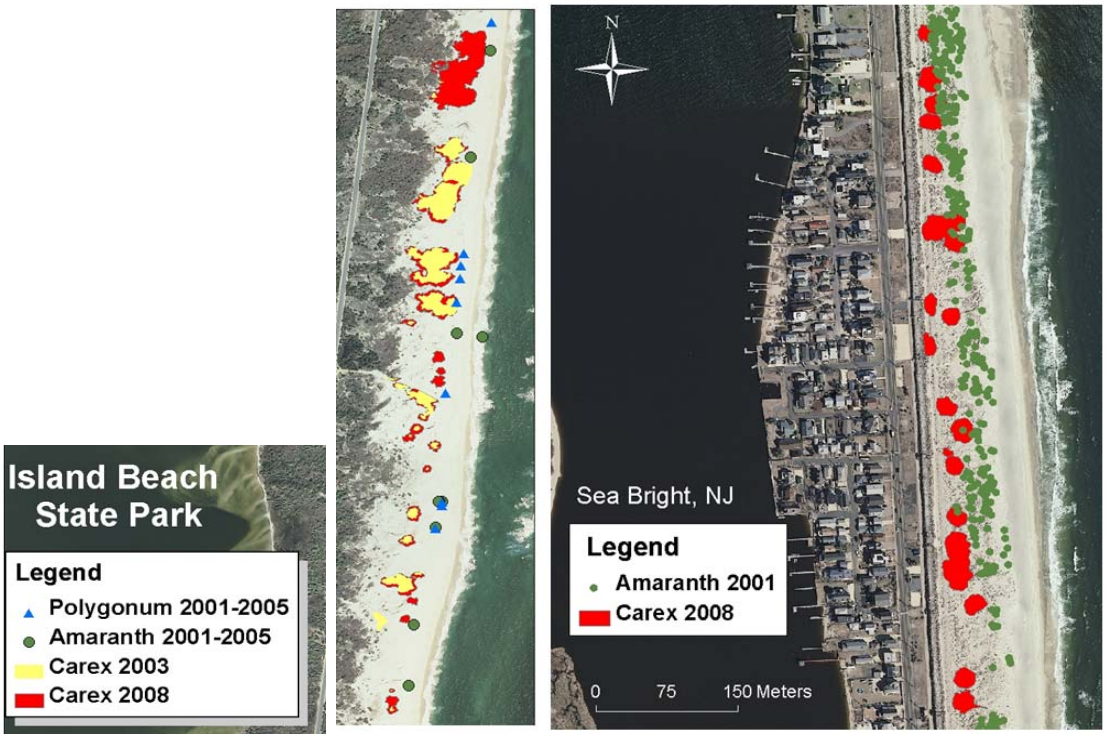

Figure 2. Relative positions of *Carex komomugi* populations relative to as sea-beach amaranth (*Amaranthus pumilus*), seaside knotweed (*Polygonum glaucum*) at Island Beach State Park (left hand panel) and Sea Bright, NJ (right panel). In the left panel, red areas represent areas into which *C. komomugi* has expanded between 2003 and 2008 No data were available for the location of populations of *C. kobomugi* in Sea Bright in 2003 (Right panel), so only the location of 2008 populations are depicted.

Conclusions

Our results so far suggest that managers need to focus removal / control efforts on *C. kobomugi* primarily on high beach habitats in the immediate vicinity of existing populations, especially when those habitats support known populations of T&E species. Unfortunately, the ability of the species to undergo long-distance dispersal via ocean transport in storms means that monitoring activities for potential early detection, rapid response will need to extend well beyond the areas currently affected by this invasion if they are to be effective.

References Cited

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Summary of Panel Discussion: Invasive species management policy: challenges and ways forward.

While we chose to include a verbatim transcript of the panel discussion, we also wanted to provide a brief compilation of some of the main ideas that emerged from the discussion. Those ideas are summarized below:

1. There is a need for transition in the way we manage dunes such that we move away from managing dunes solely to protect their function in shore protection so that we also manage them for their role as a key habitat for a number of species – to take both ecology and dune morphology into consideration. While managing for habitat may be harder, protecting diversity maintains the resilience of the dune plant community, which in turn feeds back into resilient shore protection. Thus, managing for habitat IS managing for shore protection.

2. There is a need for improved intra- and inter-agency cooperation and communication. For example, secrecy about locations of Threatened and Endangered (T&E) species compromises our ability to adequately protect T&E species in areas being managed for invasive species.

3. The fast paced changes in the species arriving in each region, along with changes in our understanding of the impacts of those species and of the best management practices to combat them mean that regulations need to be maintained as living documents which are regularly updated. This creates challenges for increasingly overburdened agency staff members who need the time and resources to stay informed of the most recent information pertaining to invasive species and their management.

4. There is a strong need for both public and expert input and advocacy whenever opportunities arise for input to regulations. Thus, it is important that stakeholders be informed of opportunities for feedback, so that appropriate guidance can be provided to those professionals involved in developing and updating the regulations. When submitting comments, stakeholders should not just request specific changes, but also explain WHY those changes need to be made whenever possible.

5. Maintaining and building management capacity is important, but the regulator cannot solve problems in isolation. It takes an educated and engaged populace. Thus, it is important to build effective peer to peer education programs that work to change public perceptions about invasive species, to build buy in for any regulations or management requirement, and to create a degree of self policing within the public. As

agency funding decreases, the importance of such education programs increases in order to fill gaps created by such cuts.

