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Stabilizing Dunes and Coastal Banks using Vegetation and Bioengineering: Proceedings of a Workshop held at the Woods Hole Oceanographic Institution, Woods Hole, MA

edited by

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Woods Hole Oceanographic Institution
Woods Hole, MA 02543

December 2002

Technical Report

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WHOI Sea Grant

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Cape Cod Cooperative Extension

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The members of the workshop planning committee are also thanked for their time, effort, and assistance in planning and executing this successful workshop:

- Jim O'Connell, WHOI Sea Grant and Cape Cod Cooperative Extension
- Bill Clark, Director, Cape Cod Cooperative Extension
- Bill Burt, Cape Cod Cooperative Extension
- Judy McDowell, Director, WHOI Sea Grant
- Tracey Crago, WHOI Sea Grant
- Sheri DeRosa, WHOI Sea Grant

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Abstract

The primary objective of the workshop and these proceedings is to share with a broader audience the valuable information and extensive dialogue that took place amongst over 100 individuals who attended the third in a series of workshops on the science and management of coastal landforms in Massachusetts. The workshop took place at the Woods Hole Oceanographic Institution (WHOI), Woods Hole, MA on February 28, 2002. The individuals who attended the workshop are actively engaged in planning, managing, regulating, engineering, educating, and studying the interaction of human activities with coastal landforms and coastal processes, particularly erosion control related activities.

This workshop titled, *Stabilizing Dunes and Coastal Banks using Vegetation and Bioengineering*, was a natural follow-up to two previous workshops: *Can Humans and Coastal Landforms Co-exist*, held at WHOI, January 24, 2001 (proceedings published as WHOI Technical Report #WHOI-2001-14), and *Coastal Landform Management in Massachusetts*, held at WHOI October 9-10, 1997 (proceedings published as WHOI Technical Report #WHOI-98-16).

This workshop had a very practical, applied focus, providing state-of-the-art scientific and case history engineering applications of non-structural/bioengineering and coastal vegetation-related erosion control and wildlife habitat enhancement techniques. The history and theory of bioengineering in coastal areas was discussed as well.

Introduction

Jim O'Connell, WHOI Sea Grant and Cape Cod Cooperative Extension

Non-structural coastal erosion control takes many forms. Stabilizing dunes and coastal banks (bluffs) with vegetation and bioengineering is an umbrella that includes many methodologies, along with beach nourishment and structure/dwelling relocation, that would be considered non-structural erosion control. Storm damage reduction and flood and erosion control using coastal vegetation and bioengineering techniques work with coastal processes and coastal systems, and oftentimes enhances the natural coastal environment.

In Massachusetts, there is a preference by state and in many cases local regulators for non-structural erosion control methods over hard, engineered erosion control structures, such as seawalls, revetments and bulkheads. This preference is Massachusetts state environmental policy for the coastal zone. Furthermore, the state Wetlands Protection Regulations prohibit coastal engineering structures, such as revetments, seawalls and bulkheads, on eroding coastal banks that are supplying sediment to downdrift beaches, dunes and barrier beaches that are proposed to protect structures built after the promulgation date of the regulations (August 10, 1978). That is, if the coastal bank is determined to be significant to storm damage prevention and flood control because it supplies sediment to these other resource areas. This is in recognition that the primary source of sediment that feeds Massachusetts' beaches, dunes and barrier beaches comes from the erosion of coastal banks.

Therefore, for many shorefront property owners non-structural erosion control methods, in the form of planting coastal vegetation and bioengineering, is of vital importance, and in some cases the only alternative. Understanding the present state-of-the-art and knowledge of the variety of methodologies and approaches that can result in success or failure of planting coastal vegetation and constructing bioengineering techniques, is of utmost value to homeowners, consultants, regulators, planners, and researchers. This required knowledge includes, for example, appropriate vegetation species and planting densities for site specific application, fertilizing techniques, and the variety of materials and applications available for bioengineering, such as bio-logs, bio-tubes, fiber rolls, jute, coir/coconut or cotton netting, along with anchoring techniques and material selection (synthetic vs. biodegradable).

This workshop brought together 100 plus attendees who actively work in fields directly related to coastal erosion control. Through a series of slide presentations from practicing specialists describing case histories of successes and near successes of projects involving coastal plantings and bioengineering applications, followed by an active open discussion on the efficacy of bioengineering and coastal plantings for erosion control and wildlife habitat enhancement, the state-of-the-art of these techniques in Massachusetts, and elsewhere, was exchanged.

What became obvious as a result of this workshop is that a tremendous variety of applications have proven successful, using different techniques. The performance of many of these techniques, however, is dependent on site-specific conditions. It was clearly acknowledged that 'maintenance' is the key to these applications, the frequency of which depends on local weather and, thus, coastal processes-related conditions. Lastly, it was recognized that these applications, at least in Massachusetts, have not been in place long enough to determine the ultimate effectiveness or typical longevity, although several case histories did reveal this on a limited case by case basis.

Should coastal vegetation be fertilized? If so, what type and at what application? Is burning of beach grass that is thatched and dying an effective method for revitalization? What are some of the reasons for massive beach grass die-off? Are non-structural erosion control methods appropriate in FEMA-mapped Velocity Zones? What coastal vegetation can be used to enhance wildlife habitat? What methodologies can be used to stabilize an over-steepened, severely eroding coastal bank? Do these methodologies really work? Read on!

WELCOME AND WORKSHOP OBJECTIVES

William Clark, Director, Cape Cod Cooperative Extension, Barnstable, MA

MR. CLARK: Good morning. We're still waiting for a number of people to come, but we thought we'd get going so we don't get too far behind schedule. Welcome to the 'Stabilizing Dunes and Coastal Banks using Vegetation and Bioengineering Workshop'.

My name is Bill Clark. I'm the Director of the Barnstable County Office of the UMASS Extension Program, the Cape Cod Cooperative Extension. This workshop is co-sponsored with the Woods Hole Oceanographic Institution Sea Grant Program. Several years ago Barnstable County established a partnership with WHOI Sea Grant so we could better utilize our resources, personnel, and so forth. And this is one of the products of our partnership.

As you might know, Cooperative Extension and Sea Grant are in the education business. We conduct educational programs, research, and provide information on a variety of subjects. In the last few years, we've had a lot of questions, inquiries, about soft solutions to stabilizing coastal banks and dunes. And the questions come from a lot of different directions: Landscapers who are installing plant materials and looking for information on appropriate plant materials; consultants looking for the same type of information when they go to permit a project; as well as town officials and state officials, who are looking at the regulatory aspects of these questions.

So today, we have invited an audience, and it's quite a diverse audience, of those groups. We have green industry officials, landscapers, tree companies, public officials - both town and state - as well as the environmental consultant industry.

So, we should have an opportunity to look at the what, where, why, how, and so forth, of soft solutions, such as vegetation — appropriate vegetation — and bioengineering for stabilizing coastal banks and dunes.

One of the objectives of today's program is providing information. And we've invited several speakers who are considered expert in this field to give you information on vegetation, as well as bioengineering solutions.

We also want to look at the practical approach, and we're going to have several speakers on case studies, so that you'll see, again, the what, where, why, and how, and what has worked and what may not have worked.

And finally, we want to offer a forum, or an opportunity for you all to ask questions, discuss these issues, and that will come at the end. And again, with this diverse audience, I think we should have a lively discussion.

So, I hope you enjoy the day. I'm sure you'll find it informative.

I'd like to now introduce Jim O'Connell. Jim is a coastal geologist. He's the coastal processes specialist with both WHOI Sea Grant and Cape Cod Cooperative Extension, one of the products of our partnership. Prior to working with Sea Grant, he worked with the Cape Cod Commission, and prior to that, he worked thirteen years with the Massachusetts Coastal Zone Management office as their coastal geologist.

Jim actually orchestrated today's meeting. In addition to his introductory program, he'll serve as today's moderator.

Thanks, Jim.

THE CHALLENGE OF STABLILIZING COASTAL LANDFORMS USING BIOENGINEERING TECHNIQUES: DOES IT REALLY WORK?

Jim O'Connell, Coastal Processes Specialist, Woods Hole Oceanographic Institution Sea Grant Program and Cape Cod Cooperative Extension

MR. O'CONNELL: Thank you, Bill. And a hearty welcome from Judy McDowell, the Director of the Woods Hole Sea Grant Program, who will be joining us a little bit later.

Welcome, and welcome once again to a lot of you. This is the third in a series of coastal workshops held here at WHOI, this one being sponsored by Cape Cod Cooperative Extension and Sea Grant. The workshops have been designed around sharing our understanding of the function of coastal landforms, and using all our collective experiences discussing how we can attain that delicate balance between allowing the beneficial functions of coastal landforms to continue while also allowing people to develop and enjoy their coastal properties, particularly waterfront properties.

The first workshop, in October of 1997, was titled "Coastal Landform Management in Massachusetts". At that workshop, we were trying to answer the question, 'how well are we doing in terms of managing our coastal landforms and maintaining their sustainability or beneficial functions?' We discussed issues related to open ocean or high-energy shorelines, issues related to inner shorelines or estuary and bay shorelines, and also issues related to altered or heavily developed shorelines. In attempting to answer the question, 'how well are we doing', one of the outcomes of the workshop was that most of the participants felt we were doing a pretty decent job of managing coastal landforms and in attempting to attain that balance. But what we realized was that our information was all anecdotal. There was really no quantifiable evidence to conclusively say how well we were or were not doing in managing our coastal landforms and maintaining their beneficial functions.

So what came out of that workshop was a WHOI Sea Grant coordinated project called the Coastal Landform Systems Sustainability Project, which was initiated by Dr. Graham Giese who was in my position here at Sea Grant at the time. I subsequently expanded the project and worked with the Conservation Commission Agents and the Conservation Administrators in all fifteen towns on Cape Cod. We reviewed, catalogued, and rated all proposed activities that received Orders of Conditions for activities on or adjacent to coastal landforms in the fifteen communities on Cape Cod for the entire year of 1999. In total we analyzed 319 projects. The result of that study suggested, in part, that we were not maintaining the beneficial functions of our coastal landforms in the way we were presently managing and regulating them.

Now, that statement, to me, is really not a stand-alone statement, because the study was done principally based on the science or the technical basis of the way coastal landforms function. I think we all recognize that in reality, we must make appropriate decisions based on science. However, in the real world, I think we also oftentimes factor in economics, societal will, and the rights of private property owners to develop and allow reasonable use of their waterfront properties.

So given that the study suggested we were not maintaining the beneficial functions of these coastal landforms, we orchestrated a second workshop titled, "Can Humans and Coastal Landforms Co-exist?" The proceedings for that workshop were just recently mailed out to the attendees and participants and are available from WHOI Sea Grant.

I thought it was a tremendously successful workshop. There was a lot of valuable information exchanged, and through the proceedings that information exchange was documented. But at the end of the day, and in numerous discussions after that workshop, I continued to ask people their opinions, 'can humans and coastal landforms co-exist?' And there was never an outright yes or no answer. There were always qualifiers. Well, yes, they can co-exist if when we build a house in dunes we elevate it on pilings. Or, we can live with coastal landforms if after revetment or seawall construction we compensate for the material that would have eroded out of the coastal bank by bringing in material from an outside source and putting it on the beach. So, there are always qualifiers. It's not a simple yes or no answer.

So now here we are today. I think realistically we know that people are going to continue to live along the shore. And in my experience, they're going to live as close to the water as they can possibly get. And I don't blame them because it's so beautiful ninety-nine percent of the time. Rob Thieler and Courtney Schupp from the USGS here in Woods Hole, and myself through the WHOI Sea Grant Program and Cooperative Extension, recently completed an update and statistical analysis of the state's shoreline change data. The results of that update and analysis of shoreline change data, funded by the CZM office, revealed that about two-thirds of Massachusetts' ocean-facing shore is eroding. So now we have people who are going to continue to live along the shore, and they're going to live close to the water. We know that about two-thirds of the shoreline is exhibiting a long-term erosional trend. And we know now, following discussions at that previous workshop, that we have to factor in the term "mobility of coastal landforms" in our planning. In other words, in order to maintain the beneficial functions of coastal landforms, we've got to allow them to move and migrate, to erode, and to reshape in response to winds, waves, tides, and sea level rise.

If the international panel on climate change predictions are correct, and we end up with almost a two-foot rise in sea level within the next fifty to one hundred years, then those erosion issues faced by waterfront property owners are only going to be exacerbated.

So here we are today at a workshop titled 'Stabilizing Dunes and Coastal Banks Using Bioengineering and Coastal Plants'.

Well, my perception is that I think using bioengineering and plants for erosion control is a good compromise, in attempting to achieve that delicate balance that I had mentioned. But does bioengineering and coastal plants for erosion control really work? I hope by the end of this workshop we can answer that question.

Fig 1. Innovative non-structural erosion control methodology on a coastal bank: A matrix of hay bales

(Slide Presentation)

MR. O'CONNELL: In Massachusetts, I think it's particularly challenging for bioengineering and coastal plants to stabilize coastal landforms. We have hundreds of miles of coastal banks, anywhere from a couple of feet up to well over a hundred feet. And there have been a wide variety of coastal landform erosion control systems tried on many of these landforms, such as we see here today along the bluffs of Plymouth (**Figure 1**).

Many of these erosion control projects have had varying degrees of success, such as we see here in the bluffs of Wellfleet where sand fencing and vegetation were used (**Figure 2**). Further down the coast in Wellfleet, we see a combination of coastal plants and sand fencing apparently stabilizing the bluff (**Figure 3**). Again, each has varying degrees of success.

My experience, going back to the real estate industry's famous quote "location, location, location", is that erosion control using bioengineering and coastal plants appear to work in certain environments — more specifically under certain environmental conditions, and not in others (**Figure 4**). What I mean by 'do they work' is, is it cost effective in meeting the primary goal of erosion control; does it have minimal adverse impacts to other resourc-

Fig 2. Partially successful non-structural erosion control on a coastal bank

Fig 3. Erosion control using sand fencing and vegetation on a coastal bank

Fig 4. Failed erosion control on a coastal bank in a high wave energy environment

Fig 5. Bio-engineering (bio-logs and vegetation) in a low-wave energy environment

Fig 6. End scour on flanking erosion around bio-logs

es and property; and, hopefully enhances other environmental factors, such as wildlife habitat.

Massachusetts has 681 barrier beaches resulting in numerous estuarine and bay areas. Perhaps these techniques will work more successfully in these low to moderate wave energy environments (**Figure 5**), as opposed to high wave energy environments. So I ask myself, and I ask the audience here, and hopefully we can discuss this throughout the day, should we be installing bioengineering and coastal plants for erosion control in high-energy areas, such as velocity zones or areas subject to high wave activity? They certainly appear to have less of an environmental impact.

But I think it really depends on what your expectations are for the project. I hope that's something we discuss in detail today.

I have a couple of questions that I'd like to throw out, and hopefully we can discuss and have these addressed throughout the day.

Have we successfully come up with engineering solutions to flanking erosion or end scour (**Figure 6**), not only using bioengineering but also typical coastal engineering structures?

Fig 7. Coastal bank erosion control using bioengineering (bio-logs, jute netting, plants) and a system for watering and fertilizing

Should we fertilize coastal plants in these

Fig. 8: Well designed bioengineering for coastal bank erosion control

areas? If yes, how often, and with what?

The diversity of appropriate types of plants for different areas is something we'll cover today — but should we water these coastal plants (**Figure 7**)? And if so, how often? And, if so, what techniques can we use to get the water down these high bluff sites without de-stabilizing the banks?

I'm particularly interested in the economics of bioengineering and coastal plantings for erosion control. I think that's probably the area most lacking — what are the economics? If they're cost-effective, and we know for the most part they are environmentally acceptable, then certainly this would be the preferred way to go because it is, as I mentioned, a good compromise between landform sustainability and protection of property.

But is it cost-effective? I show this picture because this appears to be a well-constructed application of bioengineering **(Figure 8)**. But when we're in the field after construction of many of these projects I ask project engineers and consultants how much the project cost, and oftentimes they don't know the complete costs, or can't answer at the time, simply saying—expensive. So, I'm hoping we can delve into costs.

So today we'll begin exploring the diversity of the types of coastal plants used for stabilization in different coastal environments. Then we'll launch into different bioengineering techniques, including the history, theory, the actual process and application of bioengineering. After the break, we'll have a series of case studies presented that address coastal planting on dunes and barrier beaches, and then case studies on how to stabilize coastal banks using bioengineering and coastal planting techniques.

So with that I'd like to introduce the first speaker.

CHOOSING APPROPRIATE PLANTS FOR COASTAL STABILIZATION

Roberta Clark, Extension Educator, Cape Cod Cooperative Extension

MR. O'CONNELL: Our first speaker is Roberta Clark. Roberta has been with the Cape Cod Cooperative Extension since 1980 as a horticulturist. She primarily focuses on plant materials. She has a BS in plant and soil science, and an MS in entomology and plant pathology, both from the University of Rhode Island. She's going to talk about criteria for determining invasive qualities of plants.

MS. CLARK: I'm not going to talk about specific plants this morning. Those of you who have heard me speak before know I usually show up with at least three carousels of slides of nifty plants. I'm going to leave that to the other folks that are talking today.

Before I start, Bill talked about a diversity of audience, and I'd just sort of like to get an idea of what the composition is here. How many of you are involved in green industry and landscaping? A fair amount.

How about consultants? Okay.

How about public officials? Conservation commissions? All right. So it's a pretty even mix.

In some capacity, each one of you is involved in determining what plants are going in these sensitive areas. Some obvious criteria come to mind. These have to be tough plants for tough situations. They need to be tolerant of the coastal environment, the salt, the droughty soils. They also need to have the ability to become established fairly quickly either through seed dispersion or good strong root systems, et cetera. Many of these qualities that make them good plants for this type of a location may also make them invasive.

There is a big debate in horticulture today on what is an invasive plant, and why are they a problem. Well, they can be considered a problem because they create monocultures that are generally at the expense of more complex ecosystems. There are a whole lot of ramifications that come out of this.

But, what actually makes a plant an invasive plant? There are a lot of subjective opinions on this. We all may have our ideas about certain plants. I'll just use Rugosa Rose as an example. The invasive plant debate also seems to fall into native versus introduced plants: if it's not a native plant, then it must be one of those awful, exotic, invasive introduced plants. I think the issue of science needs to be brought into this debate. Not every plant that goes into a particular locale, be it native or introduced, is going to be invasive. There has to be criteria by which these plants can be evaluated in order to determine whether or not they are invasive.

Many native plants actually have a fairly narrow range of environmental tolerances. They may not be appropriate for certain situations, where an introduced plant may have great qualities that would lend itself to that particular location. Again, Rugosa Rose. This is a plant that you find traditionally used along coastal landscapes. It works extremely well in holding together soil.

It offers the landowner an opportunity to have some aesthetics, beautiful bloom, nice red rose hips. Good, nice plant. Not native. Is it invasive? Well, we have to subject it to a list of criteria in order to determine that, and I think the end result will show that it's not invasive.

I'd just like to share with you how plants are being looked at.

There is a group in Massachusetts known as the Massachusetts Invasive Plant Committee. They've been meeting for quite some time, working very closely with groups in other states to come up with criteria that will scientifically establish whether or not an individual plant or an individual species can be considered invasive. It has to be based on actual science, not on someone's, "I hate that plant, it's introduced." Just for an example, I don't like Norway maple, and a lot of people will say well, Norway maple is very invasive, and indeed in some areas of the country it has shown the potential for becoming established in areas far away from where it's actually introduced. So, if it is subjected eventually to these criteria, it may eventually be determined to be invasive.

There are a number of criteria for including a species as non-native invasive or potentially invasive in Massachusetts (**Figure 9**). This draft was finalized on February 12th of this year, so this is the most recent issue, and the plant list that I've given you are the first thirty plants that are being subjected to this (**Figure 10**). You'll see there are landscape plants that are commonly planted on this list, Japanese barberry, for example, so there are some things to look at here.

If it's going to be considered invasive, it must meet criteria one through nine (**Figure 9**). If it is likely to be invasive, it must meet one through five, and at least one of ten through twelve. I'll just briefly go through these because we're on sort of a time frame here.

Non-indigenous to Massachusetts. Well, that's obvious, you know, but does that mean did it come from Europe, did it come from Asia, did it come from some other part of Massachusetts? So there's a lot of debate on just what constitutes a native plant. If you look at that list (**Figure 10**), you'll see Black Locust is on it. Now, this is not native to Cape Cod, but it is native to the mid-Atlantic region of this country. Some people will say, well, if it's native, it's not invasive, it's just aggressive, and so we get into a question of semantics. If it's going to be invasive, it will meet these criteria whether or not it comes from our own country or whether it comes from Europe or Asia.

Naturalized in Massachusetts. Black Locust could be considered naturalized on Cape Cod. If you go down to Eastham, you'll find lots of Black Locust. But do you find Rugosa Rose naturalized on Cape Cod? Not really. Okay? Think about it.

It has to have the biological potential for rapid and wide-spread dispersion and establishment in minimally-managed areas.

It would have the biologic potential for dispersing over spatial gaps, and I find this one to be critical. You're going to find a plant that is invasive in areas away from its point of planting. I've been growing Rugosa Rose in my own yard for a number of years. I probably have a lot better conditions in my yard than on a coastal bank, and the Rugosa Rose has spread out from suckers. It's a huge plant, but I'm not finding it anywhere else in my yard, nor am I finding it in the surrounding yards or the minimally managed vacant lot next door to me. And this is not even considered spatial gap. So it's not dispersing over long distances.

An invasive plant would have the biological potential for existing in high numbers away from intensively managed artificial habitats. Landscapes are artificial habitats, you know. It would be hard to go to anywhere in areas of development and find places that aren't disturbed by human interaction.

Further, to be included as a non-native invasive species, it must be documented to be widespread in Massachusetts or at least common in a region in the state.

It should have numerous individuals in many occurrences in the state... and this is important, ...be able to out-compete other species in the same natural plant community.

Have the potential for rapid growth, high seed, or propagule production and dissemination. I think if we look for a number of invasive plants that are here on the Cape, things like Autumn Olive, the Bush Honeysuckles, Multiflora rose, these obviously have fruit that are attractive to wildlife and are dispersed and disseminated over very wide areas. They have a high biological potential for distribution.

If a species meets the five criteria but does not at this time meet criteria six through nine, it may be considered to be likely, not definitely, invasive. And if it meets one of the following three criteria, then it is also on that list of potential candidates.

One occurrence in Massachusetts with high numbers of individuals forming dense stands. I think a landscape plant that falls into this category would be Japanese Barberry. In areas not necessarily on Cape Cod, but in other areas of Massachusetts, you'll find very high stands, dense stands of Japanese Barberry occurring as an understory in minimally managed areas, out competing much of the local vegetation.

It should have the potential, based on its biology in the northeast and elsewhere, to become invasive. We see plants that are in other states that are on invasive lists that have not yet shown up in Massachusetts, but based on their history in similar areas in the northeast, could be considered likely to be invasive, should they show up in Massachusetts. A good example of this is the weed called Mile-a-Minute, which was in Connecticut, has now been identified in Rhode Island, and has the potential to become very invasive in Massachusetts. So it would be on a likely to become invasive status — and it should be acknowledged to be invasive in nearby states, as in Connecticut.

So I think if you look at these criteria, and you look at the types of plants that we might subjectively consider to be invasive, they don't always match. I think we need to put plants, both native and introduced, through this evaluation process before we label them one way or the other. But I think it is important for plants to be looked at in this regard.

As I said, if you want a copy of this, I have them at my office. I'd be happy to pass them out to you if you want to give me a call. And that's all I have to say this morning.

Thank you.

MR. O'CONNELL: Your phone number?

MS. CLARK: 508-375-6692.

MR. O'CONNELL: You know you'll be getting at least one call.

Criteria for Including a Species as a Non-native Invasive Species or a Potentially Invasive Species in Massachusetts

These criteria were developed in order to objectively list vascular plant species* that are invading minimally managed habitats. They were developed by the George Stafford Torrey Herbarium at the University of Connecticut and modified by the Definition and Criteria subcommittee of the Massachusetts Invasive Plant Committee. This last group includes representatives from the Nursery Industry. They have been reviewed by many scientists, conservation professionals and nursery representatives. Additional input came from the Connecticut Invasive Plant Working Group, State Geological and Natural History Survey of Connecticut and the Connecticut Biodiversity Forum.

Tabular summary of how the criteria work:

To be considered	Criteria that must be met
Invasive	1-9
Likely Invasive	1-5, at least 1 of 10-12

The Criteria:

For a species to be included as a Non-native Invasive species or as a Non-native Likely invasive species in Massachusetts, it must be substantiated by scientific investigation (including herbarium specimens, peer-reviewed papers, published records and other data available for public review) to be:

1. Non-indigenous to Massachusetts.
2. Naturalized in Massachusetts.
3. Have the biologic potential for rapid and widespread dispersion and establishment in minimally managed areas.
4. Have the biologic potential for dispersing over special gaps away from the site of introduction.
5. Have the biological potential for existing in high numbers away from intensively managed artificial habitats.

Fig 9. Criteria for including a species as non-invasive or invasive in Massachusetts (Part 1)

Further, to be included as a Non-native Invasive species, a species must be documented to:

6. Be widespread in Massachusetts, or at least common in a region or habitat type(s) in the state.
7. Have numerous individuals in many occurrences in Massachusetts.
8. Be able to out-compete other species in the same natural plant community.
9. Have the potential for rapid growth, high seed or propagule production and dissemination, and establishment in natural plant communities in Massachusetts.