6. To build public buy-in and effective public education programs, rallying points need to be created to focus and inspire people's energy. Two key components of such rallying points are (a) charismatic species that inspire people's desire to get engaged in order to protect something they care about and (b) charismatic people who can go out into the community and become the champions of the cause and engage stakeholders in both direct actions and advocacy to address the problems caused by invasive species.

7. Effective management of invasive species requires the availability of adequate fiscal resources / grant funding. Successful models for funding invasive species initiatives exist wherein small activity fees are levied on things such as boat or fishing licenses, beach user fees etc. An important additional consideration is the importance of publicizing success stories arising from funds raised by these means in order to fuel support for similar initiatives in the future.

8. There is a strong need for prohibited species list and clean lists. Without these there is no tool for enforcement. Currently, should someone decide they like *Carex* because it stabilizes lower dunes, for example, we have no tool to prevent its sale or usage. When such lists are implemented, it is important to work with vendors and nurseries in order to provide adequate warning and lead time to prevent them from investing resources in propagating soon-to-be-banned species.

9. It is recommended that managers always consider relative costs and benefits of all available approaches for best management practice, and not treat any one approach (e.g. herbicide use) as being automatically off limits. Several of the presenters showed examples of successful use of peer mentoring in overcoming any initial stakeholder-resistance to management efforts or specific management strategies.

10. The importance of, and need for, early detection and rapid response (EDRR) programs for minimizing the damage done to ecosystems by invasive species, a theme that emerged widely across the conference, was again reiterated throughout the panel discussion.

Panel Discussion Transcript

Invasive species management policy: challenges and ways forward. Panelists: Chris Dolphin (CD), Colleen Keller (CK) and Michael Van Clef (MVC). Moderator: Dr. Susan Halsey (SH)

SH: I would like to ask each of the three panelists their "number one" recommendation from what you have heard the past two days, and Chris, from this morning, what would your recommendation be to get this started?

CD: In terms of where we are as a regulatory agency and your question, if I'm going to take it in a regulatory context, I think what is lacking at this point is a real good understanding of the issue for not just the regulators, but the regulated public. Everybody has their niche and everyone has their role to play, and I think that what needs to happen is that the lines of communication need to be reopened. It's difficult in this area. The ability to get out to conferences is difficult. This is the first conference I have been to in a decade or something crazy like that. It's difficult for myself and my staff to know what's important out there, and to know what is on the cutting edge as we think that with the Internet, email and technological advances we have and information is flowing extremely rapidly, but I find that it's difficult to find the information if you don't know what the question is that needs to be asked.

SH: When you say "myself and the staff," you are the Section Chief?

CD: Yes, I am the section chief for the coastal program.

SH: How many staff have you been able to retain?

CD: We are probably down a good third, so we were up to about 15 people and we are now down to 10 people and that's the group that does coastal permitting, essentially everything for the southern part of the state. There are other people within this regulatory program, however. There are people devoted to doing wetlands and flood hazard work up in north Jersey and the like, but people who are involved in CAFRA (The Coastal Area Facility Review Act) review and the waterfront development reviews, we are down to about 10 people.

SH: Colleen?

CK: I think that, listening to everything, Louise has come to us with the *Carex* situation and you know, Chris said in his talk this morning that the primary concern is shore protection and that's how we look at dunes, so I still kind of see *Carex* as a very stabilizing plant. I didn't know the history of the Governor's Mansion and how that held during the '62 storm that Sue covered. I do see that it is an issue as far as height as concerned, in that it doesn't grow very high and it

doesn't seem to capture sand as well, but usually it's on a pretty nicely developed dune that we've seen. I'm still being educated.

SH: Mike?

MVC: I think the biggest policy-related issue is having a prohibited species list and ideally, to go along with it, a "clean" list. That balance would go a long way towards making everyone work together better.

SH: So really, a preventative management tool?

MVC: Yes

SH: So that no Beach Vitex comes to NJ?

MVC: Right

CD: One thing that struck me with Randy's talk that started this whole thing off was the whole concept of biological pollution. I found that interesting because he is right. There is a lot of emphasis on chemical pollution. There is a lot of emphasis on water issues. There is a lot of emphasis on air pollution and the like. But there has never really been a lot of concentration or thought given to the concept of biological pollution. Again, in terms of changing the discussion from strictly a regulatory program to a regulatory response, changing the environmental ethics, a lot could happen in that regard. That really takes place outside of regulatory agencies. That's really something that, as people who are interested in the program are needed to go out there and spread the word. There is a whole other way of polluting our planet.

SH: I was fascinated by the request for new resources in the regulations. I happen to be the one that found the Florida Sea Grant specs for the wooden walkways. And I was the one that wrote the little dune handbook for the Legislature after the 1984 storm that's in there but there hasn't been much added since I've left the DEP. So in regard to new resources being added like the NJ rendition of the NC Dune Book for people might be a good idea. So, with that, I'd like to open it up to the audience here for any questions or new ideas. What can we do? Bring in from other states people who might see holes in our approach and things that we need to do? This is your time to suggest them.

Chuck Grisham (Baruch Institute of Coastal Ecology): Other than your committee, I don't see a great deal of task forces, I don't see a great deal of interagency cooperation, not only inner, within a level, but also federal, state, NGO, and private. Not to brag, but that's been a strength with the Beach Vitex Task Force. We had a high diversity of people who were all on the same page. It smoothed things out greatly.

Louise Wootton (Georgian Court University): That's a good observation. How can we make that happen in NJ?

Chuck Grisham: First, I want to correct the record. I didn't make it happen. It was Betsy Brabson at Randy's urging. When Betsy realized she had a problem, she went to Randy and he had the solution and that was the message he was preaching is cooperation and partnership and that's what you saw on his presentation. How did it happen? It was at the first Vitex conference. It was Betsy and the aquatic extension guy and she really picked his brain and thought of all the sectors of the society and invited Federal, State, private sector, NGO, municipal government and municipal Mayors. You've just got to rack your brain as to who are your natural resource stakeholders, or anyone in natural resource agencies, and invite them to the table. Because of that, you will have a pretty long partner list. Some are more active than others, but everybody should be there.

MVC: I think for the council, the NJ Council, the Federal part is completely lacking at this point. But there is an acknowledgement that it shouldn't be the case. For the strike team I'm involved with, we just started to get the National Park Service involved and we are working on US Fish and Wildlife but that probably won't happen so we are working on the MOU (Memorandum of Understanding). We are trying to take that lesson so we will have Federal down to municipal, non-profits, private land owners…the whole works. We are trying to replicate that.

Chuck Grisham: The other advantage to that is that the Federal sector is the money source. That's what we survive on. To do something, you have to have resources and you have to have a means to those resources. Get all involved on the same page. But we saw that early on. We live and die by grants. Since they were with us from the beginning, they awarded us the funding

MVC: The backbone for the strike team is two organizations, two non-profits, Friends of Hopewell Valley Open Space and Upper Raritan Watershed Association. Together, we seek grant funding. It's great that those two organizations are putting their own personal resources into it but we are not going to make it without grant funding long term.

Chuck Grisham: ….and you have to have an organization like that because direct funding requires a match. You have to have a backbone to come up with 25% of something like that!

SH: And it has to be non-Federal funding, too.

MVC: We definitely have some of that in place. There's a commitment from both organizations to put their resources into it. It never feels like enough. When you see the size of the problem, we see we need more, which means we need more interns, we need more staff, we need more everything but we are only a year and a half old so we will see.

CK: In South Carolina though, your interest, your common ground is sea turtles, correct? So we don't really have anything in NJ that motivates that, where everyone has one commonality to understand and realize the issue.

SH: What about Tiger Beetles?

LW: It's hard to get people to care about beetles!

Chuck Grisham: You're right. Everyone saw the sea turtles and realized that there was a long history of caring about sea turtles. That was a step. That's were Betsy came from. Everything just fell into place. It was step by step.

CD: Before we move on, again, I sort of mentioned it in my talk that I was very impressed with what you were able to accomplish and again, from a regulatory perspective, I have found that over the many years that I have been a master regulator that the public's response to us is either one of two things: (1) they hate us because we are telling them what to do or (2) they have a perception that we can do everything; that we can somehow stop development in its tracks, that we can go out there and tell property owners to pull this plant out of there. I think that where you have success in a lot of respects is through building that grass roots effort where it wasn't a regulatory response: Nobody was on those dunes telling those people "You've got to get this plant off of here"! What happened was a grass roots movement where the importance of the environment and the importance of what was going on was conveyed to them and people could buy into that. So I think the lesson from your experience really is that grass roots can work but grass roots have to be realistic. Also, you have to understand that grass roots doesn't mean calling up the DEP and saying "You have to do this for me". A good grass roots movement is out there telling people and convincing people and being effective communicators and conveying what is important and what's not important.

SH: And because of the regulatory timeframes you DEP guys are under for permits, etc, the 90-day clock is always over your head, you don't have time to check with the strike team. It just doesn't happen.

Doug Jensen (Minnesota Sea Grant): Just because you don't think a beetle isn't important, that doesn't mean it can't be made to be important. You have to remember that the Zebra Mussel is also not very charismatic and is the poster child for the invasive species world across the United States. One other comment in terms of what I've seen at the State level nationwide, and I've been working on this issue now for about 16 years, and those states that have benefited the greatest from invasive species programs have sought long term funding and they have done it in a number of different ways. So one of the key things I think should be investigated further at the state level in NJ are ways, and mechanisms to garnish some funding to augment the invasive species efforts that have already been started here and build upon

those success stories. In Minnesota in 1981, statutes were put into place that gave the authority for Minnesota DNR, gave them some funding, some of the funding came from ecological services, some from fish and wildlife and established the exotic species program which worked into the invasive species program as it is today. Some of the funding came through from a surcharge on licenses for recreational watercraft and Minnesota at that time was 4th in the nation, we are now 3rd in the nation as we just passed Michigan with 866,000 registered boaters. Every 3 years, every boat that is over 10 feet is registered and that brings in over $400,000 into the state and depending on the sequence of new boats coming in and that sort of thing, may be more than that. That is used then to help fund the salaries for 80 watercraft inspectors which reach 46,000 registered boaters in the state of Minnesota both residents and nonresidents. It's a point of education at the water accesses (which I will talk about later). The point here is that in our state, as well as other states that use a gas tax, Wisconsin has garnished $300,000 of gas tax to augment some state funding to establish an invasive species program in the Wisconsin DNR. The point here is that there are a lot of different models out there and a lot of success stories out there.

SH: Unfortunately, NJ is the highest taxed state in the nation, even overcoming CT now, even though we have a much lower gas tax, which is a sacred cow. But it's a possibility we can think about.