If a species meets the initial 5 criteria but does not, at this time, meet Criteria 6 – 9 (all), it may be considered to be a Likely Invasive Species in Massachusetts if it meet at least one of Criteria 10 – 12. In the past, some of these species have been considered invasive in Massachusetts, at least in part because they are known to be invasive in other regions and thus expected to be so here.

10. Have at least one occurrence in Massachusetts with high numbers of individuals forming dense strands in minimally managed habitats.
11. Have the potential, based on its biology and its colonization history in the northeast and elsewhere, to become invasive in Massachusetts.
12. Be acknowledged to be invasive in nearby states but its status in Massachusetts is unknown or unclear. This may result from a lack of field experience with the species or from difficulty in species determination or taxonomy.

*Species as used here includes all subspecies, variety, forms, cultivars, and synonyms unless otherwise noted.

Fig 9. Criteria for including a species as non-invasive or invasive in Massachusetts (Part 2)

FIRST REVIEW LIST FOR MASSACHUSETTS PLANT EVALUATION SUBCOMMITTEE

Scientific Name	Common Name
Aegopodium podagraria	Goutweed
Ailanthus altissima	Tree-of-heaven
Alliaria petiolata	Garlic-mustard
Berberis thunbergii	Japanese barberry
Calomba caroliniana	Fanwort
Celastrus orbiculata	Oriental bittersweet
Centaurea biebersteinii	Spotted Knapweed
Cynanchum louiseae	Black swallow-wort
Eleagnus umbellata	Autumn olive
Epilobium hirsutum	Hairy willow-weed
Euphorbia cyparissias	Cypress spurge
Glaucium flavum	Sea- or horned-poppy
Iris pseudacorus	Yellow iris
Lonicera japonica	Japanese honeysuckle
Lonicera morrowii	Morrow's honeysuckle
Lonicera x bella	Honeysuckle hybrid (*morrowii x* Tatarian)
Lysimachia nummularia	Moneywort
Lythrum salicaria	Purple loosestrife
Myosotis scopioides	True forget-me-not
Myriophyllum heterophyllum	Variable waterfoil
Myriophyllum spicatum	European waterfoil
Najas minor	Lesser naiad
Phragmites australis	Common reed
Polygonum cuspidatum	Japanese knotweed
Ranunculus repens	Creeping buttercup
Rhamnus cathartica	Common buckthorn
Rhamnus frangula	Glossy buckthorn
Robinia pseudoacacia	Black locust
Rorippa nasturtium-aquaticum	Watercress
Rosa multiflora	Multiflora rose
Potemogeton crispus	Curley pondweed
Trapa natans	Water chestnut
Tussilago farfara	Coltsfoot

Fig 10. First Review List for Massachusetts Plant Evaluation Sub-committee

VEGETATION ADAPTED TO MASSACHUSETTS COASTAL CONDITIONS FOR DUNES AND COASTAL BANKS

William Skaradek, Director, U.S.D.A., Plant Materials Center, Cape May, N.J.

MR. O'CONNELL: I'd now like to introduce Bill Skaradek.

Bill has been the Director of the USDA Cape May Plant Materials Center in New Jersey for the past eight years. He was assistant director for USDA Natural Resource Conservation Service, National Plant Materials Center for four years, and was a soil conservation land use planner in the Natural Resource Conservation Service Field Office for three years. He was also in private practice as a land use planner for two years.

Bill is first going to share a little information about the plant materials program that he directs, and then talk about management insights into American beach grass and about the diversity of plants, particularly what type of plants can be used in conjunction with beach grass for performance and diversification for the stabilization of dunes and banks.

MR. SKARADEK: Bill Clark said he invited experts here. When I realized he was referring to me, I got rather nervous. One thing I've learned is the more you learn, you realize the more you don't know. So I never call myself an expert. I'm always a student.

Originally my counterpart, Chris Miller was going to be here and talk specifically about bioengineering applications on some of these high bluffs. My experiences have been more directed to the stabilization of beach fill projects and natural beach processes, although I've had a lot of exposure to bioengineering.

Jim and I went out yesterday and saw a couple of sites. He felt I had some input into the bioengineering concepts, so in the slide show — what I'm going to do, is to present some topics that I feel qualified on. I just want to give a quick limited background on the facility first, then I'm going to go through some beach processes that for some of you will be very rudimentary, if not boring, but for some of you it will be informative because it's watered down to a very understandable level. And by working through that, you're going to get a better understanding for when I tell you that beach grass is not meant to be used in bio-logs and in the application it's being used in. You're going to understand why now. So let me just work right through that. I'm ready for the slide projector.

MR. SKARADEK: We get lots of calls from the National Park Service. All kinds of people have been calling us to come out and look at beach grass die-out problems. Of course, they're standing in a field wondering what happened. And so we get out there to these million dollar beach restoration projects, this being a road that wants to be protected by this artificial berm. The beach grass is all dead. And this is just three years after the project was installed. And when I come back to this slide at the end, you're going to know why it's all dead.

This is a site up here, Cape Cod National Park Service, where they planted beach grass on dunes, and it's all dead within two years. I've been to a hundred of these sites. My service area runs from Cape Cod all the way down to Wilmington, North Carolina. So I'm covering 1200 miles of shoreline. And I've been to over a hundred of these locations. This is down in Cape May Point. This is the city, Cape May, the Promenade. This is at the state park. It's all dead. And that's our tax dollars. So I have a concern with our tax dollars being used in that manner.

The USDA Natural Resources Conservation Service, which used to be the Soil Conservation Service, maintains a facility. We actually have a network of twenty-six plant materials centers strategically located throughout the United States. The Cape May Plant Materials Center has a service area, like I said, that runs from Massachusetts right down to North Carolina. So it's a pretty big dinner plate if you will.

We have an eighty-eight acre research facility. Our buildings are up here. And then we have these eighty-eight acres here. This would be the Garden State Parkway, heading down towards Cape May. Tidal marsh here, and then the barrier islands are sitting out here. And it's a really nice facility for doing the type of work that we need to do.

We got our birth after the 1962 Ash Wednesday Storm that wiped out the shoreline, and basically just devastated a lot of infrastructure. And over the years, we've looked at things like the aerodynamics of the dune systems, sand distribution dynamics. We also looked at uncontrolled pedestrian traffic dissecting the vegetation. And we came up with — and after many years of research, we developed and cultivated Cape American Beach Grass, which is primarily what a lot of you are using. And you might be concerned about the performance, so I'm going to tell you its really application not performance that's causing your problems.

So using our materials, and many municipalities are using the power of volunteerism, we've gone in and we've created the technologies for creating densely vegetated healthy dunes to protect valuable infrastructure and also to help generate tourist dollars. In the five coastal counties of New Jersey alone, twenty-seven billion dollars is spent in the fourteen-week summer season. And I'm sure it might be even more up here. But there's a lot of money in the beaches.

And it's also for wildlife habitat, so let's not forget that all these things co-exist together.

The whole beach process starts here. When you get a healthy beach, where you're getting some sand coming into a system, the sand might be coming in because it's eroding somewhere else, but that's part of a dynamic system, if you will. Erosion is necessary for accretion in another place under natural processes. But anything on that beach will accrete sand.

Now, I'm not an engineer, and I don't aspire to ever be one, but I know that when the wind passes through and it hits an obstacle that slows its velocity down, its ability to suspend sand particles is decreased. And you get the sand fallout, not only here where the wind ran into it, but also behind it. And that can also be seen with the effects of vegetation. Cape American Beach Grass, or any *Ammophila*, is not one leaf of grass. If you actually look at the leaf, it's like looking at the end of a phone book with a bunch of multiple leaflets. So the friction co-efficient of this plant is very high. So as the wind passes through it, it will create a sand shadow behind it, and make a lot sand fall out of the wind system.

And here, this shows a good shot on the aerodynamics of how the sand is passing through and then falling out and creating these massive fall-out areas.

Using these principles, over time, snow fencing was designed for spacing and everything else. So as the wind passes through, you get the sand accreting in here.

A lot of people will look and say, wow, look at that healthy beach. And actually, there could be a beach problem in the making, and this is one of the reasons why I'm here.

What's happened is Cape American Beach Grass, or any *Ammophila* beach grass, physiologically evolved in an accretion scenario only. That's where it thrives, is where it's being dumped on. And notice what's happening here. This snow fence, see these posts here that are buried? That was buried in three months. By the fifth month, they put up another row because there's so much sand naturally coming into the system. Now, five months prior to this, this was the foredune. Or actually, it was the season before this. This was the foredune. This was covered in healthy beach grass.

But because we've artificially pulled the zone of accretion forward, at an unnatural rate, the beach grass is going into decline because the nutrients that would be on the soil particles that would be coming in from the ocean that would normally fertilize this and bury the thatch which can harbor pathogens that leads to its demise, it's not being buried, the thatch builds up, creates a harbor, the material isn't vigorous anymore because it's not being stimulated, and so it starts to die. And these are the reasons why the beach grass doesn't work on the bio-logs with some of these bluffs. There's no sand coming in to bury it. And I'll show you a couple more shots on that.

This looks like a healthy ecosystem. It's not. When you look into this stuff, you'll see a real thick thatch development around that healthy beach grass. This is in the City of Cape May. The Arcade.

They called me up and they said, Bill, we have to do something about this, all the beach grass is dying. And I said, well, set it on fire. And they said, are you crazy? I said, well, that's beside the point, yes, but set it on fire anyway. They said why? I said, well, you're going to burn out the pathogens. You're going to burn off the thatch, you're going to open up that stand and allow the sunlight to come in, so that you can put other plant species in there that are better adapted to no accretion scenarios. So they did. They went into the site here. They burned it off. And there was very little vegetation growing in there. And you can start to see now the ones that are alive, some of the new growth is coming back from the root reserves. But then you'll see these rows, right here, where we seeded in Atlantic Coastal Panic Grass. And that material is taking off.

The other thing we're seeing on beach grass — they had just got done installing this beach grass. The technical recommendations say to put it twelve inches down, eight to twelve inches. They put it in two inches. And then they're going to call me back next year and say, hey, it all died, why. Didn't you read the sheets? Well, that's why. So they're spending a lot of money on these types of activities, not only putting it in a place where it doesn't physiologically thrive, but also in a manner that it won't survive, which is improper depth placement.

So that when you go back now to that original site at Cape May at Sandy Hook in upper New Jersey, you can see that these are a couple of diagnostic features I want to leave you with — whether or not you've got a system that's going to accrete sand. Is your snow fence empty or full? That snow fence is two years old. I showed you a snow fence three months old that was filled. And the beach grass was healthy. There is no sand coming in here. None. So if there's no sand coming in here, what's going to be the stimulus for healthy beach grass sand? There isn't any.

So, in fact, I want to even take this a little bit further. Has anybody ever been involved in beach replenishment activities or beach fill projects? Okay. So you're going to know what I'm talking about. The reason you do a beach fill project is because you have erosion. You're in a segment of the beach that is not receiving sand — it's losing sand. And just because you hired a dredge to pump it up there, doesn't mean that everything's fine and dandy now, because you're still in an erosionary zone.

Now, I'm going to be working with the U.S. Army Corps of Engineers to change the technical standards and specifications for the re-vegetation of these beach fill projects because right now it just specs out beach grass, a pioneer accretion plant on a non-accreting site. And then everybody up and down the coastline calls me back exactly two to three years later and says, it all died, why? And this is why — because it's not the system for the plant.

I'm going to show you a couple other plants that can be used. Of course, this just shows the other diagnostic feature. Other than the fact that you didn't get sand in the snow fence was that when you put that beach grass in, did it kind of just stay there like a vase shape? You didn't see all the rhizomes coming up, where the fresh toe was coming up. Did you get a lot of thatch buildup around a plant? In a healthy stand, you'll never see all this thatch. It'll be buried by new sand. So these are all the diagnostic indicators that you're going to look at: snow fence activity, and then the presence of thatch, and then the presence of rhizomes.

This is Avalon, New Jersey, like up here, intensively developed. But it had areas of high dunes, where they've kind of maintained a lot of the vegetation. This kind of shows you some of the processes of a complete dune ecosystem, or as complete as you're going to find down there anyway. Where you have the maritime forest in the background, the controls come through, and then you break down into this scattered shrub stand, then a mixed grass stand. And then you'll notice right out in here, along the foremost line, see how green, lush green some of the vegetation is right here? That's the American Beach Grass, the *Ammophila breviligulata*, which is receiving sands coming in and is stimulating new growth. And then right behind it you're getting these patches of beach grass die-out because the sand's coming in here now. And then, of course, other things are coming in.

Another shot as we hovered down a little bit closer, showing that real green strip of beach grass up front, the area where it was starting to die out and other species of grass is coming in.

One of the recommendations I want to leave you, if you want recommendations on good plants to use to diversify the plant communities as you plant these bluffs, go out to some of your natural areas in the local landscape, and take an inventory of what's there. Other than the invasives that have come into the unmanaged areas, take an inventory of what's naturally occurring there. What are the big patriarchs that have stood the test of time from storm damages and salt, and just the wear and tear of the climate, and just take a look real close at what's up and down through those sections.

Now, here's a plant, it's called *Panicum amarum* which is Coastal Panic Grass. In our facility, by the way, we developed the patented lines Cape American Beach Grass, and Atlantic Coastal Panic Grass, and Beach Plums and Bayberries and Goldenrods and everything else for these applications.

Again, it shows a nice big vase shape, this is a C4 warm season grass. It tolerates drought, infertile conditions, hot, dry conditions. When Jim and I went out yesterday, we looked at a bluff. How high would you say that one bluff was that we talked about, the first site?

MR. O'CONNELL: Between thirty and forty feet.

MR. SKARADEK: Forty foot? We talked about the slope that still had erosion on it and the fact that there wasn't enough vegetative cover on it, and perhaps looking at the length of slope from the universal soil loss equation standpoint, decreasing the length of slope by putting in vegetative terraces. Now, I don't mean coming through with equipment and cutting a terrace, but putting up grassed-hedged terraces every fifteen feet or so, whatever the Russell equation says is the best thing to do. But this is the type of material you want to plant, a warm season grass that grows in fertile conditions. High stem density. You plant a solid wall of this stuff along that bluff, and as water moves down, it hits that stemmy front, if you will, it slows it down, sediments fall out, and you actually start building a little terrace there naturally.

This is a cedar that's very low tech. If you have a small job along some of these bluffs, you can use an Agway push seeder to actually seed in *Panicum Amarum*. It's one of the only ones that we have right now that you can direct seed into the dune — you don't have to get vegetative plugs which is expensive.

This was a site down in Delaware. We went into the back dune. And because this was an area that generally speaking wasn't receiving a lot of sand, there was some areas that we had blow-over that came in and buried some of the seedlings and they broke their neck trying to get up out of the soil. But generally speaking, it really results in a good stand in a hot and fertile dry site.

Another plant you might want to look at in some of these sites is *Spezachorium sp.* which is coastal little bluestem. And that's a material that's native to the ecosystem. It provides function in terms of erosion control and diversification of plant communities, and it's a pretty plant to boot. Catch it on a nice sunset evening, with the sun coming through there.

And this is another plant, it's called *Elymus virginicus*, which is Virginia wild rye. I'm not sure, Roberta, do you have that up here that much?

MS. CLARK: I haven't seen a lot of it.

MR. SKARADEK: Have not seen a lot of it, okay.

We have a lot of this from Long Island right down through the Carolinas. So I'm not sure how much, if any, you see up here.

That's more like what it looks like. It looks like rye. It's called wild rye. And this is a material that actually is a cool season grass. And if you have some of your areas where wildlife component is a thought, this adds a nice greenish forage in the winter months, so you diversify the feed value for any of the rabbits or whatever else you might be targeting for a wildlife habitat standpoint.

Solidago sempervirens, which is a seaside goldenrod. We have a material coming out of our facility called Monarch, named after the butterfly. It's a major food source in the winter for migrating Monarch butterflies. It helps, again, to not only diversify the plant community, the function of the ecosystem, but also has an aesthetic value as well. I doubt very many people would have a problem with something that beautiful, particularly when you get it covered in Monarchs, two, three hundred Monarchs on a couple of plants.

Another plant to consider is *Ebolis strophostyles sp*, I get the two mixed-up. Some plants are noted by scientific names, some of them are noted by common names, and I always get this one kind of flipped around, but its trailing wild bean. Nice little flower on there, little bean pod. Helps to fix nitrogen into the soil. So if you're getting into trying to diversify the plant community, it helps with soil function.

Some other materials that you really ought to consider would be things like Virginia creeper. I imagine you have plenty of that up here.

Some other vines would be things like summer grape, fox grape. Did you ever have musketing grape up here?

AUDIENCE MEMBER: That's not considered invasive?

MR. SKARADEK: No, not where we are, no. I mean, we have very little of it left actually. It's a native grape. I've seen poison ivy very invasive. Virginia creeper smothers complete stands of red cedars. However, it's not considered an invasive plant where we are.

This is a material action going up — right up a red cedar. Eastern red cedar — *Juniperus virginiana*.

Trumpet vine — a great summer food source for hummingbirds. So when you get those buffer areas at the top of the bluffs, and you want to put in a diverse plant community that can help wildlife, this is another material here that really has a lot of phenotypic variation, oranges and reds. So that adds a lot of components for that.

Wing sumac, this is our production field, a wing sumac. We call it wing sumac because of the little wings, if you will, between the leaflets.

Bayberry — *Myrica pennsylvanica*. I'm hearing — I don't know if this is fact — maybe

Roberta can correct me if I'm wrong — but I guess the Colonial Candle Corporation, through the early '17-1800s impacted the female populations by harvesting out the bayberrys for bayberry candles, so the sex ratios between males and females are off. So when you spec out some of these things, to be able to restore ecological restoration, put some of the females back into the system. A close up of its fruit.

Prunus maritime — beach plum. Do you have a little bit up here, quite a bit?

MS. CLARK: A lot of beach plum.

MR. SKARADEK: Okay. Down in New Jersey, we wiped it out. Basically it was wiped out of the dune systems completely due to people like to make jelly and wine.

How am I doing on time, Jim? I don't want to go over.

MR. O'CONNELL: Plenty of time.

MR. SKARADEK: And it's a material with a delicious fruit. In fact, through Bill Clark, Rich Uva at Cornell is actually going to be looking at developing an agronomic line of beach plum.

Eastern red cedar, down where we are is another great plant. Grows in these hot, dry sites. Close-up of the seed.

American holly. Another awesome plant for the back dune areas — up on the bluffs. Again, another shot of Virginia creeper where it might look blasé, but I tell you what, when you start getting a diverse plant community and you walk through during the fall, these are things that the leaf peepers look for up in the Adirondacks. Brilliant colors.

Jim, am I missing a couple of comments that we made yesterday during our site visits that you thought would be important?

MR. O'CONNELL: No, for the most part, you've covered it, particularly the notion of planting or not planting one hundred percent strands of beach grass on coastal banks, and in some bio-logs.

MR. SKARADEK: Yes. I hope you can now appreciate when I make this statement that could have seemed harsher earlier, to use beach grass with bio-logs in these bluffs is not the most appropriate application of that plant.

Now, you can use it, and I think you find that probably for the first year, it grows well; is that right? And maybe by year two and three, you start seeing it die out, not perform as well? And the note of caution I want to leave you is that now knowing that the plant doesn't physiologically thrive in that application, consider at the time of installation putting other plant materials that are better adapted to that segment of no accretion, things like the coastal panic grass. The *Spartina patens*, believe it or not is the predominant salt marsh plant, but it's also, when you go into the secondary dune off of a beach, the predominant dune plant. And we're trying to develop right now two different genotypes. We already have the one, which is used for the saturated marshes, for toe, slope stabilization. We're going to be doing one I call high and dry because it's coming from a dune ecosystem. We're going to be running through the reign of amplified polymorphic identification of DNA rapids gene testing, DNA fingerprinting, to see if there's a genetic variation between the wet type and the dry type, so we can justify having two different lines available commercially.

And so I would just say if you are using the beach grass, you're probably seeing some failure in the application of using that. Now you know why. And you just need to be thinking about some of these other plant materials.

Any questions?

MR. O'CONNELL: Before we open up to questions, I just want to mention, the workshop is being recorded and there's going to be proceedings, so if you're taking copious notes on the different types of plants and their applications, you'll all be receiving a copy of the proceedings. We have a stenographer, so if you have questions, please state your name first, and then speak loudly so she can hear you up here. And I might want to repeat the person's name and repeat the question when you ask it just so she can get it.

MR. SKARADEK: All right.

MR. POOLE: Rick Poole, from Duxbury Beach Reservation. Would you talk a little bit more about the fire that you mentioned earlier, and give everybody a little more comfortable feeling on that.

And secondly, would you talk a little bit about the successional processes, add a little bit more to that going on in dune development?

MR. SKARADEK: Two good points, actually. I went over that on a previous talk last week, and I kind of skipped over it this time.

The first question dealt with fire, the burn management. And again, that was for the purposes of removing that thatch. And what we find through some of the research of Denise Selizar and Jack Gallagher down at the University of Delaware, is there are about five different pathogens, if you will, that will kill the beach grass when it's in a decreased vigor state. And that would be things like the nematodes, the small scale insects, the Hessian wing flies, the picture wing flies. I think I'm missing a couple. The marasmus blight.

What we're finding is we have not seen in over a hundred sites that I've been to, beach grass dying out in an area where it's receiving sand, if it's continually being stimulated to new growth and all that harboring is not there. So when we burned it, we not only wanted to try to kill off whatever was being harbored — the decomposers being harbored, and also releasing the nutrients back into the soil for the next crops coming up, but then we also wanted to take that opportunity to see then these other species that are more adapted to the no accretion scenario, being the coastal panic grass and the goldenrods and things of that nature.

Now, on the site where I showed you the foredune that had been pulled out at an artificially unnatural rate, and the previous foredune now becomes the front of the secondary dune, which is where beach grass does not thrive well. And that's fine to do that because we all know that dunes are migratory, and we sometimes call them the first line of defense because they're like the bumper on a car, you get into a hurricane or accident, you let the bumper take the damage and save the body. So when a hurricane hits that beach, you want as big of a bumper as you can find or build over time. There's no problem to pull that dune out towards the ocean and make it thicker and wider and taller, but now you've got to realize when you do that, you're going to kill everything back here.

So don't wait for that to die to realize you have a problem. Know that you're going to have a problem now. Start planting these other materials in there now before it dies, so that when it does die out, or as it's dying out, the other stuff becomes established and you never get these various soil layers.

In fact, can I go back to one slide? I want to just explain something about the aerodynamics. Can you turn the projector on again and I'll try to zip through.

MR. POOLE: Bill, while you're waiting on that, timing on the fires?

MR. SKARADEK: You definitely want to get in there before any birds like plovers or some type of endangered species gets in there. It's going to be weather dependent.

Now, see what they've experienced here — this shot was taken a couple of years ago, and I just went back there two weeks ago. From an aerodynamic standpoint, only a small percentage of the air passes through the snow fence. A lot of it jumps over it. Well, now as you get this coming up — and I'm not an engineer, and I know there's engineers here — but as they come up and then they reconverge, there's a slight increase in the velocity. Well, now, that's going to slam right into this area. And if the vegetations not there, the sand will be dislodged, you'll get these blowouts, so that you'll basically sandblast the people walking down to the beach.

I was trying to determine how can you sell this additional cost management to public works officials, and I guess really the only way you can do that is say, well, look, if you keep that stuff there, you're not going to be bulldozing it out of the street later or trying to get it out of your storm pipes later. I don't know how much time and money they spend on rerouting stuff in the streets and out of the pipes when they get clogged, but it probably would exceed the cost of putting in five dollars worth of Atlantic coastal panic grass.

So it's not that the approach of doing this is bad. This is good. But it's just realizing that this activity will adversely impact this plant community. Now because you instantly created a secondary dune, you can look at a whole bunch of stuff. I would say experiment, and try to throw some bayberries and beach plum in there.

Also knowing that a lot of these back dune species will be somewhat salt spray sensitive, the ones that aren't very tolerant of salt will be pruned back to death, and others will thrive and do quite well.

MR. GRADY: Joe Grady from Duxbury. I'm actually going to talk a little bit about some of these same issues this afternoon, but I have two comments for you. My experience with fire is that if it burns in the summertime, it will completely kill whatever is there. Nothing will come back that was rooted in that area.

MR. SKARADEK: Well, that's a good point. We burn in the winter only.

MR. GRADY: That's right.

MR. SKARADEK: Okay, yes.

MR. GRADY: And second of all, some of this dieback with grass, I think may be a result of the strain of grass that's been developed by your agency. The Cape American beach grass that you provide now as seed material is much taller and much thicker and much heavier growth than the native species that we see around here. The native species of beach grass is much shorter, much narrower, much thinner, grows in a much thinner pattern.

Has there been any move by your agency to try to develop that type of grass rather than this very aggressive, very thick stalk that's now available?

MR. SKARADEK: Cape American beach grass received its name because it came from Cape Cod. So it was a material that we collected from Cape Cod, and we brought it down and then propagated it out. Now, what we did was we compared its growth form to other beach grasses from Rhode Island, Connecticut, Long Island, New Jersey, Maryland, Delaware, and North Carolina. And we found the Cape Cod population to have more stems per hill, a slightly wider leaf margin by a couple millimeters, so it gave you a better friction co-efficient for trapping sand. So we selected your local ecotype as the cultivator. Vegetative propagule never seed produce because the bracts that came out of there, there was no viable seedling in it whatsoever. So it actually came from your local system. And so if somebody's telling you use only local genotypes, well, that's Cape American beach grass.