Lee Rosenberg (City of Norfolk VA)**:** NJ does a tremendous amount of beach nourishment and those projects, just looking at the funding that comes in to do those projects, that if there is a way to coordinate those projects in that they do dune building, they plant grasses and it's basically a protection of their investment in their project particularly if you can get it incorporated into the Corps of Engineers specs or if there is federal money coming in, they come in to maintain their dune system, they need to keep the invasive Carex out. Just one idea if that avenue can be breached because I know for us in VA, it's my involvement with beach nourishment and protecting the dunes, the last thing we want is for the whole ecosystem of the dune to change, basically for the dune to become destabilized because the Carex can grow through sand as well. Just one suggestion.

CD: Not to throw anyone under the bus, but the way that the beach laws work here in NJ and probably elsewhere, but the Corps sponsors the initial program and the maintenance of the structure itself then falls to the state and the local sponsor. Again, within the Department of Environmental Protection, there is an office of coastal engineering and as the name sort of implies, their focus is going to be coastal engineering. They are looking at it as protective structures. Down in Cape May, the Cape May Refuge, where they recently just did a beach-fill, they did actually incorporate into some of the design, habitat enhancements that allow for plovers to cross over the built dune to get into some of the fresh water ponds for feeding.

There were a lot of issues back and forth because the coastal engineering people were not real excited about this because they were concerned about that if you lower the dunes and lower the slopes, is that going to make it more vulnerable and then they are going to be put in a position where they will have to come back later and rebuild the dune. The wildlife people were able to prevail and said 'let's give it a try' and put in some habitat enhancements.

Pete Rowe (NJ Sea Grant): I guess this is more directed at Mike since he seems to know most about the draft. An issue came up yesterday, and as we were talking about the plovers today, it's something to gather around. In the draft, does it talk about how to deal with invasives? How to control invasives in relation to endangered species?

MVC: It suggests making management plans. It suggests using particularly important elements of biodiversity to help you prioritize where you should put work, put money towards control efforts, but it's not that descriptive as to say: piping plover, do this or that, consider this or that, it's more generic about prioritizing sites to do work.

Pete Rowe: some of the discussions were, I guess in terms of directed spraying, how focused you can be, and there were some concerns on that. Maybe *Carex* was in the back dunes as a specific species.

Louise Wootton: In terms of the management plan for *Carex* that we developed for the Stimulus RFP (which ended up not getting funded), one of the concerns was use of the spray in an area next to, or near plovers or sea beach amaranth or any other threatened or endangered species. We created BMPs for how to minimize the impact. For example, with the plants, we would have put boxes or some kind of protective covering over any T&E species. We also times the spray applications to miss the plovers by applying before they got there or late enough that the plovers would have moved on. Most invasive species management plants are going to need those kinds of provisional plans or plans for how to reduce the impact on one or more threatened or endangered species in the impacted area.

MVC: I think it is definitely on the mind. There is no office of invasive species in this state but we do have rare animal people and rare plant people and there is certainly concern from those folks that focus on the rare things, that don't run "willie-nillie" killing stuff without knowing what you are doing. I think you really do have to address these things on a case-by-case basis because there is publically available data that will put you in the ball park whether the area you are in has something rare in it. If you make data requests, you will get somewhat more specific information. In some cases, it's actually a stumbling block because of data secrecy issues. So I've heard issues where someone wants to do management on a site for invasive species control and they know they can drill down to the fact that they know there is a rare species somewhere on the property and then the question is "where exactly is that 'somewhere' so I

don't accidently spray. Because I'm creating bird habitat, I don't know a lick about plants, but I don't wanna kill the rare plant, tell me where it is." "Nope." There are a lot of things that need to be worked out on that scale with rare things.

Bill Shadel (American Littoral Society): This is really more of a point. It sounds to me that we are talking about two different things in NJ anyway. The idea of controlling or eliminating the *Carex*, an invasive species, is all well and good as far as I'm concerned. It's an ecological benefit, yet we are not managing dunes for an ecological benefit. We don't allow them to break through like they naturally would. Barrier islands in NJ, if we had our way are going nowhere, they would naturally. So it's sort of a conflict of two things we are trying to manage. Although I think from a way, with no science behind it, diversity of species on a dune to me always seems like a good thing even for stabilization. If we have a monoculture of *Carex* and something should kill it off, what's going to replace it?

CD: That is a valid point and one of the things I think I'd like to see happen within my own agency is a change in the focus, away from strictly stabilization and it being a shore protection structure. I think in some respects you can have both. You can manage these spaces or habitats. I think, unfortunately, where we run into the strongest thing that we face is that people are looking to develop these spaces so you are absolutely right. It's very expensive real estate. People are developing right up to the edge of these dunes. In many instances, they are really pushing us to build out on top of the dunes. It's hard enough to fight that fight at times without having to say "we also want you to manage it for habitat."

CK: When we do a beach and dune management plan, we can only recommend species. Most of the time, each of the clubs or communities will plant the lowest species that they can so that it doesn't interfere with their view. So, if they find out about *Carex*, that it's low and that it makes a low dune, then we're done in! We really don't have any law or anything that says no use of that plant.

SH: Let me give you a little bit of history if I may as to why dunes were turned into shore protection structures as opposed to habitats. Back in the mists of time before the Presidential disaster declarations, etc. dunes were dunes. Dunes weren't part of the management plan. They weren't thought of as structures. But when FEMA came in, after the '84 storm they had a 15-day report requirement in which the Federal agencies and the State sit around a table and discuss what can be done differently in the future. Things like "do not have any more senior citizen buildings in that zone, because there are too many people we have to take out by stretchers before a hurricane in Atlantic City." HUD was there. We wanted dunes to be considered structures because then they would be built and funded. Before that the Corps would come in and beach fill and would not put in dunes. We had to twist their arms to consider funding dunes as structures. A good sized dune will give you more time to get in your

car and get the heck off the island. The idea is to prevent flooding of the only evacuation roads off the island, which are the lowest places on the island. This made sense to them. So, the Army Corps of Engineers agreed to include dunes to be structures and to write their creation into the new regulations so that dunes would be built to protect the evacuations routes.

During those meetings they were passing memos under the table at one another and they wouldn't let me see them. So I reached under the table and grabbed one. It said to Washington: "Don't give them any money for beaches or dunes because we can't prove they were there beforehand. We can't prove how big they were. They have no history." That allowed us (DEP) to send money into Stew Farrell down at Stockton to monitor all our beaches and dunes all along the coast so we would have a baseline for the future. Before that we had no baseline as to what Mantoloking had done in their dunes or what Lavalette had in terms of dunes etc.. So Stew's work provided a baseline for the DEP. He's done his studies for years now and we have continued funding for it. So that if we have a big storm now, we have a baseline of 5, 10 or even 15 years of what that dune and beach looked like before the storm so that we can get funding for beach and dune fills when they are needed. Dunes were literally a four letter word to the Corps before that!

Louise Wootton: Can we go back to Chris's idea of the sea change. Is there anything, anyone in this room can do anything to help move that idea forward? It seems like it would be beneficial for a lot of management issues for that to happen. Not just for invasive species but for a lot of other things. It's important that dunes should be seen as multi-purpose structures that are important for more than just their job as flood protection mechanism. We are saying now is the time, the time is right, what do we do to hit that tipping point?

CD: Time is short. We are under a rule-making process. We are looking at… (SH: You've started it?)…it's under way for the CAFRA Rules, and for the Coastal Zone Management Rules and we are looking at some of these structures, some of these issues in terms of incorporating changes into some of the rules and regulations that would allow us to consider modifications to the dunes for habitat and the like. I know Stephanie Egger from the Fish and Wildlife has been working on some issues. We are accepting public comment. If it is worthwhile and people feel strongly about it to write to the DEP, to the Director of the program, and say, "I think you need to incorporate X into your rules''. I think it's really helpful though, like I said in my talk, that you say 'why'. Why is it important, how it benefits, because, to be honest with you, if you write in and say, "I want you to protect the bunnies," we aren't going to give it much thought but if you write in and say 'You need to protect this rabbit because it has 'X' value to the environment' and things like that, it changes the discussion a little bit. Time is short. We have certain deadlines with where we are going with certain rules.

SH: Do you have a draft that we could look at and augment?

CD: Part of the problem is, once you get into a draft, once you get into public comment process, it's like a train, it's slow but it's moving.

SH: If we follow the comment of what to do, and why, and any references we may have and possibly examples, illustrations are good, and make a case.

Chris Miller (Cape May Plant Materials Center)**:** Just a comment. I've heard Karl Nordstrom has done work on the value added or benefits of dunes. Maybe you can look at some of the work he has done and draw on those resources and draw on that information and maybe that would help you.

Louise Wootton: Karl was away this week. Maybe that is something we can take out of this conference, which would be to drop a line to him and see if maybe we can collaborate on a document that would bring that in and merge with that comment process.

Chris Miller: He gave a talk about 7 years ago and I went up to him afterwards and asked if he was going to take his show on the road. He said that that wasn't really his role because he was a researcher. No one else has really taken that role so it's one of those things that have sort of just dropped.

Barbara Edelhauser (Maser Consulting and GCU Graduate Student): We've been talking and a lot of people have mentioned how important it is to get the public involved. Mike, has your group developed any ways to reach out to the public?

MVC: Yes, we have done a lot of public events. A lot of them are training events but they are geared toward getting members of the public to help volunteer. We're hoping to sort of ramp that up to be a little more outreach. I can tend to be very task-oriented so a lot of our outreach is task oriented in terms of getting volunteers to specific events, but we do want to expand upon that for sure. Everyone knows there is such a gap in public knowledge about invasives.

Louise Wootton: Do you guys want to comment a little bit? There was a comment made yesterday or the day before about how watching laws be made was akin to watching sausage being made. You don't want to see it happening if you were going to consume it later! I was wondering if you had any insights on what is a relative role of the policy, which is sort of the hammer, versus education, outreach, and how do we balance them to have the most effective mix? It seems that we don't want to do everything with a hammer. But at the moment, it seems like we're not doing a good job with education. I'm sure some of you read that story in the newspaper recently that said science is slipping in North America, that people no longer have the awareness or the respect for scientific findings. So in light of the fact that we seem to be doing a poor job with the kind of science education that would prevent the need for policy;

do you have any comments on that kind of antagonism between wanting to educate so that you don't have to regulate versus needing to regulate?

CD: Well, I always think about Ghostbusters and the scene where the EPA guy comes into the courtroom and gets absolutely toasted. It's like a painful memory to me all the time. It's like my point about the grass roots. Because of the way a lot of people in our society see the sanctity of private property, it does become very difficult to do everything via the hammer. In a lot of respects, the other thing is too that personally I think that where we are in terms of government, is about to shift fundamentally. People, especially in NJ, are tired of taxation. They think that they are taxed way too much. They still want services and they still want to have clean streets and safe streets but I think people in NJ are on the cusp of saying, 'You know what, having a good environment is nice but maybe I don't want to fund it to the same degree' or 'You know I'd like to think that I'm a green person but I'm not too concerned of invasive species or the like'. I honestly think that over the next decade, it's going to be increasingly more difficult for state governments and local governments to really start to look at some of these issues because the funding is simply don't going to be there. So, I think in the next decade or so, if you don't look towards other avenues to promote your concerns that they will just fall to the wayside.