Now sure, within any native population, you're going to get genetic and phenotypic variations where you're going to get some that are a little scrawnier, some that are a little beefier. And actually, Cape was the middle of the line. There were some that were real thick. In fact, if they're too thick, what they do is they just go to maybe six or — maybe fifteen large cigar size stems. And they have problems, because it couldn't survive the burial rates. And some of the real thin stuff didn't have the trapping co-efficient.

See, our whole purpose in 1965 was, let's trap sand.

Now, we also have a couple of lines that came from North Carolina. We have Boag and Hatteras and a couple of other unimproved, unnumbered lines that we had down there.

I would say as far as beach grass goes, we've done about all we're going to do. And if anybody wants to go farther, hey, we'll work with you.

MR. O'CONNELL: I have a comment, then a question. The comment, looking at this slide here, had they put the sand fence closer to the toe of the primary dune, perhaps they could have accelerated the accretion of sand and thus stimulated the vegetation growth. They could have accelerated the growth of the foredune vegetation by accreting sand on the front part of the dune. Do you think that will work?

MR. SKARADEK: Well, again, you can see the buried line of snow fencing here. See the posts? That's all buried. Their whole goal — these people, back in 1962, they were standing on their porch looking down at water. Now they've got about eight hundred to a thousand feet of sand between them and the water. So their whole goal here was that this part of the island where it was accreting, they wanted to widen the dune system out because the beach was already widening out, and they wanted to take advantage of it.

Yes, you could do that. You could put it here, and it would accrete here and stimulate that. But at some point in time you're going to reach a height limit where you want them to start pulling forward now; then you could actually come in here now and put another line here, and then bring another line back here and actually build this higher and higher and higher if you want. But they want depth as well as height.

Did I answer your question?

MR. O'CONNELL: Yes. I think you're going to have to artificially plant now, where they may not have had to if they put the fence a little bit closer to the seaward toe or slightly up the seaward slope of the foredune.

MR. SKARADEK: Right. But their line of defense — some people don't like that term — but their line of defense is greater. In other words, they have a greater sand bank there that can withstand hurricane erosive forces before it gets to the infrastructure. They're intentionally doing that, just to make the bumper thicker.

MR. O'CONNELL: But it would be best to plant or they're going to lose the sand quicker.

I have a follow-up question. Has your agency done any studies on the burial of beach grass? How much overburden of sand from a nourishment project could you put on top of American beach grass before you kill it?

MR. SKARADEK: There's a lot of work done. I think it was Maun out of Ottawa, up at the University of Ottowa, did a lot of that work. He did that years ago, and he actually filled these cells, ten by ten pressure treated boxes, put beach grass in there, and put like a foot of sand down. And then it went on to a couple feet here. He actually developed some thresholds. That's something that still needs to be really refined because when I talked about going to the Corps of Engineers, and revising their technical standards and specifications — engineers like to talk in terms of its performance — its performance standards. How does it perform in the standards?

MR. O'CONNELL: Well, I know beach grass will withstand a foot of cover. It'll withstand in some cases, two feet. This is from observations.

MR. SKARADEK: Right.

MR. O'CONNELL: Up to two feet it has survived. Beyond that, I don't know.

MR. SKARADEK: I would say if you do a literature search and look for the author Maun, out of Ottawa, he's done a lot of work on that.

MR. KEON: Ted Keon, Chatham. You mentioned I think early in the presentation fertilization of new dune nourishment. Should you, and if you should, what levels, what type.

MR. SKARADEK: That was actually Jim's comment. I made notes of his comment because this is something we're concerned about right now. Avalon, by the way, just to give you a little background, they've taken the National Hurricane Conference first-place prize for the past several years. They're the first municipality in the nation that's received a massive FEMA insurance reduction because they're a national role model for dune management. They aerial fertilize their whole dune. But even though that beach grass is being aerial fertilized, it's still dying out.

When you get into the fertilization recommendations, Chris Miller, the plant control specialist, and I, are realizing that our original recommendations in our book, *The Restoration of Sand Dunes in the Mid-Atlantic*, we believe that that rate is too high. And I also believe that we need to have better quantified — better quantitative studies on the fertility recommendations based upon rainfall patterns because, if you say okay, we'll go out and put out fifty pounds of ten-ten-ten on April 15th, and then you get a three-day northeaster on April 16th, do you go out and put down another fifty pounds of ten-ten-ten on April 20th? I don't know. Did it all flush out?

So there are so many variables in the dune system. I don't have the answers for it, and I know we don't have the capability of doing the study right now. So maybe you can work with Jim and Bill. Bill?

MR. CLARK: We did quite a bit of work with fertilizer applied research back probably ten or fifteen years ago. And you're right. I think your recommendations are too high. We came in with approximately a pound of nitrogen per thousand square feet. We found that you could stimulate real good growth with maybe a quarter of a pound, so we cut it back in fourths. And we recommend totally water insoluble. So formulations like IBDU. Obviously, if you do have those rain events after you fertilize, we don't want the nutrients entering our water bodies. So if you use the water insoluble, low levels — low rates in water insoluble nutrients, it's time released, it doesn't go into the ecosystem, it stays where it's supposed to be. It's worked very well. And we tried it at the National Seashore. We had some flights over Sandy Neck maybe fifteen years ago, and it worked very well.

MR. SKARADEK: So we probably ought to work together in comprising that standard.

MR. CLARK: This seems to work the same way as the covering of sand. The sand, as you mentioned, if the beach grass is not covered by sand, it does die out. Well, very low levels of water insoluble nitrogen seems to replace that need for sand, at least temporarily, so that you can incorporate other woody vegetation and so forth in an unstabilized situation.

MR. SKARADEK: Thank you.

MR. CLARK: The other thing I want to mention, a follow-up. I haven't seen panic grass go through our — well, this is not a typical winter, but panic grass doesn't seem to make it through our typical New England winter. Do you have any varieties that you are familiar with that — or have you worked with any this far north?

MR. SKARADEK: My understanding is actually Cluster Belcher, who was the plant growth specialist back in the late '80s, planted a bit of that up here, and its still here, what he planted. However, I'm also being told that Massachusetts Audubon doesn't like the plant because it wasn't naturally occurring to Massachusetts. But then my question was, well, what was naturally occurring when the ice sheets were here. I mean, seriously, talk about native plants. What was native here when the ice sheets were here? So what you got actually came from New Jersey to begin with anyway. So our thought was why not try some coastal panic grass?

MR. CLARK: Oftentimes you run into a situation where you're looking to stabilize an embankment or a coastal dune that's not going to be covered — predictably is not going to be covered by sand.

MR. SKARADEK: Right.

MR. CLARK: Typically, the first year its planted with beach grass, and it was planted maybe in subsequent years with Rugosa rose, beach plum and so forth. What are your recommendations for spacing for beach plum, Rugosa rose, or typical woody vegetation that grows in this environment? That seems to be controversial.

MR. SKARADEK: — and it would be. It's going to get into I would say desired function. You know, you're throwing it in there to really create a maritime forest or you just want another component for landscaping. And I think based upon your desired outcome or end use of how you intend that site to look and function is going to drive your spacing.

I know that the plants, when we plant them out on the farm for a tree orchard, we put them on like ten to fifteen foot centers, we wind up with a solid canopy. They grow up and they touch each other. Whether you want that on some of your sites, I don't know. Whether the landowner will be receptive to blocking their aesthetic views with a shrub, a solid line, I don't think so. But I would say it's going to be interpretive.

AUDIENCE MEMBER: Just one last question.

MR. SKARADEK: Sure.

AUDIENCE MEMBER: Regarding compatibility with plants. We have some gut feelings that in some alleopathic picture certain dune plants that are native plants to other plants.

MR. SKARADEK: Like *Hudsonia tomentosa*?

AUDIENCE MEMBER: *Hudsonia* is a good one.

MR. SKARADEK: Right.

AUDIENCE MEMBER: And some of the more common native heathers and heaths seem to be potentially allopathic to other plants. Have you seen that?

MR. SKARADEK: Absolutely.

AUDIENCE MEMBER: So we wouldn't want to recommend it be planted that way?

MR. SKARADEK: No, absolutely. Every time I see — going all the way from Fire Island on Long Island, when I see *Hudsonia tomentosa*, which is beach heather, it's usually in these monostands. There's absolutely nothing growing near it, and there's massive areas of exposed sand in between the plants, which is susceptible to wind blow and dislodgement. But that's the only one I've come across was the heathers, so far.

Yes, sir?

MR. MERLIN: I'm from Massachusetts Audubon. One minor point. I think you seldom find this far north *Spartina patens* jumping out of the marsh and into the dunes. You don't see it as a dune plant.

MR. SKARADEK: It's actually occurring on your bluffs.

MR. MERLIN: A tiny bit. If you go down to the outer banks its more prominent.

MR. SKARADEK: It's everywhere. Okay, thanks. That's a good point.

Yes, sir.

MR. FLAHERTY: I totally disagree with Dennis' statement.

MR. MERLIN: It's more of the dune areas where you go down to the bank.

MR. FLAHERTY: My name's Tim Flaherty. Coastal panic grass—I've done several test plantings up here, and it doesn't survive.

MR. SKARADEK: It doesn't, okay. Thank you.

MR. SOLOMON: My name's Dave Solomon of Wellfleet. You mentioned at the end of your talk about the mass plantings of beach grass didn't work out, and I know the answer, if it might help to explain it more to other people.

Our supplier of beach grass has recommended or alluded to as we understand the idea where you don't have sand covering beach grass, eventually it's thatched out and loses its vigor, and typically we use irrigation and other things to keep it vigorous. What he recommended, mowing it to the ground, thatching it, destroying it. The other thing I was wondering, how you felt about hydroseed. I've done it on sandy loam, it's worked out. The picture you showed using that deep root seeder, you know, with no water, pure sand, when we're working with ornamental plantings in residential settings, we don't have the leeway of sparseness. People want the full look right away. So we're dealing with ornamental factors.

MR. SOLOMON: I've read about the national park at Provincetown, they tried to do acres and acres of mass plantings, and a lot of them died and the national park spent a lot of money trying to figure out why.

My theory is, number one, it's not planted deep enough. Number two, if it's not planted thick enough, the sand blows from around the plantings, takes the roots even higher up. It's just drought that wipes it out because for a year or so it doesn't have an established root system.

When we planted, we planted thick and we irrigated the first year. After three, four, five, six, seven years, we don't have that sand accretion type scenario that you mentioned. It just thatches out and eventually a lot of times we end up just losing it or having to thatch with a pitchfork. Our supplier, he suggested that we mow it.

MR. SKARADEK: I've never heard of mowing.

MR. SOLOMON: There's so many roots in an established stand of beach grass, if you artificially irrigate it, you can literally mow it to the ground and you can hit it with an excavator and it'll grow.

MR. SKARADEK: Yeah, if you have a lot of healthy rhizomes, it's not the roots that are going to survive.

MR. SOLOMON: The other thing is everybody's mentioning they're having a hard time with switch grass and panic grass. If you introduce a little sandy loam when you're planting it, rather than try to plant it in pure sugar sand, and if you irrigate it a little bit, it could work.

MR. SKARADEK: A lot of the areas where we're looking at, which would be state parks, fish and wildlife refuge locations, highway jobs for National Park Service where you have like five miles, irrigation just isn't an option for us. Just put it in and God will take care of it.

MR. SOLOMON: I understand. But, I don't know, a lot of people here are from regulatory committees; a lot of this is high-end waterfront residential property where people are involved in erosion control and ornamental landscaping.

MR. SKARADEK: The comment was the high-end landowner wanting things now and wanting good quality results. That right there would probably drive their desire to use vegetative tropicals because the C-4 warm season grass, the switch grass, coastal panic grass, they're slow to establish. And, in fact, at the end of one summer growing season, you've got a plant that's tall, you've done really good. So you might want to just go ahead and get like some four-inch pots, like quart-size pots with some nice thick stems on it and just plant them out. It may be a quicker way. That's a good point to make.

Do you have a question?

AUDIENCE MEMBER: The lower end of the Cape is mostly National Parks. Are they using your recommendations? Are they actually looking seriously at the recommendations that you give them and spending our tax dollars for the best benefit of the dune erosion?

MR. SKARADEK: I don't provide technical oversight to the activities of the National Park Service. Actually, our activities have been limited to helping them with restoring impacts from highway crossings, or when we need to collect certain native plants for the development of commercial availability for a nursery and for the trade, if you will. So I can't tell you — I couldn't answer your question because I'm not the resource manager. And I do know Mike Murray, and I did know Mike Reynolds was here. My conversations with them are probably once a quarter.

AUDIENCE MEMBER: What is a bio-log?

MR. SKARADEK: Bio-log? That's that biologically degradable coconut fiber that you roll into a net; is that correct?

MR. O'CONNELL: We're going to have a couple of speakers discuss what they are with a site analysis. Coming up next.

MR. SKARADEK: It's a byproduct of the coconut industry when you rip that husk out, you get all those fibers and stuff, so rather than throw it away, you have shiploads of the stuff and they roll it up into netting and create a log of different density.

Yes, sir?

FALMOUTH CONSERVATION: Maybe it can be answered in the next session, but I just wondered your experience with bio-logs and shrub material that has been planted.

MR. SKARADEK: The question was bio-logs and shrub material. I'm not sure. Has anybody worked with these bio-logs?

AUDIENCE MEMBER: Yes.

MR. SKARADEK: You have? Did it work well?

AUDIENCE MEMBER: Well, it all depends on what you end up with for soil contact with the coconut fiber materials, and again, what sort of propagule you're working with, how well established it is, and how well it will be

(Discussion interrupted)

AUDIENCE MEMBER: — fiber breaks down, gets replaced by windblown and water borne soil mineral material. It's a matter of all the regular things about plant selection and plant establishment.

MR. O'CONNELL: Thank you. We're going to have to move on now. If you didn't hear that answer, she was describing the use and installation of bio-logs. That topic will be covered in detail by the next speaker — Wendy Goldsmith.

MR. SKARADEK: All right. Great. Thank you.

MR. O'CONNELL: Thank you Bill. Lets take a fifteen-minute break.

HISTORY, THEORY & PRACTICE OF BIOENGINEERING IN COASTAL AREAS

Wendy Goldsmith, President and Geomorphologist, Bioengineering Group, Salem, MA

MR. O'CONNELL: Our next speaker is Wendi Goldsmith. Wendi is the president, founder, senior bioengineer and geomorphologist for The Bioengineering Group located in Salem, MA. She's worked for The Bioengineering Group for the past ten years. She has extensive experience in all phases of bioengineering project design and implementation for lakes, rivers and coastal areas.

She's well versed in the structure and biological characteristics of erosion control materials and native plants and their suitability and limitations for use in the bioengineering system. She has a BA in Geology and Geophysics from Yale, an MA in Landscape Design from the Conway School in Conway, Massachusetts, and an anticipated MS in Plant and Soil Science from UMASS Amherst. Her subject today is going to be the History, Theory and Practice of Bioengineering Design in Coastal Areas.

One announcement. At the end of the day we're going to have an open discussion and an opportunity for questions and answers on all these issues, which I usually find very useful and informative. Wendi however is not going to be able to stay for the entire day. So she said it was all right if you wanted to interrupt her with appropriate questions while she's going along. There'll also be a little bit of time after her talk for questions as well.

MS. GOLDSMITH: Thanks.

I'm really excited that this whole talk is going on and that the level of discussion is where it's at nowadays. I've been involved in this country and outside of this country for the last twelve years, exclusively on salinization and management of the land-water interface in coastal and freshwater systems. And actually a couple of people have come up to me this morning saying, oh, I remember when you were wandering around these areas ten years ago introducing the notion of trying something other than hard structures on some of these areas, and explaining some of the things that were going on in some other countries. And Dave Lyttle said, I remember when you showed up in jeans and sneakers and kind of made this pitch that sounded kind of funny at the time. What is that, you know? Is that an ugly handbag under your arm? No, that's a sample of fiber erosion component materials that's going to be useful in these applications.

So we've all come a long way, I think. And ten years ago, people were very curious yet skeptical about using vegetation and some other nontraditional systems for coastal stabilization. Even from a regulatory point of view, these ideas were often met with more resistance than when people responded to some conventional hard structures. We've seen a lot of progress and a lot of clarification about policies, technical issues related to the reliability and predictability of different approaches, and yet there's still a lot of room for change. And I hope that as I give my talk, you can see where some other regions have learned different things and perhaps start thinking about how some of these systems can come into play to address some of our regional problems.

The fact of the matter is, some of these nontraditional systematic soft structural treatments to coastal erosion problems have been around for a fairly long time. All of them, if successful, are based on a sound knowledge of the very complex and often quite unforgiving dynamic systems in a coastal environment.

There are a number of very active factors that contribute to coastal erosion. We have waves. That's usually the first thing that comes to mind. Actually, there's a fair amount of wind-driven process, wind-blown soil and sediment movement that both causes erosion and sometimes replenishes and restores land that's been lost to wave erosion.

Frost, thaw, groundwater migration, and just plain old surface erosion due to rain splash and runoff also play a role, but these are generally somewhat on the back burner compared to the more obvious wind and wave-generated erosion. But all these things need to be understood and addressed, whatever the system you're employing may be.

There are also a number of passive factors to coastal erosion. These are the luck of the draw. Different sites have different configurations: The geometry of the bank, the underlying geologic material, and its engineering properties, how it interacts with wind and waves primarily. These are all factors that, to a certain extent, you have because they're there. But in another way, you have the opportunity to remold, modify, and to some extent alter those configurations as well.

It's the same with beach characteristics. You pretty much have what you have. But in these dynamic systems, the sediment that makes up a beach is actually not just a static thing that's there forever. There's a lot of movement and exchange of materials over time. And to some extent, if we think about the assessment and engineering process for a coastal management project, if we think about it over time instead of as a static snapshot, it allows us to better understand the processes and to identify some management solutions where over time we manage these processes.

So the composition: you have fine sand, coarse sand, well-sorted materials, a mixture of different particle sizes. What's the composition of your beach, what is its width, what is its slope? All of these things influence how those active factors play out on the site.

And the same with offshore characteristics. What is the slope and depth and the benthic environment offshore from your beach. What's the fetch? Are you sheltered by headlands or islands or different offshore barriers, natural or built? These all have to be well understood. And every site, of course, becomes entirely different from any other site. The one thing you can rely upon is that all these sites are going to have their own unique attributes and ultimately probably some headaches and things that you face major challenges over.

It's also true that when Mother Nature builds coastal environments, she does not tend to assume that they are stable. She is very aware of all of these different processes, and essentially the most active and dynamic coastal environments are well understood at this point in time to be changing on a pretty rapid basis on a geologic time frame. We sometimes forget that because the geologic time frame is a little bit slower at least than the engineering time frame, we're also dealing with problems where homes, roads, boat regulated facilities are built in geologically active areas. And we're in a bind. There's a lot of infrastructure. There are health and safety factors that were we starting over today, we might not be citing these things where they are. But how do you manage them when they're already there?

The fact is, there's no simple answer. But by understanding the nature of the dynamic processes, we too can design on a geologic time frame, design hand in hand with the processes of change that are active on the site. This often helps us get out of the bind, and in a satisfactory manner.

In fact, even the hard engineering disciplines have evolved over the decades to recognize that harder is not always necessarily better. Even the engineers of hard structures have been humbled by the forces active in many coastal environments. Rather than trying to build the biggest, baddest, toughest, most reinforced bulkhead in a coastal environment, there's been a shift towards building structures that themselves have some resiliency and flexibility.

These are like twenty feet by twenty feet cast concrete reinforced jacks, just like you played with when you were a kid. Only these multi-ton structures are lowered by crane into place on a shoreline. And every time these major Pacific waves crash into it, the whole thing gives just a little bit, but because of the interlocking properties of the materials, they don't just roll away and fall out of the site. They tend to stay. And over time, they can be maintained by being picked up and placed back where they were originally intended.

So an engineered system like this flexible revetment has a set of attributes that's very similar to the beach and dune system on a barrier island that is also changing over time, being moved around in response to major storm events, coming and going over a geologic time period, but essentially doing its job even though it's not holding a hundred percent rigid under all the forces.

We also recognize that the most rigid structures themselves have a number of drawbacks. The New York Metropolitan area, including the extensive coastal systems on the Long Island and Jersey Shores, and Staten Island, too, in the middle there, they have a number of interesting attributes because these are intensively thickly populated areas, and ironically, due to the high, high level of urban development, it's been well-documented that natural sediment supply from normal watershed process has been truncated. A lot of these watersheds are so heavily paved that the natural yield of sediment in the form of silt and sand-size particle grains is actually sealed off. So this stuff is not getting out into the beach environment. That is one of the things that's triggered — actually accelerated beach erosion. But then there's the same old problem of should people have been building there ever? It's an area that's subject to change.

Well, for both of these reasons, people had, of course, the motivation to go out and provide various structural systems to manage erosion. In addition to just armoring shorelines, which is expensive and not always easy to do, there's obviously the opportunity to use perpendicular groin or jetty structures to capture the sediment that Mother Nature is moving around on the beach, and help keep it where people want it.

The problem is at the end of the day, this tends to be a zero sum game. And in many cases, you see where sediment supply is pretty rich, like up here, and all these perpendicular jetties do a very good job and are functioning more or less the way a dam functions on a river to create a trap of sediment. The sediment is normally moving, carried by currents, down this way.

And here we see plenty of sediment, a wonderful beach. Not quite as much sediment, but still a wonderful beach. We start to see areas where, oop, there's no more sediment getting by from up here, so this beach is holding its own, but it's not in all the width and glory of the upper area. By the time you get down here, there's nobody screaming for sediment, they haven't been sticking in extra jetties or any other supplemental measures. And by the end of the game, where the jetties end, you're in a natural area, a wetland, who cares, nobody's screaming for help from the government, we see ongoing loss and erosion.

This phenomenon is well documented, and for this reason, there is a lot of regulatory resistance to using much of any hard structure based on the assumption that these things sooner or later are robbing Peter to pay Paul, that in this zero sum game of sediment balance in coastal areas, somebody's got to lose, and usually it's the resource base that has no vocal advocacy that tends to lose.

So it's awfully hard nowadays to even approach the idea of managing coastal areas with structures like this. As it turns out, from a science and engineering standpoint, it is awfully hard to pinpoint one way or the other how these kinds of systems will work. It's very difficult, if not impossible, for the best of experts to predict exactly what the sites will end up looking like, exactly how these structures are going to interact with the dynamic movement of sediment along the coastal area.

So we find ourselves in this predicament. Clearly, there are people and private and public property and infrastructure that people are motivated to protect. There are many clear reasons why some of the more obvious choices to protect them are met with some skepticism and resistance; and it's also obvious that even within the field of coastal engineering, there is a movement away from some of the older, more rigidly-based design protocols into some much more adaptable, flexible systems, systems that are themselves dynamic and adaptive.

Now, the most amazing dynamic and adaptive coastal erosion project I'm aware of is a very old, very large set of civil works projects spanning from the coast of Denmark, through north Germany, into the North Sea area of Holland. Of course everybody knows of Holland as being the lowlands and is familiar with all of the land reclamation work, but what a lot of people don't realize is how they got started at doing that, and how they got good at doing that. And a lot of that has to do with problems they faced related to the geomorphic conditions along the North Sea coast. It's a very shallow sloping sea, and when the wind blows from the north, walls of water just push inland. It's awfully hard to draw a line on your GIS map in the natural landscape of northern Europe, the North Sea coast, to define where's land and where's water. The distance between normal low water and normal high water is actually about two to three kilometers wide, and in extreme events, the high water goes much farther inland than that.

So people care an awful lot about these small vertical changes and people expend a lot of energy, as everyone knows, and I think Holland in particular, to just keep that water at bay.

What people often don't talk about is how hard it is to create and maintain those dike structures to define the border between the sea and the land. And I'll show you some of the interesting things that they do.

These systems not a hundred percent built. This is a path through the dune system on the North Sea coastline. I know I was struck the first time I visited one of these areas by the fact that they were bold enough not only to fence alongside the path to keep people on it. Keeping people on a path through the dunes is quite a good thing to do. As we all, I'm sure, are aware that if people are blundering around off the path, they can be very destructive. They're very secure in Germany and Denmark about fencing these things, and darned if they don't use barbed wire, too. It's a little unnerving actually to see the Germans so comfortable putting barbed wire around, but it works. It suggests that they're aware of just how important it is, the wind erosion and sedimentation processes and the health of the vegetation and of the dunes in protecting their boundary between land and water.

But then just out in front of the dunes, we have the major dikes. I took this picture while standing on one of these major dikes. This is just looking out across kilometers of mud flats, looking pretty much due north out to the North Sea. And we see that in addition to the dike itself, that it's about fifteen feet high and forms the edge between land and water. There's also these perpendicular jetty structures, and even these little smaller versions of jetties creating this intricate sort of checkerboard baffle pattern because for this structure to be protected, this structure and all these little substructures need to be breaking up the powerful wave energy coming in off this long, long fetch out to the North Sea.

But interestingly enough, these major rock armored dike and jetty structures are themselves made out of fairly locally quarried basalt rock — it's a columnar basalt. So even though each one of these stones is roughly a foot to eighteen inches in typical diameter, each one of these stones is actually at least a meter long. So each one of these structures tends to fit together, kind of like a child's puzzle, and each one of these things — these rocks are hard to move, but they're also dry laid. There's lots of smaller fragments of rocks filling in all the chinks and cracks between these. So again, when the waves slam in, the whole thing just kind goes poof, and gives just a little bit, but it pretty much settles back the way it was built. So again, a very successful application using locally available construction materials to create these flexible hard-faced solid structures that aren't so solid after all.