CK: Right now, we don't have an active public outreach program. We try to do it on a day to day when we are on the front line reviewing permits. You try to educate the person when they want a bulkhead and you are trying to educate them that they should try other options but we are sort of bound by the regulations so education only goes to a certain point and depends how receptive the person really is.

MVC: There are definitely some examples of that during cases broadly. The St. Louis Declaration, which was a meeting of conservationists and industry. I guess it's over ten years now. It's a nice thought, but when push comes to shove, I don't think it's curbed any production. I would assume that that's the case. I know there is one study but I can't remember all the details but it basically showed that it wasn't really an effective mechanism. One of the things, certainly we have to do the education broadly for having a land ethic which invasive species would fit in to but one of the thoughts that has popped into my mind is that it's just too damn much to ask everyone to be a botanist. People, even the broader scale people, aren't going to become botanists so you basically have to limit their choice. You go to the store and there is no barberry to buy. You don't have to be a botanist to know whether the species you might buy may be invasive or not because the invasive one is not there.

Louise Wootton: Which brings us back to the hammer because the only way that happens is with a hammer.

MVC: It doesn't have to be

Louise Wootton: You think it could be built by consensus without regulation?

SH: We are trying to do that with lawn fertilizers.

Louise Wootton: …ordinances so you are back to regulations on that.

MVC: …for invasive species production through nursery trade? Is that what example you are saying?

Lee Rosenberg: Betsy went to Lowes and Home Depot and just talked to them about the problem and they voluntarily pulled it from their chain. She went to local nurseries and said this is the problem with sea turtles and they voluntarily pulled it.

MVC: She must be extraordinarily gifted speaker. When I heard that I was like, that's totally awesome. That's a fairly uncommon situation. A lot of it depends on how you approach the industry too. If you approach it with your hammer, that's different than saying let's work together here. That's why I'm trying to emphasize the need for a clean list because a lot of ecologists say why are you doing that? Why would you give them the light of day? Because that's fair, that's why. If we think we know what we can call an invasive plant there are some that we know we should call a non-invasive plant. That's not coming at them aggressively with the hammer but its saying, you know what, we got to have a regulation, we got to have a banned list, but let's not do it like jackasses.

Doug Jensen: Mike, I'm interested in getting the reference for the evaluation of the single support.

MVC: I have to look for it.

Doug Jensen: ….if you could send it to me that would be great. My comment is, is that I think it has made a significant change in the attitudes of business and industry. There has been a change in Minnesota with the Minnesota Nursery and Landscape Association and I think I've mentioned this to several people inside conversations, that they are very interested in knowing what species are invasive that they can agree with that they shouldn't be selling, let them know in advance two to three years down the road so that they are not investing significant resources in production and left with a product.

MVC: Absolutely

Doug Jensen: That gives them time to find another product that has the same color and same texture, something that their clients will appreciate that they can then substitute in that is

hopefully less weedy. I think that has made a significant difference, because it acknowledges that they were part of the issue but also the solution.

MVC: In NJ, as the draft stands right now, if a plant is found to be or needs to be prohibited, you have three years to stop production, and if it's barberry, it's five years. There was some of that equity to it; realizing people were in business, trying to make money. You can't just pull the plug and tell them to throw out 10,000 plants they have in their yard. There are right and wrong ways to bring down the hammer so to speak.

SH: Home rule has come up in this discussion at least twice now. For the people who are not from this state, my sense of how home rule works in NJ is municipalities say "Don't tell me what to do, but bring the money down from Trenton, leave it on my desk and don't let the door hit you in the rear on the way out." Until we had these federal regulations and state regulations as in the Coastal Zone Management Rules and others like them, each community could set their own ordinances, so you had a real hodgepodge of lousy things done. For example, Lavallette would just mow down anything that looked like a dune from the boardwalk seaward, and bulldoze the sand right into the ocean at the beginning of the beach year. This is after putting out fences on the top of the berm in the fall to collect the sand. They had the idea that the beach should be flat as a Kansas wheat field! As a result, they lost their boardwalk every time we had a northeast storm, since the ocean came right up under the boardwalk and popped it off. These are what I call "cult practices." There was no regulation against them doing that. Moreover, they perpetuated that practice all up and down the Jersey Shore through conversations amongst public work superintendants. So, until the federal regulations imposed a Coastal Zone Management Plan for NJ, everybody did their own thing and that's what home rule is.

Steve Atzert (US Fish and Wildlife Services): More of a comment than a question. We talk about a clean list. I don't know if anyone has heard of Dr. Doug Tallamy and his book on *Bringing Nature Home*? You want a clean list and some of the benefits from providing native plants and what that does for bird life and butterflies and for all kinds of things. People can be encouraged and made excited about. A lot of people love birds and you need to try and grab their hearts. I think of birds and butterflies with native plants…I've sort of come up with a supplement list based on what he said. If you put invasive out there, you might as well have a plastic tree out there because it's about that good for birds and bees and wildlife.