But even in order for all of these structures to do their job very well, there's all of this wild stuff going on on this gently sloping inter-tidal landscape. And we see increasingly small-scale networks of little baffle and jetty structures. And, of course, all the while, these things are interacting with the tidal circulation and all of the sediment that is being brought in from the whole North Sea coastal zone (**Figure 11**). What happens when it enters this whole baffle structure system? The energy levels are slowly brought down, and sooner or later, whatever sediment is carried in the circulating water has been managed to effectively allow it to deposit. So there's this continually accreting sediment source. The very energy that normally is so destructive and actively modifying the system is incrementally being tamed so that it's instead actually bringing sediment in. And not only is the passive intervention re-forming the land creating these baffles, the North Sea is depositing sediment, but then things start to get more active, too. Ingenious little amphibious excavator vehicles are slithering all over the mud flats, scooping stuff out of the lower areas, piling it up on the higher areas, and the new deposition tends to occur in the lower areas. So there's this active movement and manipulation of the sediment that's brought into this zone of the landscape.

Fig 11. Soft structures for sediment control along the North Sea

And once the sediment level gets built up to a certain height, crews of people are out there using the tops of trees, from the forest, harvested in timber operations, and all of the slash from forestry operations, all the fine branches. They're building these little biodegradable crib wall structures to further accentuate the baffle system, which especially is very, very effective at promoting sedimentation right up close to these. But, in general, these do play their own role at further trapping sediment and elevating the offshore topography. And after not that much time, these little baffle structures have become — this is kind of a high point — they start to become physically stable and at a suitable inter-tidal elevation, but they're colonized by salt marsh plants (**Figure 11**). Folks up there are really alarmed. There are local *Spartina alternaflora* that colonize that are not their native *spartina* low marsh species.

But all in all, it does a magnificent job. Even further, through the effects of the foliage that further adds friction and energy dissipation and traps and holds sediment in the root system, the land just keeps building and keeps building until eventually, here's the low marsh, in the low spots, and this starts to be dominantly freshwater marsh. Eventually, this stuff is built up so that it's above the mean high water mark, and actually, ends up being used as grazing land. So it becomes a useful resource zone that's simultaneously creating this major buffer strip of land to change the offshore geometry and ultimately protect the dike system, which makes living on the North Sea coastal plains a lot easier because you don't have to be ready to move your whole family two miles every time the wind blows from an inopportune direction.

AUDIENCE MEMBER: Do you know the time frame of that process?

MS. GOLDSMITH: The time frame of this process is about a decade or so. And the folks throughout Holland and north Germany have this down to a real science. They've been puttering around, using all sorts of different materials, and they feel very strongly that you need rock structures for some of these things, you need rock structures initially when you're dealing with water depths and fetch distances of certain magnitudes, but that once you've tamed the site enough it becomes possible to get very effective results with the softer biodegradable materials.

And they've got also down to a science how to move the sediment around in order to end up with the most usable land, which is another element of their multifaceted land management here.

Question?

AUDIENCE MEMBER: The picture that we're looking at now was once mud and sand flats?

MS. GOLDSMITH: That's right. And it's not too far — I actually shot a bunch of these photographs about a decade ago while driving — I actually visited probably ten different sites along the North Sea coast, and in some cases, they made land here, then they built another whole dike out in front of it, and they were kind of incrementally marching the land out to the North Sea, which raises a lot of other issues. But what I thought was very fascinating, just from an engineering standpoint, was how these different major and minor structures and sediment management with these little amphibious excavators and natural plant colonization, as well as ultimately — they actually do seed fresh — they seed upland meadow species onto their grazing areas.

All of these things suggest and demonstrate a whole set of tools that can be used in any number of ways that are — including some that are a little different from how they're being used here.

AUDIENCE MEMBER: Two questions. Is this done by private enterprise or by the government? And second of all, when it's done, who ends up owning the land?

MS. GOLDSMITH: Well, in this area, all of this is being done by the government, and ultimately, all of it becomes government-owned land that is actually — grazing rights are being leased out. So, some of the legal and property rights issues are kind of neatly managed by that scenario.

Ultimately, however, some of these works are happening seaward of private property. And in most cases, at least in this geographic region, any property owner tends to be wildly grateful for some of the protective efforts being made here.

I have a great deal of respect for the importance, the benefits, and the detail-oriented nature of the permitting process we're all familiar with here in the New England region, Massachusetts in particular. You ain't seen nothing till you've gone to Germany and Holland, partly because the systems are much more complicated, and the nature to the solutions to problems — you're not talking about, you know, the coastal bank is getting closer and closer to my back porch. I'd like to do something about it. You're talking about huge, regional scale interventions like this that need to be thought through from many different perspectives. And solutions like this have actually evolved in the context of an extraordinarily rigorous and comprehensive amount of public feedback, regulatory review from an economic and ecological analysis point of view. And for example, all of these systems turn out to be a huge boon to local fisheries industries, because along the way you're creating a lot of substrate and shelter areas for various young or low on the food chain organisms. So systems like this are I think a pretty fair reflection of some optimal strategies, at least for these areas.

Fig 12. Sediment control using soft breakwaters & sills

And, in fact, the engineering communities throughout Germany and Denmark and Holland began realizing about twenty-five years ago that a lot of the things that have been adapted and established out of necessity on the North Sea coast could actually be very effective when applied elsewhere. And here's an example of a dead branch breakwater structure with some freshwater plantings being used in a lakeshore setting (**Figure 12**). And sure enough, when you see one of these things being built, it's working a lot the same way as the North Sea systems. A structure like this is very effective to serve as construction phase sediment control. It'll help effectively trap and maintain any erosion from the land surfaces. From a regulatory point of view, these structures, which can be made with dead brush, they are often made of coconut fiber fascines. They're being made out of — in some cases, they do include rock as an element, but their function remains the same, or close to the same. In this case, this is accepted as a construction phase sediment trapping mechanism, even when new fill soils are brought in to create a proper geometry that optimally interacts with the wave environment.

These are often combined with vegetation-revegetation measures that are very immediately effective. Right in this slide you can see some high strength woven coconut fiber matting pegged in place on the toe of the slope in an area that during a major windy storm event becomes part of the splash zone. These are actually some pre-vegetative coconut fiber mattresses cultivated in a specially designed nursery that can be brought to the site and staked in place. And they contain very mature plants that quickly establish a buffer of plant vegetation that itself is very effective at stabilizing the shoreline. In fact, in some cases you don't need a breakwater at all — you just need the plants.

And also, ecologically, this allows the whole structure to get up and running, in terms of providing a water quality buffer, providing food source for various terrestrial estuary and aquatic animals and so forth. It's up and running at a high level of function from the initial installation, and continues developing at a pretty fast pace.

There's a lot of hemming and hawing going on currently about — in fact DEP and the Corps of Engineers are doing some major studies as we speak in New England and in Massachusetts, about does wetland creation work. Are mitigation wetlands successful? For the most part, that's the only kind of wetlands people have been building. But there's a lot of skepticism about whether other functionally significant wetlands designed to perform specific goals — fulfill specific goals.

People doubt sometimes whether they're effective. And to this I would answer, they need to be designed properly and they need to be engineered as aggressively as engineers have engineered anything else they take seriously, which is a little bit on the over-design end and you probably feel pretty safe.

I would argue that most wetland creation projects have been accomplished on a fairly minimalistic basis, where people are trying to get by with as little as possible, which is an attitude, I don't mind pointing out, that the engineering community doesn't accept in any other realm of engineering, and probably shouldn't be accepted so easily in this realm either.

This is an example of very robust re-vegetation methods. And sure enough, they work. And this is just to remind us this particular project has — the breakwater is visible during low water periods.

MR. O'CONNELL: I had a question — seeing the stone breakwater out in front. I think the skepticism may come from if a marsh is not there now –and they're trying to establish a new marsh for erosion control, perhaps the hydrodynamic system or the wave climate wouldn't support building an artificial marsh there. So I guess my concern would be if the marsh isn't there now and you recreate the marsh, how long will it last, and is it really cost effective?

AUDIENCE MEMBER: Well, isn't that when we talk about changing the geometry?

MS. GOLDSMITH: That's right. You can't just park any old marsh system any old place and expect it to work. But you can recreate the whole system in which another marsh exists, and your marsh will work. Sometimes, it's enough just to create the sort of shallow bench, and Mother Nature will spontaneously come in and re-vegetate it. Then again, it may not work out that way. So your level of certainty increases the more steps you take to establish the final full end condition that you desire. This is actually a dead brush filter layer, so there's no plastic base geo-fabric involved in this. Dead brush, but there is a little apron of stone sitting on top of that dead brush filter layer. And then this is a branch cribbing breakwater structure. But there is a little permanent material as part of this particular system. There are many ways to design these, and they should be designed to be very specifically tailored to your site conditions.

And there are some spots where it's attractive or necessary to build this kind of vegetative system where you're going to need a little bit of structure to make it possible.

AUDIENCE MEMBER: I guess I would just point out that obviously there are going to be effects of anything that you implement in something like this where you're creating a marsh, you're eventually or you're ultimately slowing the sediment deposition or sediment transport patterns and potentially estuarine system slowing down seaward deposition towards the coastline and — I mean, there are obviously effects on every facet.

And I guess one of the things I'm wondering is what is the setting of this particular restoration project in the hopes, obviously, of protecting upland property. But can you give us a little bit more background as to why this was implemented.

MS. GOLDSMITH: Sure. This is partly to protect upland property, party to re-establish lost wetland habitat in conjunction with the water body. This happens to be a freshwater system. But the system is — it's part of an irrigation reservoir system, so the water levels fluctuate, and it's got some pretty wide fetches – with the wave environment, so physically it's very similar to many coastal environments.

The other thing going on here is a water quality buffer. In this case, it's mostly some intensive agricultural land uses around the reservoir system, and having a little bit of buffer to manage surface runoff was very valuable. Of course our coastal areas are under the most intense development pressure, although on a case-by-case basis, the situation may be different. We've lost a huge amount of coastal wetland areas, so from a habitat and a water quality balance, we've already lost some of those functions. And some of them were urbanized settings that I've studied, although there tends to be a pulse of sediment during an active construction and development phase. Once new development occurs, there does tend to be, all other things being equal, less of a sediment yield to the system. So keeping some of the sediment within the system and delaying its time leaving the aquatic system can actually be a smart balancing countermeasure to some of those trends.

Currently, Massachusetts' regulatory policy is such that it's recognizing how hard it is to precisely model exactly all of the effects that any hard structure has — it's hard enough to predict the effects of hard simple structures. It becomes a real challenge to effectively predict the performance of some more intricate and less well-studied systems. And, in fact, everybody involved in this field tends to recognize this, just about. Anybody who gives you a precise answer is either deceiving themselves or you.

So I think it's helpful to start looking at past and present and potential future trends to make some qualitative — to account qualitatively for some of these things.

I have yet to see a site where it's possible to argue why building — why using biodegradable materials to re-establish water's edge wetland plant communities would be counterproductive to the system.

Yes?

AUDIENCE MEMBER: Have these methods been employed anywhere near here or in the United States? Especially in coastal areas.

MS. GOLDSMITH: Yeah, some of these systems have been used. But how many people in the room have worked with systems related to these anywhere, including in coastal areas?

A few hands go up. Oh, come on.

Those of you who've been employing these systems, do you generally — do you feel good about it? Do you feel that there's a pretty solid level of performance coming out of them?

Lucky you.

AUDIENCE MEMBER: I'd like to make a point about your last comment.

MS. GOLDSMITH: Sure.

AUDIENCE MEMBER: I think it's still early to say one way or the other. As you mentioned, you've only been doing it for ten years, and some of us have just been doing it for that same time period, and it can take five or six years to even get to a point where you feel comfortable with the site or determine whether something has been working well or not working well because, as you mentioned, this is a freshwater system and we're dealing with coastal situations where it may be a completely sandy beach with no vegetation. And so they are working — I guess they are working, but it's hard, it's taking time, and we have to tweak everything along the way.

MS. GOLDSMITH: Yes?

AUDIENCE MEMBER: If twenty years is a good perspective, I'm familiar with the situations in Michigan on some of the rivers where it's partly because of some extreme erosion but also cattle and things like that. Similar situations have been very successful and proved the — or greatly reduced the amount of sediment and therefore kept high quality trout streams.

MS. GOLDSMITH: There are a number of examples throughout the country where various bioengineering and other soft engineering or hybrid engineering systems are being employed very successfully. And they've been — these kinds of treatments have been used in Europe with more widespread and technically reviewed — they've been part of the mainstream for significantly longer. And for my own part, after coming out of undergraduate and graduate training and being very interested and being involved with some of these things, I kind of popped out of school and said, oh, the real world isn't doing very much of this anywhere here. And so I went over and I did a year-long apprenticeship training program with a German firm that had also been building on a hundred and fifty years of traditions, including some of the North Sea work and projects like this that actually that German firm was in the middle of while I was training there. So there are plenty of places to find some examples.

I guess one of the reasons I was invited to speak today was to talk a little bit about the history and the background, to give people some familiarity with the references out there that — the fact that some of these things have gone on. And actually, we have a fair bit of this information accessible on our Web site that we maintain. And I can hand out some cards at the end if people would like to access some of that information, so you can tap into some of your own further research to answer questions you may still have.

MR. O'CONNELL: Just one comment. There are quite a number of sites where these nonstructural systems have been installed and appear to be relatively successful in the Chesapeake Bay area, if you're looking for some case examples that have been in for a number of years.

MS. GOLDSMITH: That's true. And there are an increasing number in this region. There are a lot more freshwater sites with river and lakeshore areas. The number of coastal sites has been growing steadily, but I think we probably all in this room recognize that the physical conditions on coastal sites tend to be the least forgiving, the most challenging, and the most diverse.

I've kind of heard third and secondhand about a handful of projects, including in this very close region, that haven't turned out as planned — and haven't panned out as people planned on. And this can be very discouraging, but I think it also is somewhat inevitable. I encourage that the most rigorous science be employed in the planning and design process as well as good execution.

But also, it's a little hard to predict exactly all the factors that are going to be relevant in these very complex systems. So onlookers should be somewhat understanding if there's an occasional flaw and hopefully learn from them.

Here's just a little construction diagram. This one highlights a cylindrical sack gabion type structure used as a breakwater. In some cases, you need a little bit of structure, not just biodegradable materials that are temporary in a life span. One of the kinds of settings where that type of permanent structural reinforcement can most certainly be relied upon is in barrier island and dune systems. If for various reasons one wishes to insure the permanency of a dune system, you can't really do that without some hard structure in any way that I'm familiar with.

This is an example of a project constructed nearly twenty years ago on the southern coast of England in the Dover area. And here they did a pretty good job at mimicking the topography of existing dunes — well, the dune that used to be there. And here's the site. You know, here's this building off in the background, and here's the same building. This is basically looking at this whole artificially reinforced dune system after its' been growing for about ten years. So the whole project is twenty years old now. I don't have a more recent photograph. All of the shorebirds think it's a natural dune. All of the tourists think it's a natural dune. And some of the adjacent property owners and everybody on the harbor is really grateful. But it's not a natural dune when the storm surges happen because it actually provides a very high level of integrity against — protecting the harbor against storm surges.

MR. O'CONNELL: Is that cobble or shell hash inside?

MS. GOLDSMITH: This is cobble. Here's how the project looked right after its initial construction, basically, sand fill. A little aeolian process. This is a little gust of wind-borne sand. You know, the natural dune forming wind-driven processes continually deposit more sand on this. Here's actually a little bit of the gabion face that's exposed. A storm event has washed away the sand. But quickly, the dune grass starts sending its runners down the beach slope, grabbing onto sand, reinforcing the sand, and the system, there's this kind of give and take. The structure keeps excessive loss from occurring, but it's the natural wind deposition and the growth of vegetation that's actually helping to maintain and rebuild this system.

Yes?

AUDIENCE MEMBER: We did one similar to this in Rock Harbor in Orleans, and we used two-by three gabions as the structure underneath. And it's been in about ten years, and all we have had to do subsequently is work on maintaining somewhat of a foredune in front, and it's worked very similar to your picture. So it does work in the Cape Cod environment.

MS. GOLDSMITH: I'd love some pictures.

MR. O'CONNELL: One comment on that. Location, location, location will dictate longevity or not.

AUDIENCE MEMBER: This is Cape Cod Bay with a northwest fetch. There is marsh in front of it.

MR. O'CONNELL: Yes, and there's a quarter to a half-mile shallow sand flat fronting and sheltering it. A good site.

MS. GOLDSMITH: Well, I think the point that's being made is if you want to try to build a dune, whether it's a structurally reinforced dune or otherwise, it best be a place where the supply of sand and the windblown processes are in place to have a dune. If those processes are in place, you can have one of these instead of having a rock dike the way my in-laws down on Long Island chose to defend their town from the Atlantic.

Even further afield, throughout Asia, coastal erosion — these are some very dynamic low-lying areas. Much of the economic system in Thailand depends on not only the physical protection of their coastal areas, but also the biological productivity of those coastal areas, and how they support offshore fisheries as well as major ongoing aquaculture enterprises. And sadly, a lot of recent unplanned development has greatly impacted these, triggering some ongoing erosion problems, while greatly undermining water quality and general ecologic productivity in these areas. So various international development agencies are pouring funds in to both come up with concepts for solving these problems, as well as implement them and study their effects, and continue to manage the system accordingly.

But not surprisingly, a lot of these types of approaches are being employed and with great success. This particular illustration shows some gabion baffle systems — the preferred method here in the land of coconut production is pre-vegetating various coconut fiber materials with the various mangrove species and getting colonization. But it's a two-phase process, much as what's being used on the North Sea. The first phase is to construct adequate structure to help trap sediment and to knock down the energy level during storm events, so the plant materials can survive. If they do some planting in the back of it, then over time, the mangroves are spreading themselves out as the sediments accrete, as the energy levels are managed through the built practices as well as the effects of the emerging vegetation. And these systems tend to — this whole thing becomes very biologically productive mangrove swamp, essentially replacing ones that people built next door ten years ago.

So that's very successful from a stabilization standpoint as well as general productivity, ecological productivity and quality of life issues. These are all simultaneously being managed very effectively in the system based on these principles.

Here's a typical turn of the century — labor was cheap — hand-placed rock revetment. This particular one is for the stabilization of a roadbed along the Elbe River, a tidal river in northern Germany. And this actually shows the establishment of a vegetative berm in place of that. Some of the major seasonal ice impacts have destabilized the rock berm, vegetation has grown up through the rock revetment (**Figure 13**), and in general, people recognize the value of having a water quality buffer between the highway runoff and the receiving water. And so all of these problems could be simultaneously addressed by the creation of this berm and the vegetation.

So there are many areas where these things are being perceived as well worth the effort of a little bit of experimentation, a little bit of extra detail intra-disciplinary planning and design and construction as well.

Here's an example of a real typical local scenario, where you have an eroding coastal bank. Erosion just happens during the odd storm with storm surge conditions. In this particular project done close to ten years ago, folks involved in the project wanted to use a layer of plastic based filter fabric underneath a coir fascine bank stabilization treatment. These kinds of materials tend to inhibit the development of plants, and the connection of the plant roots with the underlying substrate. And as is the case with all of these treatments, it is all about location. It's about properly characterizing all of the site configurations, all of the forces active on site, and choosing a

Fig 13. Vegetation growing through a rock revetment

Fig 14. Coir fascine for bank stabilization

design approach that adequately addresses them.

This is a site that would never be a dune. It never was a dune, it won't be. If you want to try to make it a dune, you're going to have a real uphill battle. It has some relatively minor offshore energies, wonderful, gently sloping offshore and beach geometry. So really it's a pretty simple process to stabilize this area. You don't have to worry about toe stabilization. It's a really safe bet.

Often the weak link in projects like this have to do with the fact that sooner or later you run into the property line and you have kind of a piecemeal approach to these projects. It's wonderful to look at the scale and the scope of a project like the North Sea stabilization works. It would be a glorious day, I think, if some planning level studies were done in this region. Some general permits put through at the state, local and federal level, and some of these kinds of measures could be undertaken by people — if not all in one fell swoop, at least as part of a well thought-out plan. I think that would make the whole process a lot less painful for the individuals involved, and a lot more productive for the region's ecology and ultimately perhaps economy.

There are not that many coastal stabilization projects in the country, but there are a couple that have been around a long time. This particular project is in Fresh Kills, New York. It was done about twelve years ago. The problem here was that the New York City landfill operators on Staten Island accidentally scooped up and threw out about four hundred feet of salt marsh. The site manager asked a couple of workers to go pick up some of that plastic junk that has blown out there and snagged in the plant material, people were complaining. This they did with a bulldozer. The State said, you know, ahh, put it back. But it was actually fairly hard to put back the salt marsh because this whole area included — this was the area where the salt marsh was accidentally thrown out. This wonderful marsh here, wonderful marsh there, it got removed in this middle section. And this particular channel was used as barge access to the New York City landfill. So a number of heavily laden garbage barges were moving in and out of this channel on a daily basis, kicking up an enormous wake. So even though a well-developed marsh had the structural integrity of its root system to hold up under that force, getting new plants established here was a different matter. And, in fact, it was necessary to build a baffle-type breakwater system out of these coconut or coir fiber fascines (**Figure 14**) into the coir fascines and into the land sheltered by the coir fascines, a bunch of fairly simple small-size plugs went in. Once the plug is well established, it does start sending out shoots and sooner or later, provided it doesn't get pummeled to death or ripped out by moving water, it does tend to fill in. And over time, this site filled in despite, I might add, rather adverse soil conditions.

We've seen a lot about the baffle-type structures that can allow us to manage or manipulate energy levels and talked a little bit about use of weaker temporary biodegradable materials and how they're suitable in some cases using permanent structures. In other cases, where they're necessary, I'm encouraging people to be — well, at least to recognize that there are two different realms of what's possible. And I'd like to suggest that there are ways to use either a hundred percent natural soft materials or some of the harder structural materials, and at the end of the day, still deliver attractive, but most importantly, ecologically productive landscape zones when you're all finished.

So I don't see any big split between structure versus nature. The structure is a tool, and at the end of a day, hopefully it's stable landforms with healthy soils and productive vegetation that we will have. And there are many steps we can do to achieve that.

One of them is often just getting in there and reshaping the environment. Very often, we're starting out with a profile that looks like this. If your typical water elevations during a major physically active time period such as a good Northeaster, the water levels up here, not surprisingly, you start to create a very shallow bench here and then a very steep area here. In order to come up with the proper geometry to maintain stability over time, it's often necessary to create a proper slope condition that stays within the balance of soil, mechanical tensile strength, and often to create a zone at the proper elevation in relation to water surfaces so that good plants with tough roots can come in. And for this reason there are various forms of structural materials. Again, in some cases, it's going to be possible to make this type of structure out of biodegradable materials, and other cases, it's got to be something a little more rugged. But whatever your existing topography, it needs to be adapted to meet the energy levels. This site — this kind of configuration can be stable and relatively moderate energy levels, but you actually need tremendous widths of beach or marsh vegetation to adequately buffer sizeable energy levels. We see this in nature all the time. The most active zones in the landscape along the coastal system are those systems with the widest beaches and the widest marshes.

But ultimately, when it comes to managing these systems and designing coastal stabilization strategies that work hand in hand with the dynamic processes, there are a lot of things that can be used that folks have not been actively deploying here in our region. For example, if we stop looking at structure, recognizing the role, the passive role of shoreline geometry in either promoting instability or maintaining or promoting stability, at the end of the day, it's all about energy, how that plays out over time is a function of energy. And usually the energy is our enemy. It's the wave impact that creates the problems that we're trying to solve. But ultimately, energy can be your friend, the same energy that is freeing up, mobilizing soil particles and sediment particles and transferring them, moving them up and down the shoreline. This can be the source of sediment as well as the process that takes your land away. And ultimately solar energy is an input that promotes the growth of plants that, as we've seen, can be very functional at trapping and holding sediment.

Similarly, there are some very interesting coastal stabilization techniques that have been explored, to a certain extent, with very limited playtime here in the Northeast so far that use some kind of energy. Normally they're just hooked up to the power grid and suck off huge amounts of energy every day. But there's a huge opportunity to harness wind energy to operate some of these systems.

So let me just suggest that coastal environments tend to have a lot of sun and a lot of wind, the same attributes that draw the crowds every summer, and these are the things that can ultimately be part of the process of creating stability for coastal zones.

This is just a typical schematic that includes a couple of things that we've been talking about already: various woody and grassy plants, coir fascines, coir mesh dune fence to promote aeolian deposition (**Figure 15**). These are the kinds of things we've been talking about and that people in this region have been using for a while already. They can be very effective as, say, stabilizing a coastal bank or be adapted to other parts of the system as well.

There's a related type of treatment and I'll describe a little — I'll show a few pictures in a moment. Artificial seaweed is basically a baked up plastic version of some of this stuff that can be plopped and anchored in place, even in areas where vegetation can't grow because the energy levels are too high, the water quality is too poor, the water depth is inappropriate or what have you. But these have been used with great success throughout much of Europe and Asia, and I think working on some of the same principles as this, can be a fairly effective ingredient in various coastal environments for helping to maintain this very front edge of the shoreline profile.

And then this little system is a very interesting one. This is a system that basically —imagine this as a perforated pipe that runs underneath the beach, parallel to the beach. How many people here are familiar with these systems?

AUDIENCE MEMBER: We have one in Nantucket.