MVC: That kind of stuff is great! If though outreach you are getting them to buy into that, that's incredible. At the same time, just to give the counterpoint to that, one of the selling points for plants is butterflies, right? That's great. A lot of native plants have butterflies. But one time I couldn't go to a meeting so I sent an intern who mentioned that butterfly bush is potentially an invasive plant in NJ (there are some big colonies in the state). This person was

assaulted by the butterfly enthusiasts, and meanly, which kind of raised the hair on the back of my neck. You are going to pick on the intern? So yeah, you can talk about habitat and butterfly enthusiasts and things like that but I find, and to me it's an ugly truth, that sometimes, when people are enthusiasts, they don't give a hoot about anything else except for the thing they are enthusiastic about. That's why I think we need to ban some plants, because there are people that will be hardcore about the thing they like, regardless of anything else.

SH: That's why bureaucrats get thick skins. On a good day we are public servants, on a bad day we are bureaucrats.

MVC: For NJ, a verbal example is no reference but during the council meeting, the NJ Nursery and Landscape Association put out a list of 15 plants they said were invasive and they suggested to their members they not be grown. During out meetings and cost discussions/negotiations once a month, I'd just point at it and say "Is it working? Did it work?" And I got no response. Of course it didn't work! In this particular case, it didn't work. I mentioned one reference, I think it was from Florida, on the broadest scale, sometimes you just have to force people to do what you think needs to be done. There has to be the hammer. I'm just not a fan of bringing down the hammer in a reckless or mean way.

Jacqueline McCort (Maser Consulting and GCU Grad Student): I was just wondering, I know Chris you had talked about the review of the Coastal Zone Management Rules. Now is a good time to put forth this information. I'm wondering, in general, what the communication needs to be, who do we need to talk to, and, not just for the rules, but in general, because there is outdated information and not everyone has access to the new information. It's been kind of word of mouth and it's a learning process for me over the past five years of consulting, so who do we talk to? Should we inundate you with our emails or is there a specific department we should be going to?

CD: Go to it Colleen! But seriously, that's a good question. The difficulty in answering that is that there is no one person per se. Certainly, if you have a regulatory question, you know the drill because you are a consultant, you go through the general question people and they are going to give you an answer. I think the underlying issue you are trying to bring up is that it is really about communication and these broader issues. I love my staff. They are great people. They are enthusiastic and they care about the environment but they are like anybody else. They get a pamphlet that talks about the value of a certain thing and they say oh this is great and that's all they know because that's all they've ever been exposed to. I don't necessarily know how you start to create that communication flow. Certainly having clearing houses for information is helpful but that's not my role. I'm not going to put in the time or the effort to create clearing houses but as I've gone through my career, I've tried to educate myself along every avenue. Years from now, when I'm the guy that's cleaning the toilets at the state park, I

will learn about that. But it is very difficult when you have people at the state level, and again I love my staff, but they are not botanists. Maybe they have a degree in environmental science, maybe they have a degree in marine biology, maybe like me they are a geographer but you have a broad spectrum of people who bring different elements to it but within my own agency, there is a shortage being able to sort of teach them beyond what we have to do on a day to day basis.

SH: May I make a suggestion? Since this is going to affect rule making perhaps and this adds to the compendium of rule making, I would suggest that you direct any of these reports that we are going make to the Commissioner, whoever he or she may be at this time. What that does, is that it gets received and then delegated to the proper person and usually there is a Deputy Attorney General (DAG) who is also assigned to a rule making procedure and all of that becomes part of the record. I would suggest that if we are going to get it into the right box, that we send it to the Commissioner and say this could possibly impact rule-making of the revision of Coastal Zone Management Rules. Right away that will trigger action, because what happens otherwise is that this stuff gets piled up on the desk, having been there, it gets stacked up on the desk. Most of the time, he or she will write on the top 'somebody answer this.' Then you will get a letter acknowledging receipt. Yes, we will take this into consideration…blah, blah, blah. Then you know they received it. Any kinds of reports, if you want to send an email, OK! But send a hard copy too, because things have a way of fizzling when you send them electronically.

CK: If its information you are trying to get from DEP, there is Land Use and Coastal Management Program. With Land Use, we are bogged down with every new law or regulation that they want to pass. We always implement it but we also have no funds to really go out and do conferences but then Coastal Management, which is headed by Ruth Ehinger, they get to go to a lot of conferences and so they have a lot of information as well so you can try with our program, plus theirs as well.

SH: So if you direct it to the Commissioner, it will be sent to Ruth.

Louise Wootton: What's the timeline, Chris? You said you plan to get it done soon. What does that actually mean?

CD: Realistically, I will tell you by the end of the summer. They are in the process of doing these rules. They were supposed to be all new and in place by now but like everything else, they get pushed off. I think that they are looking at maybe 18 months from now but the rule-making process is a lengthy process. Like I said, once the train starts to move, it's hard to add cars to it. You need to get your thoughts in there as quickly as possible.

CK: Is the proposal out? When is the proposal supposed to be out?

CD: I'm not exactly sure.

SH: Again, it is like making sausage. A little bit of this and a little bit of that. Anything else? Questions?