MS. GOLDSMITH: Yes, you have one at Sconset Beach. And

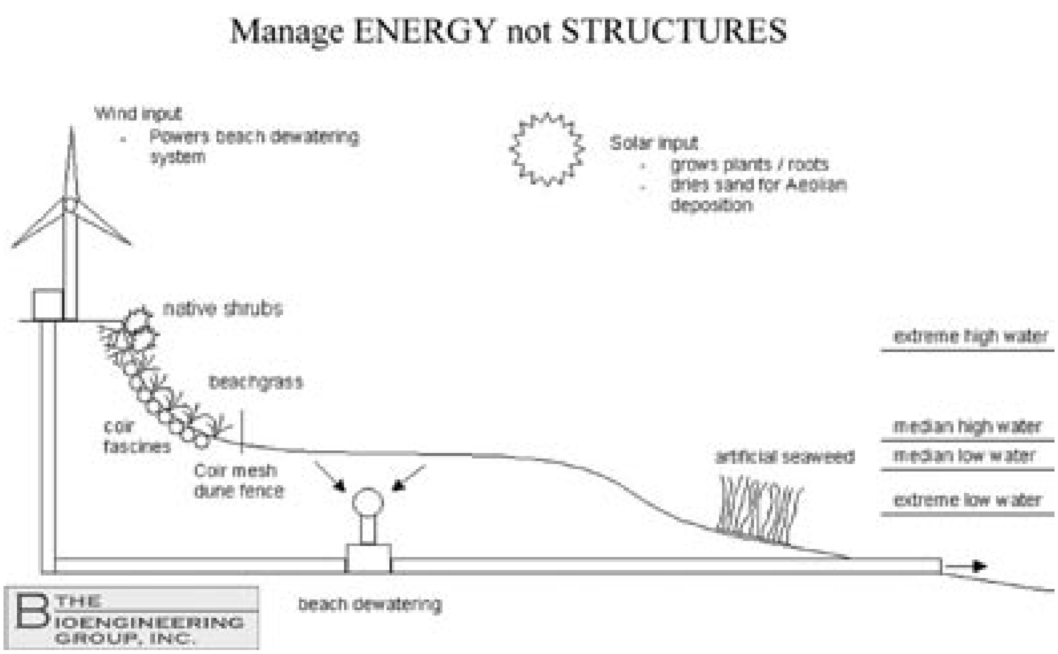

Fig 15. Manage energy not structures

there are a few of them elsewhere around the country. But they were actually discovered accidentally in Denmark when the operators of a local marine lab decided that maintaining their big saltwater aquarium — they were having a problem keeping their water chemistry right. So they said, why don't we just pump water in from the ocean and kind of keep our aquarium system re-circulating with real ocean water every day. So the engineers got to that, and they decided they were going to use the beach out in back of their marine lab — they had it almost as good as you guys have it here — they were going to use that beach as a natural sand filter. So they put a slotted pipe underneath the beach surface, and they just — they said we're going to pump water — the water elevation's going to be up here — water's going to have to pass through the beach, all of the little creatures and flotsam and jetsam and little bits of organic debris will be screened out by the sand of the beach, and we'll slurp lovely, clean, saltwater into our aquariums. They were doing this, and it was working just as they thought. It was fabulous. And then someone said, what's up with the beach? This beach has never been wider. During a storm event, it doesn't seem to be eroding, and in between storm events, it's accreting sand in a way that's completely different from what we've been carefully monitoring over the last twenty-five years.

And so they started looking into this, and they — well, they started noticing that there were physical reasons why that was happening, and that these were reasons that could be put to good use. And so this notion of a beach dewatering system to provide stability by managing the energy levels instead of the physical form made a lot of sense.

However, these are extreme energy consumers, and the one on Nantucket I think uses something like a third of the total energy consumption on the island on an annual basis. So it becomes a really good argument for a renewable energy source. I don't know how many of you are aware of this, but there is a small — we're taking some small steps toward renewable energy wind power generation in the coastal areas, even right here in Massachusetts. Very recently, Hull, Massachusetts, its first municipal electrical system wind generation station opened with great success. Technically, it's working beautifully. People have decided it's kind of beautiful, they like having it there, and, of course, on the back of the hybrid fuel vehicle, the "I'd rather be breathing" bumper sticker just points out that really renewable energy is definitely a direction we all should explore more. And any of the oceanfront sites where the stabilization problems are an issue, are, in fact, the same sites where the wind is in plentiful supply.

The way these beach dewatering systems work is that there is some kind of a pump here that is constantly drawing water in. There's some kind of a perforated pipe under the beach that water enters. And there's normally the water table where the water table of the land mass meets the water table — the water levels of the ocean. And before this pipe system is put in place, the water table may be something like this. When the water is being sucked into the pipe, the water table is depressed; in fact, there's a negative core pressure or an actual suction property within the beach sand matrix. So every time the waves slam into a sand front, you know, what happens is normally a whole mass of sand just kind of goes "pflumpt", and some of the particles become picked up by the water and carried away. In this case, the waves slam into the sand, they go down into that sand because there is some suction below the ground surface, and eventually, the amount of sand that is physically suspended decreases and actually the beach starts grabbing sand out of the water column.

So it has been shown in the areas where this has been studied to some extent that these are very effective. They're not robbing sand from other parts of the beach as much as they are collecting sand from the open water column. So this has some promise for fitting in from a regulatory standpoint.

They're also — being mostly buried, they tend to be, you know, reasonably acceptable from the aesthetic standpoint as well.

So again, as part of a dune-type system, you have the beach, you have this ongoing sand deposition happening by virtue of the dewatering system being located right about here.

Artificial seaweed is a slightly different matter. This artificial seaweed actually is made out of a lovely seaweed colored plastic and tends to have a relatively natural look. You can see a little bit of the heavy nylon strapping that makes up a large mat that can be anchored very firmly into the sea floor. This plastic tends to be buoyant and always floats up. And it functions much like the dune grass on a dune or the marsh vegetation in an estuary system. It physically slows water or air motion and tends to promote deposition. And, in fact, over time, these systems accrete enough sand to become buried. Now, during extreme storm events, some of that sand gets scoured away again, but then the process repeats itself, and it becomes buried. So this is a very soft structural way of mimicking the processes that natural plant communities employ to help create some stability at the front, most exposed edge of the shoreline profile.

And again, just putting it all together, this just depicts one possible scenario, all of which, however, has to do with using various materials in various zones relative to water surface elevations to help use the natural process, the ability to bring sediment to the site, enhance the natural process's ability or add some artificial processes to keep the sediment on site, but ultimately to keep all of the habitat zones within the area and to maintain the aesthetic characteristics of this beach system rather than imposing some major artificial structural treatments.

And I just thought I'd close with an interesting example of just how much value many people can put on the beauty of these coastal systems and our ability to manage them. We have — at our company we had an interesting opportunity to be invited to serve as technical consultants to a multimedia performance art project carried out on the island of Vinalhaven up in Maine. In this case, the property owner was a fairly well-known artist whose life work it is to restore the land that she bought, which formerly was a quarry, from which the Boston Public Library and the New York City Post Office's granite blocks were harvested — or were quarried. This bit of land was the stone wharf on which these cut blocks of granite were loaded onto the barges that took them to these major eastern cities. This area, however, had once been salt marsh. So this major stone-filled structure had obliterated this little marsh, and, in fact, there was maybe a stone fill area here.

So our project involved scooping out a lot of old broken chips and flakes and hunks of granite that were waste products from the granite shaping process, creating this little inlet that had a suitable level of stabilization, using various materials. Here's the pond, what's left of the quarry, here's the spit of land, and the spit of land provided a sheltering function that helped make salt marsh establishment in this area easier. Actually, the artist was there making diagrams and writing poetic text and basically trying to get everyone on her little island and anyone else who'd pay attention to notice the beauty and the importance of the little restoration and enhancement of the coastal resource area.

What we developed by way of a conceptual diagram showing the removal of the rock fill and the rock armor and the establishment of some various salt marsh elements, she added additional text and color to.

But ultimately at the end of the day, it was the restored resource area that was most interesting, although in addition to transforming a barren granite landscape into a vegetated coastal bank and salt marsh zone, Aviva Rahmani went on to continue producing various pieces. There's a video, there is a little dance piece that's been performed all over New England, and there are oil paintings documenting the different stages of the construction and development of the project. And my favorites are actually the stained glass period — pieces that depict all of this. But any way, just to remind us that there are many practical and functional elements to this, but as well, ultimately something that's perhaps a little more inspiring to many people.

And another thing we should all include is as a goal in how these things look, how these things educate, and how these things inspire people. It's another reason for us to look outside the box as we try to solve some of these problems, when we look a little further into less-tested terrain to try to solve some of these problems.

I'm here to gladly entertain a few minutes of questions.

Yes.

MR. KEON: Ted Keon, Chatham. One of the overriding themes that I wholeheartedly agree with is the importance of the geometry and the toe protection, if you will, by creating the transitions out at the base of the eroding bank or bluff or whatever it is you're dealing with. I also think that's one of the biggest problems that we face both from a regulatory perspective, economic perspective, in some cases a social perspective of actually moving into that zone. We are often regulated to only go to the high water point. You can't go beyond that, because then you are opening up a whole different realm of issues and again, socio-economic, et cetera. I don't know how they jumped that point. How do you actually get out into that low water area and do the proper engineering so that your shoreline stabilization, soft solution on the bank will, in fact, be effective?

MS. GOLDSMITH: Well, I think it's pretty safe to say that under the current very piecemeal, parcel by parcel approach to addressing these problems, it is just that. It's addressing a problem. And the regulatory response to one property owner protecting their interest is to basically get in the way of that. The greater public value isn't often something you can address on a site-by-site basis. And, in fact, to do the studies that would evaluate how to best achieve that, and to document the probable outcome of succeeding and achieving that, that's pretty costly to do, and it essentially doesn't happen at the parcel-by-parcel scale.

I mentioned it a little off-the-cuff earlier on, and I think it's a very worthwhile thing to consider addressing these problems on a regional scale, and to sort through some of the policy and permitting issues on a regional scale. And I think that — well, I'm hoping that some of the possible examples and methods that I've illustrated here could help introduce to a wider audience the notion that there are ways to simultaneously address the interests of the private property owner who, for whatever reason, owns a house or — maybe it's a town and they own a road or a park or whatever, in an area that's unstable.

I'm a geologist by training, first and foremost, so I take the long view. These are very ephemeral systems, many of them, and we're pretty silly if we think that there's anything permanent about them. But I have a hard time saying that to someone that has their life savings or their family's well-being closely connected with one of these situations.

And I think there's also a real opportunity, if you really assess the incremental loss of habitat and water quality within the region as well. That's no secret. There's an opportunity to take restorative measures that really do fill a greater number of social objectives.

So I'd love to see as a result of meetings like this more cooperation to help identify ways to do these things. And I hope this opens up people who may not have been aware of all of the possible strategies, to think about how they may lead into that type of scenario.

MR. BURGESS: Mark Burgess, with Coastal Engineering. You describe a lot of different soft solutions that work in freshwater environments and a lot of low energy areas. Some of the fiber roll solutions that you presented are in banks I would say, by the pictures, well above mean high water, not subjected to normal storm or wave energy. How do you feel about some of these soft solutions exposed to direct wave energy in areas such as velocity zones or below flood elevations?

MS. GOLDSMITH: Well, this talk really wasn't meant to be getting into some of the more quantitative design procedural issues, but there are a number of examples of — I personally have a lot of experience, and I know other people who have even more experience that I do working with a range of materials in situations just like what you're describing in fresh water and marine systems. So in general, I think a lot of these type of solutions can be relied upon to perform there.

I also illustrated some of the artificial seaweed and beach dewatering material as what I personally think are going to be better bets economically and aesthetically and ultimately regulatorily in a beach environment.

Any type of system that does not normally host a permanent vegetation community, can't be stabilized with a vegetative system alone. Many coastal banks are good candidates for stabilization with biodegradable materials rather than vegetation alone, and you get pretty permanent results. Other systems are going to be stable for twenty years and then experience retreat because of extreme events. In those cases, some of the soft treatments help delay and minimize some of the ground losing events, but they can't arrest it completely, nor is that necessarily what anybody is interested in achieving from a policy standpoint.

But there are other things. You know, I don't — I certainly don't want anybody to think that coconut fiber is a panacea and that everybody should use it everywhere, and it'll do everything. I don't believe that's true, and I think there are many other types of solutions that actually work at least as well, if not delivering better results aesthetically.

AUDIENCE MEMBER: I was wondering how well the dewatering system is working.

MS. GOLDSMITH: Well, I was so curious I took a peek not long ago out at Sconset, and I was really skeptical about whether that one was going to work because it's a very — it's a very active site with about the most coarse grain sand I've seen on a New England beach. And I was actually quite impressed by how well it seems to be working at this point.

I have no involvement with that scenario, but I've been following the fate of beach dewatering systems in this country for the last twelve years with great curiosity. The first system that was put in there, I believe, essentially really wasn't designed or built right for the site. It's since been completely revamped, and the system that is in place now does appear to be supporting it very well.

And I think also most beach environments have sand particle size distribution that's a lot easier to work with than the conditions out at Sconset. So hence, I think it has more promise in other sites than that one. If they can do it there, they can do it anywhere.

AUDIENCE MEMBER: How long has it been in?

MS. GOLDSMITH: I think they've only been powered up at Sconsett for a month or two. But the original system that had a number of issues went in — I'm not sure — maybe two years ago.

MR. O'CONNELL: Mid '90s.

MS. GOLDSMITH: Mid '90s or even longer.

MR. O'CONNELL: Janet, if you want to learn more about the system on Nantucket we can talk later. I've been tracking it since its installation and sat on the technical committee monitoring its progress, but there's a gentleman from DEP in the back of the room who's now on the technical monitoring committee for that project. I would sum it up saying the jury's still out on it. The pumping capacity was recently increased and new pipes installed. That significantly enhanced the pumping capacity because it wasn't meeting its design objective. That doesn't mean it's failing, it just wasn't meeting its design objective. Your counterpart, Jim Mahala from DEP in the back of the room is on the monitoring committee. So, if you want to get more updated information I'd suggest talking with Jim. He is currently reviewing the project and has been for a number of years.

I think we should probably cut it off at this point. Wendi, that was great. I think you gave us a lot to think about. Thank you.

MR. O'CONNELL: I think we'll break for lunch, so you can continue talking over lunch. This afternoon I hope we'll answer questions about installations in velocity zones and will they work there. What should our expectations be for installations in Velocity zones? This afternoon we'll discuss actual case histories presented by people who have installed these systems, both dune plants and fencing, and various bioengineering applications — biologs and so forth — in this region. So I think this afternoon we'll really get into some nitty-gritty about do they really work, where do they work, how much do they cost and so forth. So this afternoon, should be very interesting. So please be back by 1:00 o'clock, and we'll get back on schedule.

(LUNCHEON)

AFTERNOON SESSION

MR. O'CONNELL: Now we're going to get into the actual application and installation of some of these non-structural projects in the coastal environment in this region. This will be the time to ask questions about people's experiences, as well as offer your own case histories, from a planning and regulatory perspective, and get into the nuances of actually installing these type projects that were engineered prior to permitting. Please, offer experiences on site considerations or design changes based on site constraints. This is the time to give your experiences from what you have learned with these particular applications.

DUNE VEGETATION PLANTING AND SAND FENCING: THE DUXBURY BEACH EXPERIENCE

Joe Grady, Conservation Administrator, Town of Duxbury

MR. O'CONNELL: Our next speaker is Joe Grady. Joe Grady's been the conservation administrator in the Town of Duxbury on the South Shore of Massachusetts for fourteen years. He's also president of the Massachusetts Society of Municipal Conservation Professionals, which is a statewide organization of conservation commission agents. Along with myself, he's a trustee of the Duxbury Beach Reservation, who are the not-for-profit owners of Duxbury Beach. Joe was awarded the conservation administrator of the year award in 1998 by the Massachusetts Association of Conservation Commissions.

Joe is going to talk about his experience in dune grass planting and sand fencing on Duxbury Beach over many years.

MR. GRADY: Thank you, Jim.

I'll begin by giving you a little background about Duxbury Beach. It'll help you understand a little bit more about how we manage the beach. Duxbury Beach is a privately owned barrier beach on the South Shore, thirty miles south of Boston. It was purchased in 1919 by the Duxbury Beach Reservation, Incorporated. It's a nonprofit trust that purchased it to preserve it for future generations.

Both Jim and I are trustees. There's about thirty-five of us and a few other members are here today. We, on an annual basis, try to manage this barrier beach in Duxbury.

You can see here an aerial photo. This is Duxbury Beach Proper. It's a four mile section that heads south. It then turns west and runs another three miles. The section that runs from here to here (southern end) is actually in the Town of Plymouth, so it makes for some interesting management issues because it's quite a ways away from the Town of Plymouth Proper.

But as you can see, and as with most barrier beaches, there's an extensive bay behind the barrier and extensive salt marsh systems. This is Plymouth beyond. Plymouth Beach is right here in the upper right-hand corner. There's a narrow throat of water here that funnels in and out of the bay that serves the Town of Plymouth, the Town of Kingston, and the Town of Duxbury.

It's a very important barrier to the North Atlantic. It faces northeast and is the breakwater that protects thousands of private homes and private properties within the three-town embayment.

It also is host to some rare species, and it is extensively used for recreation on a year-round basis.

As I mentioned, the southern tip of the beach is actually in the Town of Plymouth. It is home to two hundred and ninety cottages, some of which are year-round. This is Gurnet, the first cottage community. You can see it's rather substantial. It has seventy homes, a lighthouse, so that the maintenance of the beach is a very important issue for these particular landowners.

There's a total of two hundred and ninety homes on the beach —on the southern section of the beach.

One of the issues that we've had to wrestle with in the 1960s and the 1970s was unrestricted motor vehicle use. You can see here that this is the area we call the High Pines Plain, and it was completely strewn with trails and just total unrestricted access, which caused a considerable amount of erosion, just from the use of the humans that visited the site.

Fig 16. Overwash of Duxbury Beach following the 1991 Halloween Northeaster

As with all of you, we also have standard coastal erosion, dune scarps that form after northeast storms, and some of them fairly substantial in size.

And then finally we have really what is total overwash **(Figure 16)** that is the result of the 1991 Halloween Storm, the Perfect Storm. It completely leveled our dune structure in probably seventy percent of the beach.

Fig 17. Rebuilt dune along Duxbury Beach

So what did we do from here? This is that same area today **(Figure 17)**. And what I want to talk to you a little bit about is some of the specifics of what we've done to try to develop a dune structure on this very narrow, very susceptible barrier beach.

I'll go back just to give you some sense of what it was like in 1991 (Figure 16). This is the exact same spot you just saw, with the ocean on the left. We had overwash from a series of high tides that completely leveled the dune structure and eliminated the gravel roadway. You can see what's left of the sand fencing, overwash fans and a considerable amount of our dune structure washed into the bay. The barrier probably moved back something in the range of a hundred to hundred and fifty feet during those tidal cycles.

So we put it back together over the last nine years, and I'll try to tell some of that story this afternoon.

Traditionally, as was discussed this morning by Bill from New Jersey, we would use sand fencing to collect sand. We liked to use multiple rows. And the sand would gather behind a row of fence. We planted. We put out another row of fence, and we'd fortify the width of dunes. This is something we did in the last ten years or so.

These are the plantings that we do in between. We plant the grass eighteen inches apart, six or seven inches deep. We'd wait for the sand to accrete within these fences, and over a period of time, we'd have row after row of sand fencing going out. If you had a period of good weather for five or ten years, you could bring the beach out seventy-five feet or so. We have photographs where these telephone poles were standing in the water after storms, and then over a period of time we were able to bring the fence out ten, twelve feet each season. And that's what we did primarily for management in those years. It was fairly successful. We ran into those same problems with beach grass dieback, those things that were mentioned this morning.

This is the same sort of thing. It's sort of a closer shot, where you can see where we would plant twelve feet of grass, put up a new set of sand fence, and hope to collect sand just like this to an elevation three, four, five, maybe six feet tall.

Since that time, we've had the piping plover listed as a threatened species. And they're very well disguised here on the barrier beach. This is a plover here. We have them nest on Duxbury Beach, as well as least terns. Because of that, we've had to modify our dune management program.

I'm in a fairly unique situation, in that I'm also not only a regulator, being a conservation administrator, but I'm a beach manager. So I have to perform both of these duties.

So we have to be very careful how we manage our dune activities relating to these particular species that visit our beach.

So here we have the beach in 1991. It's leveled — completely flat. And we have to worry about impacting endangered species habitat. As most of you probably know, being here from the Cape, piping plovers prefer nice, flat, low beaches like this, and the Wetlands Protection Act says that you're not allowed to have any short or long-term impacts to their habitat. So how in the world do you manage this piece of property with that as a threshold?

Well, what we finally did is we've developed, with the Army Corps of Engineers, a very substantial project of a sacrificial dune. Trucking in sand and constructing a dune that satisfied the requirements of the Wetlands Protection Act, Army Corps regulations, with a series of thresholds and regulations that we had to overcome. This is one of the euclids that was used to transport the material from a staging area four miles to the north. And what we designed was a barrier to an elevation of sixteen feet NGVD, ten feet wide across the top, with a slope of six to one on the back side and six to one on the ocean side.

Now, that did several different things with the design. The federal flood insurance folks funded the majority of this project. They determined that the barrier beach, Duxbury Beach, performed a substantial amount of flood prevention for all of those houses on the inland side of the embayment, and it was financially worthwhile for them to fund the construction of this dune or a dike in an effort to reduce future claims inland. So, they wanted to see that the entire structure be elevated to a minimum of sixteen feet NGVD. And I believe that was the storm elevation for a five-year storm event. The barrier was so low that they were afraid that there'd be substantial claims even on very minor storm events, storm events of less than five years. So they were willing to pay a price per cubic yard to bring sand in and sort of jump-start the beach and build some dunes to trip the waves, so that they wouldn't have additional insurance claims.

Well, then how do we overcome the endangered species situation? We worked very closely with the regulatory folks, and it was determined that we would try to develop a very gentle slope of this dike structure or dune structuring. We agreed to a six to one slope. And it was felt that the piping plover could live with that. That it was a gentle enough slope that they could travel from one side to the other, and that they may actually nest on it.

Since that time — it's nearly ten years ago — we have modified repairs to the structure. Now we're required to have it at a minimum of ten to one. The six to one was not a gentle enough slope for the piping plover. We've never documented a nest on that slope. We're not allowed to alter habitat, and so we once again have had to modify our management program, to take in effect the endangered species program.

So we constructed this dike wherever the beach was less than sixteen feet NGVD. It sounds like a tall elevation. It really isn't. We trucked in sand – actually twice. We did it in '91, and then we did it in '92. Before we finished the project in '91, we had another storm in December of '92 that took out the majority of the first sacrificial dune.

So the first project, I believe, was around sixty-five thousand cubic yards. The second project was more substantial, and it brought in over a hundred thousand cubic yards of material. You can see we ran Euclid four-wheel drive large dump trucks up and down. We spread the material with bulldozers. We were very careful to stay off of existing vegetation that had been previously planted. In some sections, it's nothing other than a long dike of sand. It's ten feet across the top – right here **(Figure 18)**, and it's a six to one slope. This is the roadway and a six to one slope off the backside. There's the bay side here and the ocean here.

We had nothing to start with, so it looks pretty bleak right here in this picture.

And this fulfilled the Army Corps requirements, and the flood insurance requirements. They wanted a big pile of sand out there. They were willing to compromise with the endangered

Fig 18. Sacrificial dune on Duxbury Beach

species regulations in order to accomplish this. It was a major negotiation process to accomplish the permits for this type of project.

Once the sand was in place, we then planted it and stabilized it, and I'll talk specifically about that. This is that same area that's in this previous picture here, the exact same spot. This is it today **(Figure 17)**, so it's pretty well stabilized. We have a pretty good dune structure to protect us. And, in fact, it was tested last March, March 4th. We had a significant flood event that overtopped the majority of the structure. The grass remained in place. We lost sand in only two locations. We really feel that this project has been a real success.

Grass planting — beach grass planting, as was discussed this morning, is a wonderful project for volunteers and for the community. Thousands of people use Duxbury Beach and feel a real love or affection for the property, and they are starving for things to do to protect the beach. We have the Duxbury Beach Preservation Society, and they raise nearly seventy-five thousand dollars a year just to preserve the beach through dances and selling T-shirts. The Girl Scouts and Brownies come out in great numbers to plant beach grass. It's a simple project. It's easy to do. With some supervision, we constructed these planters out of recycled steel from the transfer station. They're designed so that the person simply pushes their foot down to the designated depth and gets a sufficient eight or nine inch hole to install the grass in. It's a very simple project. And in 1991 and 1992, we planted over a million stalks of beach grass on Duxbury Beach. We had over eight hundred volunteers, and it was a very successful program. People were happy to come out. They were excited to be able to help restore the beach, the place that they loved that had been destroyed or flattened in the October, '91 storm.

However, once again, endangered species. The scientists tell us that the piping plover in particular do not like thick stands of American beach grass. So how do we overcome that threshold of no short or long-term impact to their habitat? We had to modify our program.

In the past, we would plant the entire area, any area that we could find that was bare, with beach grass, eighteen inches apart, two culms per hole. A culm is like a celery stalk. There's a clump of grass that's held together with several stems coming off, but it's one culm. And you put a culm in each hole.

We finally agreed with the regulators that we would only plant fifty percent of this sacrificial dune that was installed. We tried various methods of planting. We planted circles, we also planted what we called Chevrons. These are Chevrons. They're kind of Z-shaped areas. And finally, we've come up now most recently with a density of three feet on center: a broadcast planting that's only three feet on center.

And that satisfied the regulators with a density that would allow the plover to move from bayside to ocean-side freely and unobstructed. And it also satisfied the people who were paying for this project, the federal government, to stabilize this sand that they were trucking in at a fairly expensive cost. I think it was around twelve dollars a yard installed. So it was a matter of compromising, and it was a matter of trying to develop a plan that would work for all of those involved.

These again are the Chevrons that you can see, where we planted twenty-foot strips, zigzagged it across the structure and left bare areas in between. The Chevron is designed so that at no time can a drop of water travel from east to west over this dune structure without encountering a stalk of grass. So in other words, they go up to the top, and they zigzag across. They aren't straight shots across the top.

This is the way the place looks today. We then, after planting the grass, after trucking in the sand, we installed a single row of snow fence. Once again, it's a modification from our original program, where would put up series and series and series of snow fences. There were two reasons for that. One was the dieback issue. The other was the piping plover once again. Regulators felt that if there were several rows of snow fence, it would obstruct the travel of the plover chicks and the plovers themselves back and forth over this dune structure. So we compromised and we now only install a single row of snow fence. And the snow fence really, once the grass is installed, its primary job is just to keep people out of the grass. The grass will do all of the collection of sand, it will hold onto the existing sand. Once you establish a good layer of grass, it's not necessary to use sand fencing to collect or to hold onto it. But we get so many visitors here. We are inundated with people in the summertime that we really do need to actually draw a line and say, you cannot walk any further than this particular point.

And this is primarily what the fence is used for on the easterly side of this dune structure today.

I want to talk a little bit about installing sand fencing. I want to really get into some specifics here. I personally have installed miles of snow fencing. Last year I put up twenty-five thousand feet. I want to talk a little bit about how it withstands actions here. There are a few things going on in this picture. First of all, one of the things we do is we install a nail on the top to keep it from becoming a site for predators to stand on to look for plover and tern chicks. So, each of our posts has a nail spike at the top to keep it from becoming a perch.

I'll tell you, we've had limited success with that.

Secondly, we pinch the fence tight with a crowbar, and we install a staple in the fence. But what's critical here is the staple isn't driven all the way tight. It's left out a bit so the fence has the ability to slide back and forth. It's a very important thing because wind is a constant activity here on the beach, and if you pinch the fence on that pole, within a year or two the wind action going back and forth with snap that wire. So if you want the fence to last a while, you just tighten it down so that it still allows the wire to slip back and forth.

And then finally there's one other item that we do here, and on the top and bottom, we add a second wire, which gives it additional strength. We wire the fence back to separate points, and that way when the water comes over the top and comes back out the bottom, it adds more strength to the top and bottom of the fence. And it's just some little tricks that we've learned from miles and miles of snow fencing. A snow fence installed properly should last five years on its own before it actually starts to rust away.

So those are two items that should be helpful if you install sand fencing.

As Bill mentioned this morning, we have also observed areas on the beach where this die-back occurs in the American beach grass. And as he described, it is a result of the fact that beach grass is a sand-loving plant. Unless it is buried with sand or invigorated with sand, it just doesn't do very well. And as you start to stabilize areas and get areas back on the backside of the beach, we find that these areas die off, and we have to address that.

We were very concerned for quite some time as to what this was all about. I'd never spoken to Bill. I've never heard him speak before. So it's kind of interesting that we came to the same conclusions by taking separate paths.

We worked with Cornell University through the cranberry experiment station, to try to determine why the grass was dying. And what we found after a lot of research is that aphids were killing off the beach grass. The way that we handle it in Duxbury Beach is we fertilize the beach. In the past, we used to use helicopters. Helicopters can spread it pretty accurately. But, once again, in the regulatory scheme of things, we have scaled things back and now the entire beach is fertilized by hand.

As was discussed by several speakers this morning, we apply a very low rate of nitrogen, about twenty pounds per acre, and we buy the slowest-releasing nitrogen fertilizer that we can find. Now, in Duxbury, nitrogen isn't a big issue because of the tidal cycle in the bay. We have a nine foot tide on average, and the bay flushes completely twice a day, so nitrogen doesn't build up; but as a regulator, there are embayments that are very nitrogen sensitive, so it's very important if you use nitrogen — and you should if you're maintaining beach grass areas — you should put it on at a very low rate, and you have to have slow-release material. If you just pour it on and it rains real heavy as was mentioned, it's just going to run right back out into the environment, and nitrogen has some very negative impacts to embayments that have a very low-flushing rate.

So we, on an annual basis, fertilize the entire beach from head to foot, we apply by hand

— it's four miles of fertilizing. It sounds like a huge job, it is tiring and so forth, but it's the proper way to do it. You can put it where it's needed.

We feel that the fertilization is balancing the damaging effect of the aphids that are damaging the grass. It's almost like an IPM type management system, where we know that some of it's going to die off and we're willing to accept a certain level of that, but if we apply a very low dosage of nitrogen, we're able to balance some of that damage, and we don't lose the entire crop.

Realizing this dieback, we got into a program and we started looking at other types of plants. Nearly every one that was mentioned this morning is something that we have tried, not with very much successful. Our most successful woody plant that we plant on the beach is *Rosa Rugosa*. We have planted since 1991 over thirty-five thousand woody plants of various types. We have tremendous experience in trying to get things to grow in this very harsh environment. *Rosa Rugosa*, we found our best method was to plant bare rooted two- or three-year old plants directly into the sand as deep as possible and cut them back substantially. They usually were a twenty-four or thirty-six inch plant on top. We cut it back to eighteen inches. Plant them deep, deep, deep, so that they get down into that moisture and get their roots established. You also plant as early as you can. When we first started planting the million stalks of beach grass, we started planting in February. We were actually breaking the points off of those pointers because the ground was still frozen. If you can get a hole in the ground, you can put a plant in and try to get it established before the hot summer sun will start to act on these plants. Rosa Rugosa, we've had great success with. Ninety to ninety-five percent of the plants would take.

However, we then get into this issue of endangered species, and the discussion about whether it's an invasive and an exotic. As a result, we haven't planted any in the last few years. We've cut back our program. We shifted to other types of plants, but with much less success. We've planted beach plum, and we're lucky to get fifty percent of that to grow. We've tried red cedar — very poor success rate. We've tried Japanese black pine trees, even worse. Most of our activity now is focused towards the beach plum. It's a native plant. It does survive at about fifty percent.

One of the reasons that we try to plant woody shrubs in the back areas is that during and after these storm events, they still remain upright. Beach grass simply lays over when the water floods the beach. And after the event, there's sand blowing in all directions for days. This way, and it's blowing that way and it's blowing this way. And there's nothing there to catch it except for the woody plants. You can see how this — this is a beach plum bush — how the dune forms around it. Not only during the storm event do the upright plants collect rocks and organic matter and sand, but afterward, when the sand is blowing around in circles and there's nothing else to catch it. So as far as building dunes, woody shrubs are a wonderful way to do that. They're very, very difficult to get to grow in these environments though. The success rate is very low, and it's a constant, constant battle to get these to take.

Bayberry. We have planted bayberry from potted plants with great success. It's actually

Fig 19. Symbolic fencing on Duxbury Beach

a pretty good plant. It grows on its own, and it seems to be associated with birds because anywhere there's a cable for a bird to sit on, we're starting to see bayberry pop up. So it seems to come in on its own. It's a native plant. It's a nitrogen fixer as well, so it's a great plant for the beach.

Our latest technique is permanent symbolic fencing. Interesting term. What does it mean? Well, as I mentioned earlier, we have restricted ourselves now to a single row of snow fence, which is back here. During periods of fair weather, years or months, whatever it may be, the grass and dunes tend to migrate east, and we want to try to protect that area. So what we started to do was to install posts every fifty or a hundred feet, and we simply string string between them **(Figure 19)**. There's no other structure there, and we tell people that's the line. You stay away from the dunes from this line forward. It's been very successful. This right here, you can see a few posts here, was a previous year, and if the weather's good, we then have to move it out another twenty-five feet or so. And it provides another very nice buffer zone to the dunes behind. This is great habitat for piping plover and for least terns. It's a mixture of grass and sand and gravel. It also preserves the wrack line. Many of us, for different reasons, feel that this is a very successful program. It's called permanent symbolic fencing.

During the summer months, we actually have to bring metal poles out and bring it out a little further for piping plover issues.

But this is the way the beach looks today with a single row of fence, this permanent symbolic fencing that kind of moves back and forth, depending on the storm cycles.

Finally, I'll leave it with our signature birds. We quite regularly have snowy owls visit Duxbury Beach. This particular day it was about seventy degrees and they decided that it was far too hot for them, and they found a good piece of the beach to keep themselves cool. They're actually trapped at Logan Airport to keep them out of the airplane flight paths and they're deposited here on Duxbury Beach. It doesn't take them long to go back to Logan Airport, so it's a pretty good job.

But anyways, that's it. I'll answer any questions if you have any.

Yes?

AUDIENCE MEMBER: What do you think you'd have if you didn't do anything with that particular site? Not that you could have complicated management issues.

MR. GRADY: If there were no people around, the beach would heal very nicely on its own. Those overwash fans — that's all a natural process that we could talk about. The root structures from the roses and the beach plum and from the beach grass are all in that sediment that's been deposited on the bay side, and they are the beginnings of new dunes that will grow up. But what happens is we have so many visitors that the first place they go is the nice flat overwash fan, and they step on all of those root fragments, and they simply will not re-grow. It also takes time. And we're a little impatient. And so we want to give it a huge jump-start, and so we do that by trucking in sand and doing all of this work.

The beach itself has been there for a very long time. We have charts back to the 1700s, and it looks very similar today. It doesn't change like the beaches here on the south side of the Cape, where they're moving back and forth. Duxbury Beach has looked very similar for three hundred years. So I think that it would respond on its own. It is somewhat sand starved, and that's why if the federal government or anybody's willing to bring in some sand, we'll take it. We're always looking for more, but it will regenerate on its own. We just don't want to wait for it.

Yes?

MR. MEARLY: Just one quick comment. Dennis Merly, Mass. Audubon. You're selling yourself short with a fifty percent success rate of beach plum. I think that's good.

MR. GRADY: It is. Maybe we're spoiled with the other plants. The stuff we started with we get ninety or ninety-five percent, and we said, gee, great. You know, we're using a lot of non-profit money. As Audubon would know, it's not endless in supply, so we'd like to get more bang for the buck. But we also really try to balance all of these issues, the endangered species, you know, the Wetlands Protection Act, all of these things, and we're very inclusive to bring in all of the stakeholders in the process of developing these plans to restore the beach. We're always looking for new ideas. We're always modifying our program. This permanent symbolic fencing is one of the newest ideas that we've come up with. And if anyone else has any suggestions, we'd be happy to hear from them. We're always trying something else. We've tried that coastal panic grass. It hasn't worked. We tried hydro-seeding weeping love grass — it hasn't worked. We try different things.

Yes?

AUDIENCE MEMBER: What we do is around the perimeter of the plantings — we put up a snow fence. Just inside the snow fence, we put a row of Rosa Rugosa. Behind that, we do two feet of twelve on center, two culms of beach grass, then eighteen inch for the rest of the areas. And it's worked fine for us.

MR. GRADY: So you're making islands of vegetation.

AUDIENCE MEMBER: We're making islands. We leave passes through with board planks to access the beach from the parking areas. No walk zones. The best one that we have in the south coast area would be in Swansea, Ocean Road. We're about to start a new one — actually, we're going to start planting next week in Wareham, East River over at Onset Beach. It worked great for us, but the biggest thing that we found is maintenance. The Town or the manager has to go out every year to make sure that those fences are still intact — that the planks are down, because as soon as people start walking over it, it's gone.

MR. GRADY: Yeah, and that's on an annual basis. We don't just respond to storms. Every year we are doing projects on the beach. We're constantly trying to shore it up for the next big storm. It's coming. We don't know when. It could be tomorrow — it could be five years from now. And we're always working on it. And when it comes to federal funds and FEMA funds, if they realize that you've been doing it all the time, you're more eligible for disaster assistance when that occurs. As long as you can document your expenditures, you can certify that it's sort of an engineering situation.

The use of roses for people control, we do the same thing. We try to put them in dense areas around the parking lot to keep people to walkways. It's sort of the barbed wire of the north-east, I guess. The only problem is it collects trash. It's really hard to get plastic bags out of the Rosa Rugosa.

Another point. Rosa Rugs is excellent for cobble beaches. It doesn't grow very fast. I don't think I'd call it an invasive exotic. In sandy areas, we've planted plants that were three feet tall, and five years later they're four feet tall. It doesn't grow with great vigor. However, in rocky areas, if you can get it in the ground, my experience is it does very well. Very well. I would very much promote it for cobbly beach areas.

AUDIENCE MEMBER: Joe, just a reminder. If you're going to be planting that, not only cut back the tops, but also the roots. That invigorates the roots to spread out. And be careful not to J root them because they'll come with big long roots. Don't put them in a short hole.

MR. GRADY: Yeah. It's the planting technique. Rich (Poole) has provided the plants for years, and we've tried all sorts of things. We've tried buying just whips and installing them in a nursery, or installing them in containers and then transporting them out to the beach.

What we found is that if they're in containers of loam, and then you plant them balled or loamed into the holes in the beach, they never leave that little confine of loan. We now try to get them out into the sandy environment as soon as we can, as young as we can. They seem to survive better. You know, you don't want to baby them in some beautiful nursery eight miles from the shore and then dump them out onto a barrier beach. It's a huge difference for them. So I would recommend bare root whenever possible, as small a plant as possible. Plant them in groups. Someone once told me that plants should be in odd numbers, so we always plant them in odd numbers. We used to plant, you know, one here and one over there, and one down there. Now we put them all together, you know, three feet together. We try to bring them in together as groups, and they seem to do better.

Yes?

AUDIENCE MEMBER: Mashpee Conservation. Have you tried Virginia rose, the native beach rose?

MR. GRADY: No, I have not. Maybe I will.

Are there supplies of those that are readily available?

AUDIENCE MEMBER: Yeah. More all the time are available. And it is on coastal embankments on the Cape. It's naturalized there. It does very well there.

MR. GRADY: Yes?

MS. FRIEDMAN: Jan Friedman from Coastal Resources Management Council. Does your beach grass spread into the areas that aren't planted when you do the Chevron?

MR. GRADY: It does.

MS. FRIEDMAN: And do you have a problem with the piping plover issues?

MR. GRADY: Yes. We've reached a point where we've been storm free for so many years that much of these areas that were set aside for plover migration and habitat have grown in. They're not as dense as the other areas. You can still visibly see them, even after ten years. But what we've tried to do is we've actually constructed areas since then for plovers. We've brought sand in and covered up the beach grass — they look like overwash fans. It's been quite successful. It's more successful if you're able to put some native sand on top of the trucked-in sand. Color appears to be an issue. You need to match the color of the beach sand. It's hard to find it in quarry sand, so what we do is cover it with native sand afterward. Very successful. We've had some of the earliest nesting of piping plovers on these manmade sites. Give it a try. So during cycles, you do need to modify the vegetation if you want to try to continue good plover management.

AUDIENCE MEMBER: I'd like to follow up on sediment. So you get quarry sand and then cover it? Because I have trouble finding sand.

MR. GRADY: Yes, it's trucked in from a local sandpit.

AUDIENCE MEMBER: And do you have to do sediment analysis?

MR. GRADY: Yeah. We try to match grain size, but what is grain size? Grain size is wherever you pick it up.

AUDIENCE MEMBER: How do you do it?

MR. GRADY: Over the four miles of the beach, we have sections that are nothing but cobbles that are this size. And we have other areas that are sugar sand. So yes, we try to match it. We try to -- you know, we're not after every grain of sand for instance, but it's very interpretive.

AUDIENCE MEMBER: Very interpretive?

MR. GRADY: Yeah. Where do you grab the sample from?

AUDIENCE MEMBER: Right. But you err to the more coarse or the more fine?

MR. GRADY: Coarse.

AUDIENCE MEMBER: And then where do you get your natural sand to top it off and how much are we talking?

MR. GRADY: It can be as little as an inch. The sand that overwashes into the roadway and parking areas, we gather that up, collect it, store it for theses events. Sometimes we'll actually dig out underneath where we're going to put the sand and basically flip it over. Dig a hole, fill it with the quarry stuff and put the natural stuff on top.

During a storm event, it all gets mixed up and you'd be pretty hard pressed to see the quarry sand versus the natural sand. Sometimes you'll see a thin layer here or there.

AUDIENCE MEMBER: Okay, thanks.

MR. GRADY: I'll be happy to talk with any of you afterward and during the panel.

MR. O'CONNELL: One more comment about the beach looking the same since the 1700s. If you look at the shoreline change map for Duxbury Beach, the beach is the exact same width it was in the mid-1800s, only it's a hundred and thirty feet landward based on the measurements we did on the shoreline change map. Thank you Joe.

DUNE RESTORATION, COASTAL BANK, AND SALTMARSH VEGETATIVE STABILIZATION: CASE HISTORIES

Tim Friary, Owner, Cape Cod Organic Farm, Barnstable, MA

MR. O'CONNELL: Our next speaker is Tim Friary. Tim is the owner of Cape Cod Organic Farm in Barnstable and is involved in the propagation, growing, selling, and installation of coastal plant materials. Tim has been growing coastal and wetland plants for twenty years. He was a working partner at the Seabury Farm for fourteen years, and a member of the Board of Cooperators for the Cape Cod Soil Conservation District. Over the years, Tim has gained practical experience by utilizing various techniques and plants for marsh restoration, dune, and bank stabilization. Tim is going to discuss two case studies: one on dune restoration and the other a coastal bank restoration project.

Fig 20. Dune restoration project in Chatham

MR: FRIARY: I've been dong this for quite some time and I've tried different techniques on marsh restoration and bank stabilization. Most of my experience comes from practical experience.

This is a project I did in Chatham (**Figure 20**). It's a coastal dune system that was created from dredge spoils taken from Chatham Harbor. That's Ted Keon, Coastal Resource Officer. Here we are measuring out the area, and you can see there's some *Ammophilla* there already (**Figure 21**). He was trying to create a dune system with sand from a dredging project in Chatham, but he was getting a lot of sand buildup and it was spilling over onto a neighbor's property. So, the project was to keep the sand from escaping and to collect other sand that was blown by the wind.

This is what it looked like prior to the project – the year before the project in 1998. To accomplish our goal, a parallel, double-row fence was placed along the backside of the dune. Twenty-foot long embayments were created by running a double-rowed fence perpendicular to the beach. Between and behind the embayments, *Ammophilla breviligulata* — beach grass — was planted. The beach grass was planted twelve inches off center, two culms per hole. Beach grass is a front-line plant that is used to collect sand. It appears that there was a tenfold increase in the beach grass. Further back, goldenrod and asters came in, giving seasonal color. The area is becoming a diversified dune system.

Fig 21. Preparing the dune restoration site in Chatham

This next project was for an engineering firm out of Boston, to fix a problem in Barnstable Village, where a headwater was placed too far out in a marsh. The headwater had been gouged out and went down about four feet. One issue was identifying the soil and deciding what could be done to replicate the soil. Steve Spear from the United States Department of Agriculture was contacted to help identify the soil type. He brought a soil survey book of Barnstable County, published by the USDA, which plots all the soil types on the Cape. It was concluded that the soil in this area was Ipswich soil, a marsh soil. Using a screener, soil was created made up of seven parts peat to one part clay. The soil was then compacted in the gouge to a depth of three and one half feet. Another issue was that there was fresh water coming out of this headwater, most of it collected from the county complex. Through the marsh area, *Spartina alterniflora* was planted, which can grow well in brackish and even fresh water. *Panicium varigatium,* or switch grass, was also planted on the top and side banks. Another grass called *Agropyrum*, or stiff-leafed quack grass, was planted along the margin of the marsh, forming a nice berm.

This is a project that was relatively successful in Chatham. WE put fiber rolls in and planted stiff leaf quack grass on top. This was filled in with soil over coconut fiber rolls. If I had the opportunity to do it again, I think I would probably put more of a clay base to hold it better.

We planted the area with *Spartina alternaflora*, which came up nicely. On the bank where the fiber rolls were we planted *Patens*, which unfortunately is gone. But at the top the stiff leaf quack grass is actually green now. What is going to happen is that the berm is going to come up a foot or two. It's a great berm builder. I say its an underutilized grass. The stiff leaf quack grass is a prolific grass. I use jute netting to hold things on top here.

You cans see the parking lot out here. Fortunately, this particular project was in conjunction with the Chatham Conservation Commission – they're going to put in a parking lot here. We got our plant material right from then parking lot, right through the area that was gouged out.

It's a thought for conservation commissions. If you're going to be taking out an area or making something different out of a parking area, you have native grasses or material that you can use on projects, particularly projects that are right there. I think its something that should be looked into.

But I think this will stabilize. Again, I think there's a little bit of amended soil of clay and peat on that bank that will do well.

MR. O'CONNELL: What kind of material did you use underneath that eroded area?

MR. FRIARY: Sandy Loam.

This is an interesting situation. This is Phragmites. This is growing on a coastal bank in Sandwich. I want to talk a little bit about that.

Another interesting situation that occurs on coastal banks, particularly from Sandwich to Barnstable and also on Nantucket, is that the coastal banks have a clay lens that creates a wetlands situation. In this particular slide, Phragmites, a freshwater wetland plant can be seen growing on the coastal bank (**Figure 22**). Often, rather than planting wetland plants like *Vaccinium corymbosum*, highbush blueberry, *Vibirnum dentatum*, arrowwood, or rushes such as *Juncus canadensis* and *Juncus marginatus,* people will plant beach grass, which is not the appropriate application. When planting is to be done in these clay banks, a consultant should be called in to observe the site in order to decide which type of plants are right. The area in the slide was planted with beach grass, and most likely, within two years, wetland plants will crowd out the beach grass, rendering it nonfunctional for bank stabilization.

In this coastal bank area, *Ammophilla breviligulata* was planted **(Figure 23)**. One thing some people worry about is dieback and the introduction of pathogens. However, if there is a healthy stand of grass, the issue is mitigated. One key to healthy grass on a coastal bank where there is no accretion of sand is fertilization. An application of about one hundred pounds of fertilizer per year, per acre is adequate. Without fertilization, the beach grass will not stay healthy, and there will be almost total dieback that will eventually cause an erosion problem. Other plant species such as seaside goldenrod and New England asters are migrating into the area, creating a healthy coastal bank environment.

Fig 22. Phragmities growing on a coastal bank

This particular area was a job that was done in Brewster in October. It was a snow fence installation. Again, you can see the double snow fence. I like to use that double snow fence because once it hits, it falls to the ground and it doesn't get a chance to escape. This was gouged out — this back dune. I put it in maybe a foot and a half to two feet away from the gouged out area. That should all fill in. What we're going to do in the springtime is go back and plant that.

Fig 23. Healthy coastal bank environment

This particular area gets a lot of wave action, too, and a lot of wrack. And again, with the double snow fencing, I think it's a cheaper way than some of the other fencing. It collects a lot of wrack, and when you get a good buildup of rack, you get a good buildup of sand.

This was October. Here's the buildup of sand we've had so far this year. This is a couple of weeks ago. It did very well.

MR. O'CONNELL: You used just exclusively beach grass there?

MR. FRIARY: In this particular spot, yes. There is going to be a large accretion of sand. There's always going to be sand blowing. Again, you can see that wrack built up in there, too. That's going to be nice. What happens in a lot of these situations is you get a lot of sand buildup now on that wrack. You know, the fence will guard that and you get wrack built up on there.

And that's the sand that built up in the back there.

In this particular spot is *Amophilla* on a coastal bank. There's been a lot of talk about die back and a lot of pathogens coming in. This is a job that I had done five or six years ago and look how healthy that grass is there. And it's on a coastal bank, there's no accretion of sand. You know, how do you do it? You fertilize. My application may be about a hundred pounds per acre. That bank there was a quarter of an acre, and we used about twenty-five pounds of fertilizer a year on that. And that's what you get. If you don't fertilize it, you're going to run into problems. You're going to have erosion problems.

We've got other species that are migrating in there. But with a healthy stand of grass like that, that's nice. That stabilized that man's bank quite well.

A lot of customers that I run into, homeowners, won't do that, they won't fertilize, and that's a big problem.

MR. O'CONNELL: Why would you not diversify the plants there? Like stiffleaf quack grass?

MR. FRIARY: It's a coastal bank, for one thing. You're not getting diversification coming in there. You've already got plants migrating in there. You've got a healthy stand of grass to begin with. Other plants are coming in. They're going to naturally succeed in there.

AUDIENCE MEMBER: Is this in an embayment?

MR. FRIARY: This is on a coastal bank in Eastham, just on a bank. It's not an embayment at all.

Here is another area planted with beach grass in Maushop Village in New Seabury. This beach grass is in its sixth or seventh year on a coastal bank with no accretion of sand. There has been no dieback and the beach grass is very strong. Again, fertilization is a key. Another factor is pH. An application of four tons of lime per acre gives the grass the opportunity to take in a lot of nutrients, which it would not do otherwise because the pH would be too high. This technique was used on Sampson's Island, an Audubon island, and the beach grass is prolific there.

This is a great example — irrigation on coastal banks. This is a gouge here. I get customers calling me in May every year, can I go out and plant beach grass. And I tell them no. They say what if we put water on it. I tell them no. And sure enough, somebody will sell them beach grass. And you go down the coast, anywhere you go, any town, you're going to have somebody running the sprinkler out on a coastal bank. And here's your erosion. I think they kind of blew it.