Louise Wootton: One of the things I'd like to actually ask, not just the panel, but I'd be interested in hearing everyone's opinion on this, especially people from other areas. The young lady from Maine had to leave early, but before she left she told me she is managing a wildlife preserve up in Maine. That was why she was here - because of the invasive species project problems at the Rachel Carson Reserve. And I've heard this from other people who are under pressure from people who have learned from us that chemicals are bad. People have got so caught up in this 'chemicals are bad' thing that they are now not seeing that some things are worse than chemicals. In the Rachel Carson Reserve, for example, no chemicals may be used. I said, 'Not even with a paint brush?' She said, 'No, not even with a paint brush. We won't use a chemical even in that limited of a way.' I don't know if anyone here, the guys from VA and Carolinas and various other people have experience with this and if they have any other insights on this. We don't want to go back and totally undo that message. We certainly don't want people out there pouring Round-Up on their lawns! But, at the same time, maybe we have come to the point now that we have people so over-sensitized to it that they are not hearing that there are other issues that we need to find a balance with that. I know Chris and Mike, you and I have had this conversation specifically with *Carex* because the Coast Guard doesn't like the idea of us using chemicals even though we've explained to them that it's the only effective mechanism for management. We've done such a great job at getting the word out there about chemicals that now we've kind of done ourselves in.

CD: Again, when I look at your particular concern and what you want to do, I also look at the alternatives and as a regulator, we spend an awful amount of time going back to the regulated public if they want to do something and say what are the alternatives. I don't know how you help out somebody like that reserve manager to say if it's in their bylaws or if it's in the deed of the property, how do you get around that sort of thing? To me as a regulator, I'm always interested in seeing what the alternatives are. To me, with the *Carex*, if you come to me and say the alternative is to put a bulldozer on that and rip it all off, I see disadvantages with that.

MVC: Yeah, I don't know of any case-by-case issues but there had been some environmentalists trying to get the State of NJ to ban the use of any kind of herbicides in all state lands and that was a little frightening from my point of view. What I feel is happening in our forest areas, this doesn't apply to dunes really at all, but is your primary alternative to chemical use is deer herd reduction. They are selectively eating native plants preferentially. There are cases where great hunting programs have been put in place, not just to let hunters on the property but to reduce the deer population and native plants are overtopping invasive plants in forests in certain

places. It's an incredible beautiful thing to see but when I think about the biggest scale, we should not need to use herbicides on hundreds and thousands of acres that are infested even if there were resources to do it. We can't unscramble the egg at that large a scale. Deer herd reduction is the key as far as my experience here in NJ. It would significantly reduce our task ahead of us. Nature can unscramble a lot of egg itself. I think there will always be a need for a control without the option of herbicides but deer are so fundamentally tied into this problem.

Les Merhoff (IPANE): Just a couple of comments. I refer to all the guys here from Fish and Wildlife but the Rachel Carson Sanctuary in particular is a specific case because of the name. Other wildlife and fish sanctuaries do use herbicides when it is deemed the wisest and most productive tool. I think a lot of places in New England; I think it is the same. We have some groups that don't have anything to do with herbicides and 'we' are saying OK that's your business, to do what you want to do and we will go ahead and work with others around them in hopes that they will see that we are getting rid of some of these in other areas and on places that aren't using herbicides where nothing is working. One of the things with Rachel Carson that we tried, there are things out there like Japanese barberry which are so out of control, which is a serious problem, but there are other things which are very close to them, we really tried to develop an early detection component for Rachel Carson through the Fish and Wildlife Service so that none of these other things can get established. It's sort of this two-fold thing. People understand for the most part that we have to use them (chemicals) as tools. Those that don't, hopefully will learn.

Ann Faulds (PA Sea Grant): I just wanted to say that, in my mind, persistent herbicides are kind of in a different group from those that are short term that are not going to magnify or persist in the environment for a long time. I can understand people having different opinions about this and when I talk to public about this I try to point out the differences.

Chuck Grisham: A couple of my land owners did not sign their letters because I was putting poisons on their lands and they were afraid it was going to creep into their houses and kill their children and their dog and I did exactly what Les did and said fine, thank you, I appreciate your interest and I went to the other land owners who cleaned it up, and behold at cocktail parties, these holdouts got a ton of peer pressure and they called me back.

Lee Rosenberg: I'm from VA and VA is a commonwealth, so we have to differentiate ourselves. I think that what I've found over my career is that as a regulator, and I've seen it with the Federal, with the Corps, and with the state, is when the state people come in VA, if you don't live there, then you really have no right to talk about what's going on in that community. In some cases that will verify itself, you will have someone coming in and they don't know the community and they don't know the issues, they don't know the history, they don't know who the players are that are there and they come in and put their foot in their mouth and spout the

rules but it doesn't have an effect. I work in Norfolk but for years I worked in Virginia Beach and I go to these communities and we regulate the Chesapeake Bay Preservation Act and Wetlands Protection and the first question is, 'Where do you live in Norfolk?' and I would say 'I don't. I live down in Virginia Beach' and that was enough to say, I lost half my credibility there. When I moved to Norfolk, then all of a sudden it was golden. You have an advantage there where you come in and make the state laws regulated by the local board, so you are kind of an intermediary. For example you might say "I understand you want to build this bulkhead, but our wetlands board is tough on that and living shorelines are the way to go". You kind of deflect and that's what I teach my staff. It's a matter of deflection because if you are "The Man", the Howitzers come around, and are pointed at you. So that's how VA has approached it, and I'm not saying it's perfect, because it's subject to some variability. You are subject to some parochial things that might be different from one jurisdiction to another, but the state retains the oversight.

SH: Thank you all for a very interesting discussion this afternoon! Please follow up with any speakers or participants on specific issues. Again, thanks very much…

Appendix

Conference Attendees and Contact Information

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