MR. O'CONNELL: Do you think that was from the runoff caused by the sprinkler and not wave action?

Fig 24. Coastal bank stabilization with plants and a drift fence

MR. FRIARY: I've got a strong suspicion that was done one year and the next year it was like that. I don't think there was particularly wave action on that. I see it happening quite often.

This is a particular job that we did down in Truro **(Figure 24)**. And this is a drift fence here, with the green post. It's

Fig 25. Coastal bank stabilization with a variety of coastal plants

a very strong structure with a lot of give for wave action. Its stronger than a snow fence. A drift fence is basically constructed of two by fours with posts like telephone poles. It's put in in a zigzag fashion.

This particular job required a diversified collection of plants **(Figure 25)**. We planted beach grass all through here, in addition to beach plum, bayberry and *Rosa Rugosa*. The plants were mixed so as to create a naturalized system. I used two-gallon plants about three feet apart. And I get a pretty quick return on that — highly successful. The rows are five feet apart. I have very good success rate with my jobs. I do amend my soil with peat moss. And I either plant in the fall or early spring.

MR. O'CONNELL: What's the latest date you would plant?

MR. FRIARY: The latest date I would plant — I plant all winter. I grow all this stock myself. It doesn't matter if you're sitting on top of the ground in my yard or in the ground on the beach. We're talking about hardy stuff like beach plum, bayberry, Rosa Rugosa and your native grasses. I have no problem with it. Beach grass is planted from October 15 through April 15. All other coastal plant material can be planted any time throughout the year, but preferably from early Spring to early summer.

Wetlands materials, plants on a coastal bank like blueberry, probably Vibernum, Dentatum, and pussywillow, I wouldn't plant in winter. I would wait until the springtime to do that. It's more of an opportunity for it to freeze and unfreeze and ruin the roots because of the water factor.

Any questions?

AUDIENCE MEMBER: Can you show the slide that had phragmities in it, and can you discuss planting beach grass in a freshwater wetland. I didn't make the connection.

MR. FRIARY: I think what happens a lot of times is conservation commissions will go out and look at a coastal bank and don't take into account that there's freshwater there, that there's clay lenses, with water coming out. And actually the plants that are growing there are freshwater plants instead of *Ammophilla*. Somebody had gone in there and planted that *Ammophilla*. I didn't actually do that job. They had planted the *Ammophilla*, and what should have been planted here were wetlands plants and grasses.

AUDIENCE MEMBER: So what happened? The beach grass died?

MR. FRIARY: The beach grass will die in a couple of years. It won't compete with the wetlands plants.

MR. O'CONNELL: What kind of wetlands plants did you plant?

MR. FRIARY: What you see growing out there now is blueberry, *Vibernum dentatim* and *Vibernum lantago*t.

AUDIENCE MEMBER: Would you say for bare root American beach grass planting, what's the best -- is March 15th to April 15th the most optimum part of the spring for planting that?

MR. FRIARY: I grow it commercially in the nursery, and I like to lay my stock out in November or December. This year's been a little funny though. This was a warm winter, and it started kicking out the roots. But generally I have no real preference. Anywhere from October 15th through April 15th.

AUDIENCE MEMBER: Is a decent time winter if the ground is not froze?

MR. FRIARY: If you're planting on a frontal dune, you've got to take into consideration, are you going to get wave action that may take out the plants. Are you going to get a coastal storm. Or if you're planting on a coastal bank where there's a high susceptibility of losing your grass. It depends on the situation.

AUDIENCE MEMBER: When you're fertilizing, do you do it after the installation and just one time a year, or do you do it every six months?

MR. FRIARY: I do it April 15^{th}, right then. That's the end. It's kicking out really good. I'll go around to my job sites that I did over the wintertime, and fertilize them if that's what the customer wants.

AUDIENCE MEMBER: And that's the one time a year that you do it?

MR. FRIARY: That's it. In my nursery, where I want high production, I'll fertilize twice a year. I'll go in there again around June 30th.

MR. KEON: I didn't know you were showing the slides of Chatham and we hadn't really had time to talk. That one site where the fiber rolls were exposed I didn't know what had happened, so I went there this winter and saw we lost the lower half of the bank. That area is called Taylor's Pond, it's a small interior tidal embayment. Even with this winter we still had some fringe ice around the pond. I have a feeling that it was tidal action and mechanical wearing through the ice. And in that kind of a situation, I'm not sure how we address that? Do we plant it again, or are we just going to get the same result next winter if we have a bigger ice setup.

MR. FRIARY: Ted, I think what should be done there should be a spring planting again with probably a clay base soil — something that's a little heavier. And I think what's going to happen there is that the flora right in front is really going to pick up.

AUDIENCE MEMBER: Regarding your fertilizing, do you use or incorporate organics?

MR. FRIARY: I've got an organic farm, so my beach grass on my farm is organic fertilized. I don't use it out on the coastal banks though or a dune situation. I don't do it when I go out, no.

AUDIENCE MEMBER: What are you using for a fertilizer on a coastal bank?

MR. FRIARY: Triple ten. Ten-ten-ten.

AUDIENCE MEMBER: Is that a chemical fertilizer?

MR. FRIARY: It's a chemical. I use a quick-release fertilizer.

AUDIENCE MEMBER: Would you make a distinction between applying that in an embayment area bank versus a bank on Cape Cod Bay, where you have a large tidal range?

MR. FRIARY: I wouldn't fertilize it if there was a large storm surge coming or anything like that. I usually like to fertilize right before storm rain so it gets in.

MR. O'CONNELL: Thank you, Tim.

BIOENGINEERING FOR COASTAL BANK STABILIZATION: CASE STUDIES

Lee Wieshar and Leslie Fields, Woods Hole Group, Falmouth, MA

MR. O'CONNELL: We have two individuals presenting the next session. First up is Dr. Lee Wieshar. Lee has over twenty years of experience in the field of oceanography and coastal engineering. He has worked on projects requiring the evaluation of near shore processes, sediment transport, inlet dynamics, erosion control, and marsh restoration. He has a BS in engineering from Michigan State University, an MS in coastal geology from Virginia Institute of Marine Science and College of William and Mary, and a Ph.D. in nearshore processes and sediment transport from Purdue University. Lee's also worked for the Army Corps of Engineers' Coastal Engineering Research Center for eight years.

His co-presenter is Leslie Fields. Leslie has over fifteen years of experience in geological and coastal processes evaluation. She has overseen the design and construction of projects involving both soft and hard coastal engineering structures. Leslie is well versed in all permitting requirements on the local, state, and federal level for coastal construction. She has a BS in geology from Southern Methodist University, and an MA in coastal geology from Rutgers. She worked at the Coastal Engineering Research Center for five years, and has been with the Woods Hole Group in Falmouth for the last thirteen years.

Together they're going to present and discuss several case studies involving coastal bank stabilization using fill, terracing, plants, and bio-logs, both here on the Cape, and on the Islands. Lee.

MR. WEISHER: I'm glad to be here today. As Jim said, I'm going to present an introduction and two case studies, and Leslie will present another two. What we're going to talk about today is how we approach a project. When we go into a project, we look at site processes and the (state) wetlands regulations to see what our possible solutions might be. Then, depending upon what the site dictates and what the regulations allow us we develop a solution to the problem. Here are some of the different types of what we call soft engineering solutions. We don't approach a problem by saying one solution fits all. We try and match the solution to the problem based on the geomorphology and coastal processes of the site. And, of course, what we're going to talk about today is bioengineering. The two projects I'm going to present are going to show how we approached the problem and developed a solution.

Now, there are some advantages of bioengineering, which I'm sure you've been talking about this morning. Some advantages are they increase the stability of the bank, beach, or dune. During previous presentations we've been talking about beach grasses and planting. Beach grass can grow up through three feet of accretion of sand in a year. And indeed, we have built dunes just by using sand fencing and beach grass. In many of these projects there has been an accumulation of three plus feet a year and the beach grass has kept up.

Conversely, when we have overwashes, and/or the dunes shift, and there's beach grass underneath, we'll oftentimes just wait and see what happens, and the beach grass most often grows up through several feet of sand.

Beach grass stabilized dunes enhance habitat and provides a potential sediment source during storms. The engineering solution itself doesn't, because a potential soft engineering solution tends to fail and require maintenance. The failing of the soft engineering solution oftentimes provides sediment derived from erosion and replaces sediment from the coastal bank. This erosion process allows sediment to get back into the system and may dissipate limited amounts of the wave energy.

Soft engineering solutions have disadvantages. Soft engineering solutions may fail during severe conditions. We all know that. Therefore they will require maintenance. The frequency of maintenance depends on the coastal processes on the site. Additionally installation and construction may be costly and often requires heavy machinery on the beach.

A lot of times we will go to a commission meeting and show a soft engineering design, and the Conservation Commission, not so much anymore, but when we started this about ten years ago, the Conservation Administrators would go absolutely crazy because of the fact that you have a large front-end payloader on the site because you have to move and place these bio-logs on the site. The bio-logs are big and they're heavy. The commissions just didn't realize what was required to construct a project. So now we're careful to give a construction methodology and to explain exactly how the project is going to be constructed, so there are no surprises.

Design considerations. When we look at the site, we try to look at the processes that are there. We look at the wave energy, the currents, and geomorphology of the beach. You're going to see this in my first example. We had all of these processes to deal with. We also looked at the tide range, site run-off, width of the beach, and other geomorphologic features that may be present. All of these go into dictating what's possible and what might help the project succeed.

The first project I'm going to show is on Nantucket Sound, on the Island of Nantucket

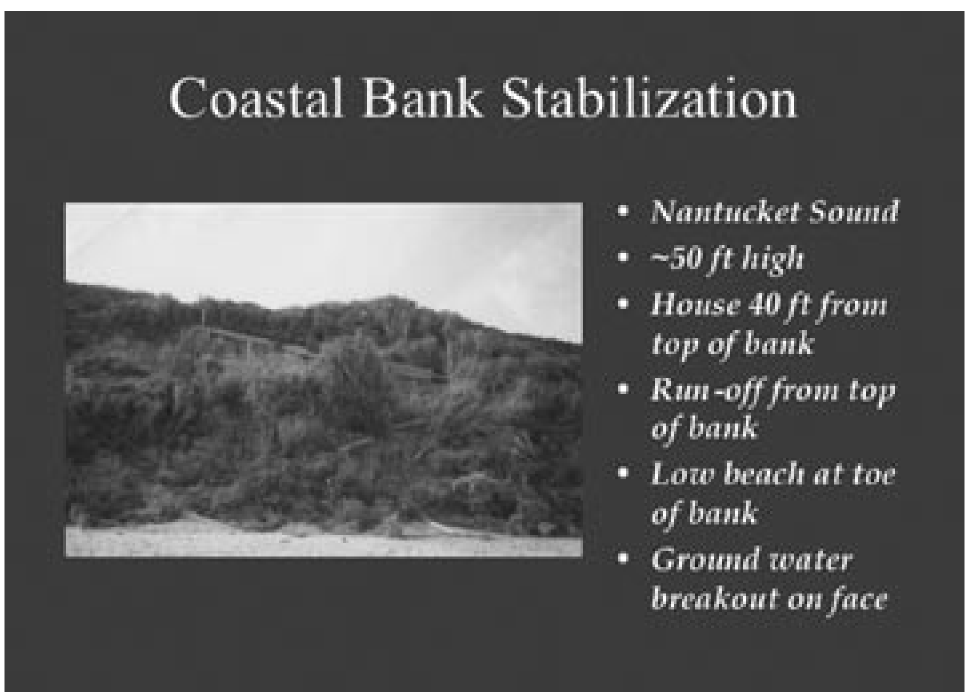

Fig 26. Coastal bank proposed for restoration on Nantucket

(Figure 26). This project had about a fifty-foot high coastal bank. This is what the bank looked like pre-restoration. There was actually a pathway (beach access) that was cut into the face of the coastal bank. People traversed the bank in a zigzag pattern. There was a handrail that was at the edge of the path and had failed. The new owners purchased the property for multiple millions of dollars and decided that because their house was only forty feet away from the top of a fifty-foot coastal bank, they might want to do something to stabilize the erosion.

Fig 27. Terraces built across the coastal bank

There were some problems with this site. First of all, because this was a single site on a long stretch of open beach there are no coastal engineering structures along this section of beach. So, first of all, even though it was an old house, it did not make sense to suggest a revetment or other hard engineering solution as an erosion mitigation solution. And so we started looking at what the project required. We had about six hundred feet of coastal beach to restore. Our objective was to restore the bank and restore vegetation to the bank. Also, you'll see in one of the slides, we also had a big clay head in the middle of the project that was channeling runoff so that we had groundwater that periodically broke out of the bank and caused erosion from the breakout. We designed and permitted the project in the fall of 1992. Construction was completed in 1993. I'll show you how the project has lasted.

Erosion began at this site during one of the large storms in the early 1990's. It eroded the beach and eroded the face of the coastal bank. Now this is the same location, this is actually the same handrail that you saw, has fallen down. The erosion left us with a very crenulated coastal bank, very steep. The erosion mitigation design had to consider all these factors.

Here is the clay head, located at one of the terminus ends of the project. You can see where groundwater breaks out of here and essentially strips the sandy material off the bank.

A look at another section of the bank. This is, again, very steep. You can see that the vegetation is sliding down the face of the bank.

This is just a section of the plan showing one of the two properties that we were restoring. Basically, you can see the top of the coastal bank is about fifty some feet. The house is situated right about here. We had a challenge of how do we develop a reasonable slope, while not allowing the top to retreat landward? We needed to maintain a stable slope, and in our estimation, that required bringing material into the site. So bringing the material into the site, you can't just dump it down onto the bank face — from forty feet up in the air and expect that it's going to stay there. These factors created a rather large engineering challenge for us.

We solved the problem by building a series of timber terraces across the face of the bank at the steepest locations, and then filled behind them (**Figure 27**). The purpose of the terraces was to catch the material as it was poured down over the bank, so that as we poured the material from the top, the terraces would catch the sand and prevent it from cascading down to the beach. The contractor got a little over aggressive, even though we over-designed these. He managed to pull out a couple of them, which was rather distressing.

We also had a stairway that we had to incorporate into the design because the homeowner wanted a stairway. I'll show you some construction diagrams or pictures that show how we completed the construction.

This is the steep part of the bank. We don't really know where these rocks came from; they were there. They essentially made this section of the bank a little headland. So our design challenge was that the bank curves in here, and out here. The clay headland is right here. As we transverse the bank curves back in and we had a steep section with the grass that was sliding down the bank.

So we first poured some material over the top shown there. And then we started constructing the terraces. So we evened out that first bank section, and, because we wanted to end up with a smooth, evenly sloped bank to plant, we put these in so that we'd catch the cover material, and also where we had actually slump faces the terraces helped reinforce the slump faces.

Now, here is the project as it looked before — just before we started planting it. All the materials are in place. Basically, the coastal stairs are there. While we still have a very steep slope here, it is now more reasonable and more able to accept plants.

Fig 28. Coastal bank with fill and jute netting being planted

The next step was

Fig 29. Completed bank stabilization project

installing jute netting. We put jute net all the way across the face of the bank. All during this process the neighbors were all terribly intrigued about what was going on and wondering what was going to happen next, and when we put all this net across the face, they were wondering what was going to happen. We had to put all personnel in harnesses and climbing gear **(Figure 28)**. The climbing ropes were fastened to stakes driven into the ground. These stakes were iron bars driven into the ground about ten feet. The planters had to rope down the bank face. Then they went over, walked up the stairs, and roped down again. They're planting beach grass here, and they're also planting *Rosa Rugosa*, which we suggested shouldn't be done in the first year because of the steep bank slope. However, the client basically said, my wife likes roses, I'm your boss, and I want roses. So we planted roses.

Here is the project now, we have this whole section planted. I was able to suggest that the very bottom of the bank be only beach grass initially because the beach grass grows quite rapidly in here, and basically we didn't want it to be out-competed early on by the roses as they gained canopy.

We then installed sand fencing in front of the bank on the coastal bank because of the fact one of the controlling parameters here is that we had a very narrow beach to work with. Basically we wanted to do is provide every possible bit of protection to the bank face. Here is one of the cases where we increased the elevation of the beach by about four and a half feet, just by using sand fencing and beach grass on the slope.

This is about a year and a half after it was done. This is what it looked like in March (**Figure 29**). Now, I have to be quite honest with you. Even though it looks fairly fine here, we're going back after next month for the first time for maintenance since 1993. There's about a two foot, two and a half foot erosion scarp here, we're going back just to fix the toe. But that's a pretty good success considering the fact that the construction was completed in 1993, and we've had no problems since then.

AUDIENCE MEMBER: Do you know what the grade of that slope is? Roughly?

MR. WEISHER: It's just slightly less than forty-five degrees. It's very steep. If you were to step over the edge, you would not stop until you hit the bottom.

This is again what we are looking at right here. This is the area where we had the breakout. The way we dealt with that in the design is we actually channeled the water to go down into the beach, and we had a couple of storms which dumped a lot of rain on the face of the bank. I think what happened here is that we actually had some breakout of the water from the bank, plus some wave action. What you can see now is that in this section of the bank we have some mature roses, which are now six or seven years old. They've propagated. They have a tremendous overstory, and they're starting to crowd out the Cape American Beach Grass.

And so we've been suggesting for the last couple of years that we go in and we actually prune the roses back down, do a limited fertilizing application to encourage the beach grass to come back. We made this recommendation because we have found that the beach grass gets crowded out as the canopy grows up on these steep faces. We really depend on the root structure to hold the steep slope. So if you look at the root ball to canopy ratio on the Rosa Rugs, we don't have an aggressive root structure to hold the bank because the canopy gets to be ungainly if you don't prune it back. And so when the wind and the rain actually comes down and drives at that bank, what happens is that we start to get rivulets forming on the bank just due to the rain hitting this fifty-foot high bank.

We're going to apply for a maintenance permit this spring. I was just at the site and saw the beach grass is still there, although it is having a hard time struggling underneath the canopy of the roses.

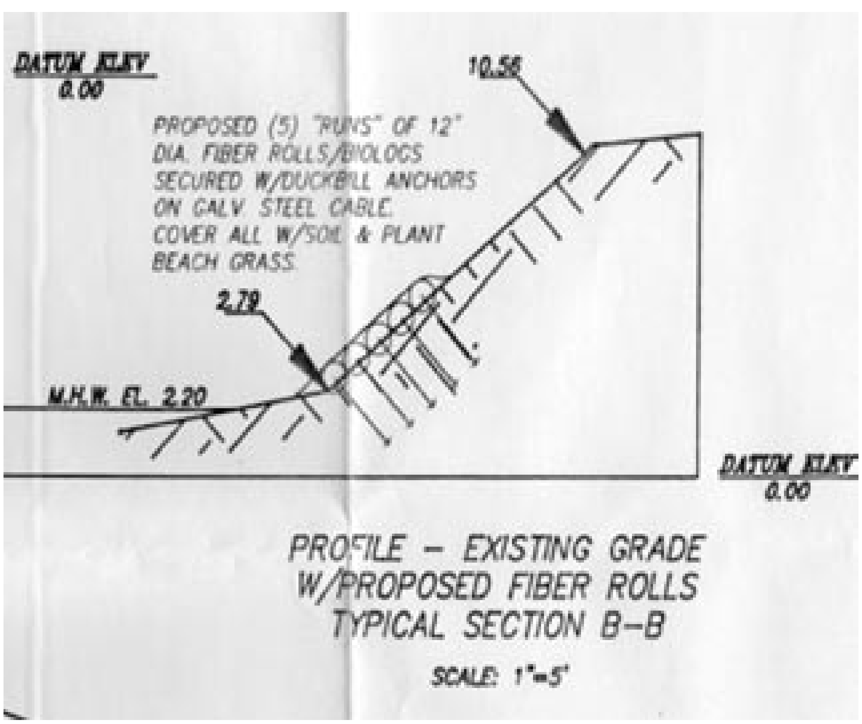

Fig 30. Design schematic for bank stabilization on Cotuit Bay

We are now going to take a look at a site in Cotuit Bay. This is more of straight application of fiber rolls. The objective was to protect the house. The site had an eroding coastal bank, extremely sandy soils, and no clays outcrops to deal with this time. There was a very narrow beach that dictated some of the design considerations. We had to stabilize about three hundred and forty feet of the coastal bank. And again, this project was completed in 1993.

Here is Cotuit Bay. This is the site. This is Tim's Point,

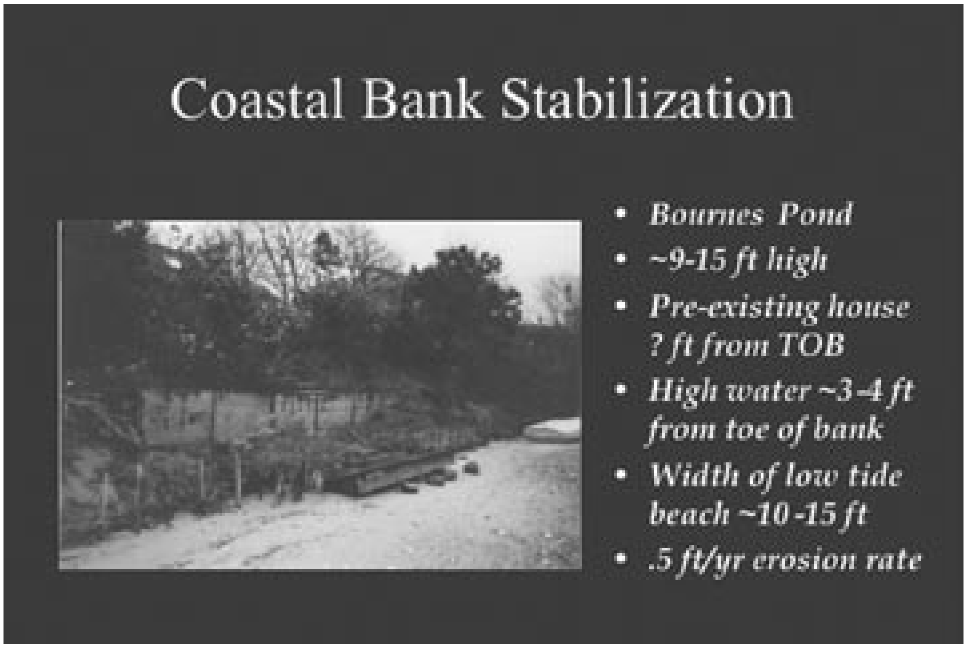

Fig 31. Proposed coastal bank stabilization on Bournes Pond, Falmouth

which is a sandy spit. Tim's Cove is an anchorage for the Oyster Harbors area. Predominant sediment transport is from the south to the north, which also factors into what we can do.

In the best of all worlds, without wetlands protection and other resource concerns, we recommend that we dredge the point, put the sand back down here (updrift), and allow to work its way back downdrift to the spit. However, there are active shellfish grounds in this area right here. And it's been growing because there has been a lot of coastal bank erosion here (updrift).

Therefore, as I said, we had a narrow beach here, which limited what we were able to do because in other circumstances, we would propose a soft solution but also expand the beach width by placing beach nourishment on the beach. But because we knew that this is a growing accreting area and might have navigation concerns, we were concerned about putting too much sand on the beach, because it's not very far from here to the spit.

This is a set of stairs coming down the beach. We put three rows of sandbags again, initially to hold the toe of the bank. The reason for the geotextile bags was is that the beach was very narrow. During extreme high tides or during the moderate storms, the fiber rolls were experiencing wave attack. Our assessment was that had we installed merely the fiber rolls, they would not last very long. If this occurred we would lose the toe of the bank, and then would work up the bank face and the plants wouldn't be able to hold the bank face.

Here is a design schematic **(Figure 30)**. This is the base layer with three bags going up the bank face, fronted with fiber rolls. Next, the bank was reshaped, sand was brought in to ease the slope and the bank was planted.

What you see here is that we have a very narrow beach. This is post-construction after the fiber rolls were put in. Here are the fiber rolls actually being put in on the beach and the bank being planted — a pretty straightforward project. I'll leave this here so you can take a look at it.

And since the time is getting short, I'll allow my co-speaker to take over.

MS. FIELDS: Thank you.

MS FIELDS: I'm going to go over two case studies — both involve coastal bank stabilization. The first one is in Bournes Pond, here in Falmouth **(Figure 31)**. This was essentially a project where there was a pre-existing house. The house was located approximately thirty feet from the top of the bank. It was a house that was built after 1978. It was not eligible for a hard coastal engineering structure. The client didn't want one. We didn't think it was warranted, so we were looking at soft stabilization here. The bank's about nine to fifteen feet high. High water was pretty close to the toe of the bank in this case, around three to four feet from the toe of the bank. We had a very narrow beach, around ten to fifteen feet. All the data that we collected showed that we had an erosion rate of around half a foot per year.

The erosion rate in this particular case had been accelerated by two things. First, the entrance to this pond was stabilized from a very small ephemeral inlet to a large stabilized inlet. That was done in the mid to late 1980s. And that had the effect of increasing the tide range in the pond. And many of the banks within this pond then readjusted as a result of that.

The second thing that really did a number on this bank was Hurricane Bob. It destabilized it, and that was what really prompted the client to give us a call.

Here's what it looked like before the inlet was stabilized, before Hurricane Bob. It was pretty nicely vegetated, still had a narrow beach, but it was in pretty good shape at this point.

This is just a locus map that shows where it is. Again, this is on Bournes Pond, one of the long finger ponds along the south shore of the Cape here in Falmouth.

This, interestingly enough, shows the location of that very small inlet. Right now we have a stabilized inlet right in this location.

Another thing about here is that this is a very low energy wave environment. It's got a limited fetch across Bournes Pond, and it's very narrow.

We looked at a number of things and recommended a number of things to this client. One of the solutions was the bio-logs, which we ended up doing. We also recommended beach nourishment, and we also recommended salt marsh restoration. There is a small patch of salt marsh off of this point of land down here, and we had recommended continuing that in front of the property, in front of the bio-logs. We're sort of doing the two projects in conjunction.

It turned out to be pretty costly, and the client just chose the bio-logs, but we'll keep the other solutions in mind if it's not working out to her satisfaction.

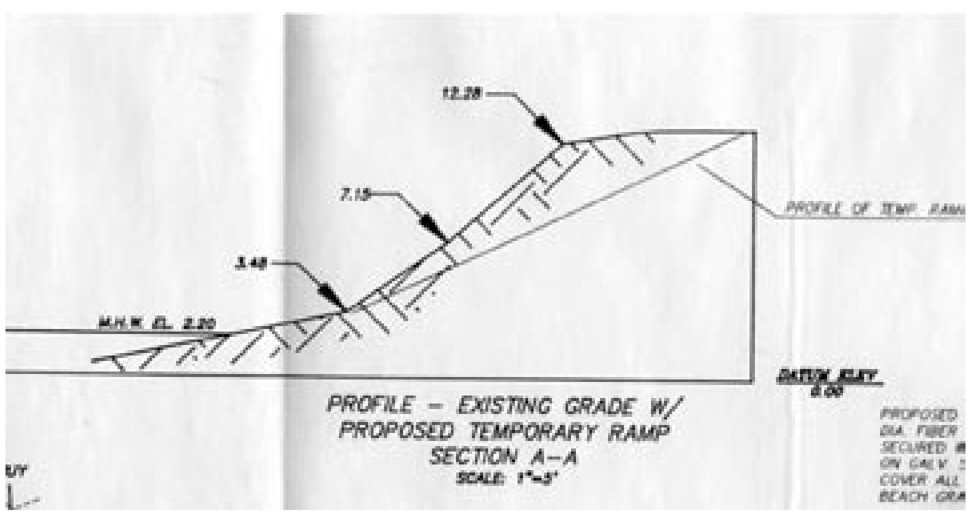

Fig 32. Fiber roll being placed in a trench at bank toe

Okay. The design

Fig 33. Bournes Pond bank stabilization under construction

was fiber rolls stacked five high. We used a twelve-inch diameter fiber roll anchored with duckbills, with galvanized steel cables. We covered it with soil, placed the jute netting and the beach grass on top of that.

So here's a few shots of just some of the construction. Again, the same thing that Lee mentioned. In a lot of these cases you do need heavy machinery to do some of the work. We've got heavy machinery at the top of the bank, sort of smoothing out some of the areas in the bank. A couple of places we had to fill and smooth out so that we could plant satisfactory.

And also the silt fence and staked hay bales at the bottom. We had about a ten foot work zone at the toe of the bank.

The first fiber roll was placed in a trench **(Figure 32)**. A duckbill anchor with a cable was installed to hold it in place.

One of the things that the client wanted to do was to keep a pine tree on the bank face. We had recommended cutting it, flush cutting it so that the wind wouldn't blow it and try to pull it out of the bank, but she really wanted it, and the landscaper determined that the tap root was in good enough shape that he thought he could save it. So that's what we did.

The contractor sort of wove the fiber rolls in and around the tap root. I think it's going to work out nicely.

Here we are during construction (**Figure 33**). We've got about four of them in now.

That's with the tree. And we're able to

Fig 34. Bournes Pond bank stabilization project completed

bring the fill right up to the level of where the bank had been.

And here's what it looks like now, planted with the jute netting on top **(Figure 34)**. This was done last season, so it's really only been in for about four or five months.

The next series of shots are some shots of projects that Anchor Marine constructed. And I know there's a representative from Anchor Marine here in the audience, so if there are questions you have about these, we can always direct them to Jeff from Anchor Marine in the back.

Fig 35. Fiber rolls covered with sediment

This is just another example of fiber roll installation, and again, how heavy machinery is sometimes required in these projects. It causes temporary impacts.

There again, just the machinery carrying a bunch of the heavy fiber rolls.

This is an example of how fiber rolls can be covered with sediment **(Figure 35)**. Again, another Anchor Marine project. You really wouldn't even know that they were there in this case.

And here's a very good example of how they dealt with a return using fiber rolls **(Figure 36)**. We still have to worry about end effects at the end of these soft structures. So they brought the fiber rolls around the end of the natural bank to minimize any sort of end effect erosion. And I thought this was a very nice treatment of that.

Fig 36. Using fiber rolls to construct a return

An example of how they can abut a hard coastal engineering structure.

Just briefly, this is another project that we did with fiber rolls, and you really can't even see them. This is in North Falmouth. The fiber rolls are right down here. This has been in for about five or six years. We have two layers of fiber rolls here, and we planted the bank with beach grass. It's been wonderfully successful. The only thing that we've noticed recently is that they're really starting to degrade, so we're expecting that in the next say three years or so, they'll likely have to come in and replace the fiber rolls.

That's the same project. This was our project here, and it terminated at the property line. This property owner here didn't do anything for a while, or I think maybe they just planted with grass. Since then, they've gone in and placed fiber rolls along this stretch here as well and planted beach grass. So it's doing nicely.

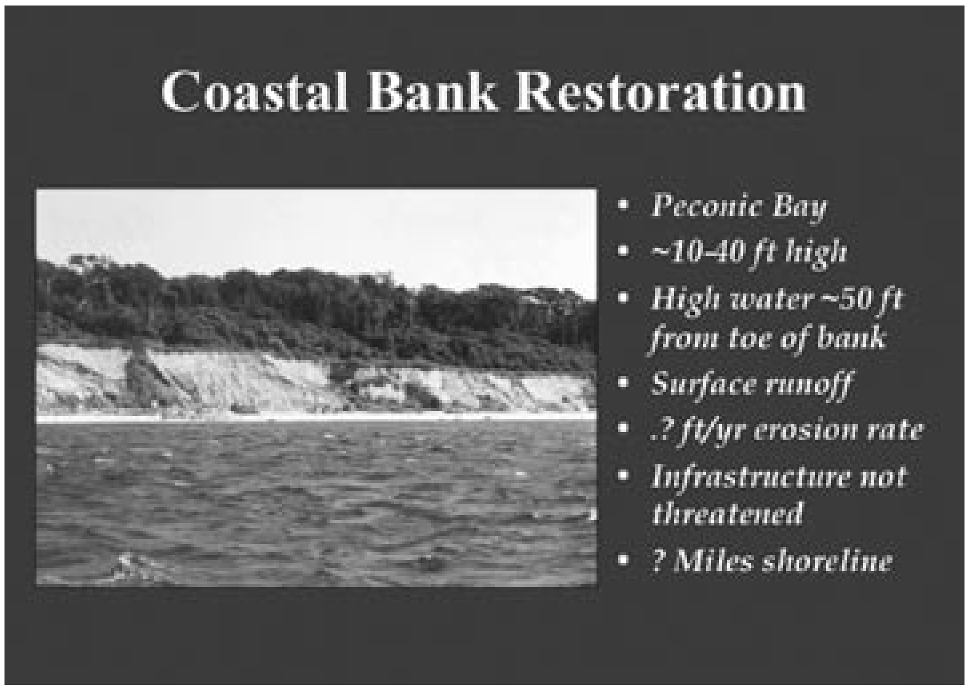

Fig 37. Bank stabilization proposal on Peconic Bay

All right. The next case study. This is moving over to Peconic Bay **(Figure 37)**. Over in this area, they have a client who's got a large game preserve, five hundred acre game preserve. It's an island in the middle of Peconic Bay. And they have very high coastal banks, ten to forty feet high. High water is about fifty feet out from the toe of the bank. We have a lot of surface runoff issues on this particular project. And I wanted to bring out some issues related to that.

We have an erosion rate here of around four-tenths of a foot per year. In this particular area there's going to be infrastructure that's threatened. Again, it's a five hundred acre island, there's a house in the middle of it, but the client just wanted to try something along this two-mile stretch of shoreline, to see if we could arrest some of the erosion.

And this is an example that I wanted to point out that shows effects of surface runoff. Before you go in and decide on a solution for these coastal banks, you have to really ask yourself, what's causing the erosion. Is it erosion at the toe from wave activity, or is it erosion from surface runoff? And this is a good example of surface runoff. What you get when you have surface runoff are these little erosion rivulets and channels. And so I just caution you all to look for that when you're analyzing these situations.

We also have some groundwater break-out that is causing a lot of erosion in this area. Again, here's an example of surface runoff effects as well as wave erosion at the toe. This is an example of where we just see erosion effect from surface runoff. The vegetation is gone. Where runoff is not a factor, the vegetation is growing nicely. There's not really any wave effect in this particular site, mainly because it's protected by a point of land.

Fig 38. Bank Stabilization by grading and planting

AUDIENCE MEMBER: Question?

MS. FIELDS: Yes.

AUDIENCE MEMBER: In that case where it was the surface runoff that was the major contributor to the erosion, was anything done to mitigate that?

MS. FIELDS: Yes. I'll explain what we did. It wasn't entirely successful, but it was our stab at what we were going to do.

This is just another case along the same shoreline. Again, in Peconic Bay. The client owns the entire island. And really all we did was we went in and we smoothed off the grade of the bank and planted it with beach grass **(Figure 38)** — densely spaced beach grass, twelve inches on center. We used bare root beach grass, three culms per hole, and it was fertilized twice; once in April and once again in August. It's been pretty successful, although you can see an area where it's sort of slumped in this area here.

One of the other things that we did up at the top was to try to control the surface runoff with berms. So we located a berm up at the top, and we also looked at some sort of French drains in order to mitigate the problem. But those are the two solutions that we've used to control the surface runoff. And I hope that answers your question.

I'm going to close with the next two slides. Again, this guy owns a game preserve. He's got lots of trees, woods, woodlands, so his solution before we came to the project was to put dead wood down here. And there are massive piles of dead wood at the base of this bank – massive. And ordinarily we'd encourage him against doing this now, but right now we've recommended just to leave them there because they are so dense that they're actually being effective. But I wouldn't recommend that people go out and do that in the future. For now, we're just going to leave it.

Remember, we've got two miles or more of shoreline, so that's fine for this little stretch here. And this is from the ground, an example of what all that dead wood looks like there **(Figure 39)**.

So I'll close with that, and if you have any questions for either Dr. Wieshar or myself, I'm sure we'd be happy to answer them.

Yes?

MR. STERINGER: Paul Steringer with the Corps. My question is with the Bournes Pond site, one of the last ones you showed there. You talked about replacing the coir logs there. Are there other ways — my understanding behind the core log was it was just there long enough in order to get proper roots established there. Could you have done more with the plantings in that area in order to stabilize that area vegetatively without having to go to a replacement totally?

MS. FIELDS: The site that I showed where we're going to have to replace the fiber rolls is actually up in North Falmouth. So it's not in Bournes Pond. And we won't recommend that they replace them until there's a storm that comes in and moves them around and erodes some of the material behind the fiber rolls.

Fig 39. Dead wood dumped at bank toe to dampen wave energy

AUDIENCE MEMBER: But do you try to go with shrubs as well as herbaceous out there, to try to get diversity?

MS. FIELDS: In that area, we have used some shrubby plants. There was some of that material existing when we looked through and we tried to leave it there.

But we've been careful to tell the client that it's really a maintenance situation.

I hope that answers your question. You know, the fiber rolls are going to last maybe eight to ten years. And after that point, if there's a big storm, these people need to expect that they have to maintain the coastal banks.

Yes?

AUDIENCE MEMBER: What is the material used to connect the fiber rolls, and is there any part of the fiber roll that is not biodegradable?

MS. FIELDS: I'm really not an expert on this, but the older fiber rolls were sort of held together with this jute netting. And recently they've started making them with more of a poly-synthetic type material, which in my mind is a lot — it's preferable especially in an area where the wave activity is going to get to that fiber roll frequently.

So I would look for the manufacturers that create these products with the poly netting. And they're held in place with these galvanized cables that are attached to those duckbill anchors.

MR. WIESHER: To answer and to expand on that is that what we found is in installing the bio-logs is that the jute around the coconut fiber is more exposed to the elements and it degrades due to ice forming in the little fibers there. If you think about it, if you've seen the fiber roll, they're very dense coconut, but the jute itself is the weak link in there, so that the wrapping was actually coming apart and then allowing the fiber roll to degrade.

Yes?

AUDIENCE MEMBER: Leslie, a couple of those pictures that you just showed were projects of the designer Bradard, Trainor and Wilcox, and they looked very nice when they first went in, as your picture showed, and we had good success with one of them and fair success with another. And later on, I'll be happy to comment, particularly about the one where we have the stone interface with fiber roll interface in the inter-tidal zone. It's an interesting project.

MS. FIELDS: Okay. Yes?

AUDIENCE MEMBER: There's another product I found on the Web, and they're called rice straw watties. I've forgotten the name of the company, but have you had any experience with those? They tout them as being the same as fiber rolls at half the cost.

MS. FIELDS: No, I've never heard of them. I'd be interested to learn about them.

AUDIENCE MEMBER: On their Web site, they show them stabilizing banks like along highway projects and things like that. Basically the same application as fiber rolls can be used on, and they say they can be used on shorefront protection as well.

MS. FIELDS: Is it a mat?

AUDIENCE MEMBER: No. They look exactly like fiber rolls. They're just made of rice straw instead of the coconut fibers.

MS. FIELDS: Yeah, it would be interesting to look into it.

MR. WIESHER: It's called wattles that you're talking about. Basically, it's temporary erosion control, in lieu of a hay bale. It's a very effective product for that. Not for these type of applications. They don't last long enough and doesn't have enough density.

MR. WIESHER: So it's almost like a quick replacement for a hay bale because it can be done continuously, they can contour it, follow the contour line, and it will act as a very good sediment stop temporary during construction — or during a highway type project. Wattles were installed out at Route 495 in Marlboro, but the product is not suitable for these types of shoreline applications. It doesn't have enough density.

MS. FIELDS; Yes?

AUDIENCE MEMBER: I don't know if you've had any experience with storm events. Will these fiber rolls float?

MS. FIELDS: No, they don't float.

AUDIENCE MEMBER: Do they sink to the bottom?

MS. FIELDS: The ends of them can sort of get moved around by the waves.

AUDIENCE MEMBER: But during another hurricane or whatever, aren't they going to go somewhere?

MS. FIELDS: Sort of roll out seaward on the beach or maybe a piece of it will still be anchored to the bank, and the other end of it would come free and might come loose — I've never seen any stranded out in the middle of the water.

MR. WIESHER: Let me answer that. Any structure, soft or hard, can go anywhere in a major event.

MS. FIELDS: That's true, yes.

MR. WIESHER: It's all due to the event. Anything that can be designed is being designed to protect for the majority of the storms. The Blizzard of '78 was a seventy-year event or so — Hurricane Bob was a 25-year event. Those were two rare events.

The answer is yeah they can move. But it depends on the frequency of the storm.

AUDIENCE MEMBER: Well, I was just wondering. It seems like if they could move easily, it would be obviously a hazard to navigation and so forth.

MR. WIESHER: They don't move easily, first of all. And if we put them down with the duckbill anchors and the stainless steel, what happens is that typically they will roll forward — they'll loosen the duckbill anchor, but they don't pull free. But the problem with that is that once they pull away from the toe of the bank, you get water behind them; or if they're hit with wave energy, they actually can oscillate back and forth.

Now, these things aren't like jumping back and forth. The things weigh several tons when they get full of sand and water after a while. But they can move — they can roll enough that you'll have some enhanced toe erosion, hence soft solution, hence maintenance, hence that's why it's a soft solution as opposed to a rock structure, where you have to tell the homeowner right up front, you're going to have maintenance on this.

When we go into a project, depending upon the site, we'll say you have annual maintenance, you have once every two to three year maintenance, you have once every five year maintenance. The Nantucket project that I showed, we told him that he ought to bankroll eighty thousand dollars to spend on his bank every five years. So just start putting it away because you're going to spend eighty grand in five years. So it's been over — it's been almost ten, and he hasn't spent a nickel, so he's been the big winner. But, you know, we tell people right up front, it's going to be a maintenance issue, this isn't something you're going to walk away from, you need to plan on it.

And it's a management issue. So when we go in and talk about soft solutions, we talk about managing the shoreline erosion, managing the beach as opposed to an erosion control device because of the fact that we really aren't controlling erosion, we're just doing a temporary mitigation.

MS. FIELDS: It's really what you were talking about at Duxbury Beach. I mean, you talked about an evolving management plan, and I think that's a great example of that.

Yes?

MR. WILLIAMS: Peter Williams of Vine Associates. I'm curious. Your application of the bio-logs, are you using them more for the backing of the slope and not for an exposed toe protection, or do you use it for both?

MS. FIELDS: We use it for toe protection of the bank, to keep the waves, the everyday waves and the low to moderate storm event waves from striking the toe of the bank, so that the vegetation can start taking hold and helping to stabilize it.

MR. WILLIAMS: Well, in the Bourne Pond, you show it going all the way up the bank. And that appeared that it was sort of the backbone of bank, to hold it in place. In the situation where you have it at the toe of the bank, do you see shorter life spans for those roles?

MS. FIELDS: I haven't seen or had enough projects to be able to answer that question.

MR. WIESHER: I can answer that a little bit. The project that I showed in Cotuit Bay, we had another project that was immediately adjacent to that. And for whatever reason, whether we had a set of bad fiber rolls, whether we had animals getting into it, or whether we had ice, well, there's pheasants on there, and they like coconut rolls for making their nests.

MS. FIELDS: So do fox.

MR. WIESHER: We went in and found these places where the coconut roll had been actually plucked out, and so we're sitting here wondering — one of the maintenance guys came over and said oh, yeah, we see pheasants are down here all the time. This is great. So we actually had to pull that out, and it was a little more exposed, and so actually, the revetment went in after the fact about four or five years after we had placed the coconut roll in. So it really depends on the site and the conditions that you experience. We've had other sites that are in embayments that are just high water, very little waves, that have lasted for eight, nine years without any problem.

MR. O'CONNELL: So they also increase wildlife habitat?

MS. FIELDS: You're leading into the next talk, right?

MR. O'CONNELL: We saw the fox den in the Falmouth project.

MS. FIELDS: Yeah, North Falmouth.

MR. O'CONNELL: I have one question. What is the typical cost of one of these projects? Oftentimes, in my experience, a regulator may say, we don't want the hard alternative first. Have you tried the non-structural? Can you compare the costs of a small bank project, say a ten to fifteen foot high bank with a toe revetment, to a bio-log project with jute netting? Are the costs comparable?

MS. FIELDS: I know that the price tag on that Bourne's Pond project, which was a hundred and twenty linear feet, five high, was around twenty, twenty-one thousand for construction. So what's the cost per linear foot of a revetment? Roughly?

MR. WIESHER: Well, in that area, it wouldn't be comparable.

MS. FIELDS: Five hundred?

AUDIENCE MEMBER: A linear foot.

MS. FIELDS: Five hundred a linear foot, so five hundred times one twenty (for a stone revetment). So it's a lot more for the hard structure (revetment).

MR. O'CONNELL: But then factoring in the maintenance — the annual maintenance requirements over a ten or twenty-year period.

MR. WIESHER: Yeah, I would be careful on that because of the fact that Bourne's Pond didn't have a wave issue to deal with or just mostly high water, so the construction was pretty straight-forward. You can go spend up to two hundred dollars a linear foot easily for a soft structure without much problem — on a pond location. But again, if you were going to look at a revetment at Bournes Pond, you would probably only look at a base rock level for a toe protection. You wouldn't have armored the entire bank. So it would probably be less than five hundred dollars per linear foot. It's going to be by location. It's going to take a lot of different things. I mean, you would probably look at maybe having in an energy zone a rock toe, and any vegetation above it, if you want try to get it in a high-energy zone. But most of the stuff is for low energy.

If I had to guess, I'd say you'd probably save about a third to a quarter on a soft solution.

MR. O'CONNELL: Soft alternative, you mean?

MR. WIESHER: Yes, right. That would be an initial cost. Maintenance is something else.

MR. O'CONNELL: Thank you Leslie and Lee. Now for our last speaker before the break. I do hope you stay for the open discussion following the break. It's going to give you an opportunity to talk about all of the issues and anything else we may not have covered. It should be quite interesting.

IMPROVING WILDLIFE HABITAT ON COASTAL BANKS & DUNES THROUGH VEGETATIVE PLANTS

Don Schall, Senior Biologist, ENSR, Sagamore Beach, MA

MR. O'CONNELL: Our last speaker before the break is Don Schall. Don serves as a Senior Biologist at ENSR's Sagamore Beach, Massachusetts facility. Don has thirty years of professional experience in conservation education, wetland mitigation planning, vernal pool investigation, and plant and wildlife habitat assessment.

Don has served as a project manager for numerous coastal and inland wetland resource area evaluations, marine and freshwater plant and animal inventory, and wetlands impact assessment. Prior to joining ENSR, Don was the education curator for the Cape Cod Museum of Natural History in Brewster, and presently serves as a member of the Brewster Conservation Commission and the State Task Force on rare plant conservation.

Don has a BA in biology from Seton Hall University and a Master of Forest Science from Yale University School of Forestry and Environmental Studies. Don's going to tell us how we can enhance wildlife habitat using vegetation on dunes and coastal banks.

MR. SCHALL: Thank you.

I think time should be spent, and maybe it'll come up in the discussion, talking to the permitting of the activities that are proposed. I mean, it's not difficult to come up with an engineering solution, and perhaps it's a little more difficult to come up with a soft solution that addresses the issues for coastal erosion. The permitting process is part of the time frame that should be considered for some of these processes and, although it was briefly touched on earlier, it can be quite long. I've been involved in projects where the actual final project may be approved two to three years after the submittal of the first application. Generally you can get over the hurdles with physical access, use of equipment, storage of equipment, management of equipment on site, but then you may deal with commissions that are, in my experience, reluctant to explore new ideas. We have offered sacrificial dunes in some projects, where I've had commissions say no to sacrificial dunes, that's not appropriate. We'd rather have the dune keep washing away. So although the literature and the science indicate that it's appropriate for the implementation of a sacrificial dune, in this case, one particular commission said no, the dune is adequate the way it is. Come back before the commission when you're starting to lose your coastal bank, and then we'll consider a sacrificial dune.

So a proactive response in that one instance was not accepted. I've also had the other extreme, where commissions have permitted major restoration work similar to that that you've seen on coastal banks in the studies presented today, without much review because they've been very supportive of the project, and you haven't the need to justify it. I've had commissions that have permitted actual re-grading not only at the top of the coastal bank but also on the face of the bank, as long as the volume and structure altered was replaced adjacent to it.

So overall, the total volume remained, but the height of the bank face was reduced so the amount that you're restoring was more manageable. Erosion in this particular case was not primarily from wave action; it was briefly touched on in one of the presentation. Erosion was from sheet flow coming over the face of the bank, causing soil slumping, collapse of the bank, and then the bank itself wearing down.

In my experience, although not everyone here may agree, I see one of the major deleterious effects on coastal environments adjacent to coastal banks is caused by allowing trees to stand precariously on the edge of the coastal bank. The advice that was given to that individual homeowner was that the tree should be removed. Because when they go, when they're on the face of the bank or at the top of the bank, they create a scar or weak spot on the bank that allows the whole bank to collapse. And then the small erosion gully serves as a focal point that concentrates the sheet flow, which accelerates erosion. And in those areas where you've seen a tree that has generally come down, you start to see where the top of the bank runs along the edge, lifts inward at the break, and then comes back out and follows a natural contour. It is usually at the base of that weakened area where it lifts in that one sees a well-defined delta of soil or a sediment fan that is carried out along the beach.

My experience working in Barnstable County is that the region is ideal if you're looking for examples of coastal erosion. Why is it? I found in my experience in trying to permit a project and to convince a conservation commission that it's appropriate to alter the environment, it's not difficult for a large state, federal, or even a nonprofit organization to go forward without major hurdles, so that a project is eventually permitted. In some instances, it's very difficult, in some cases for an individual homeowner or an individual client to go forward. The burden of proof for making your case appears to be significantly more substantial.

However, I have also found that if you can show that what you propose to create will protect a historic feature, or have wildlife value, or its in keeping with the cultural history or the historic architecture of the area, then you have a chance to make a case that what you're doing is not a drastic change in the general nature of the community. It actually may be viewed as a restoration effort in a community or a landscape unit that was a natural feature a hundred years ago, fifty years ago, or twenty years ago. Whatever the case may be, these coastal systems are viewed as areas that are constantly in flux, constantly changing, though it's not inappropriate to maintain a community like this that shows the coastal dunes with a major blowout behind the small residence in this slide from Truro.

The other source of background information, to get some feeling for what former coastal environments were like, is to go through old postcard collections. This is the railroad station in North Truro, Massachusetts. And what I have for distribution, which I will have available as a handout, is a list of references that I have found to be useful for this purpose. One in particular, which deals with the long-term changes in the landscaped environment, is a small booklet written Dr. Dunwiddie, Peter Dunwiddie. It's entitled "The Landscape of Martha's Vineyard." Peter


Fig 40. Wrackline at Morris Island, Chatham

also has prepared a small booklet similar to this for the Island of Nantucket. If you work through some of the references maintained by town historical societies or town libraries, you're able to find photographs or old pictures, perhaps even of the actual structure you're working on. The photographic record provides you with an understanding of the natural environment at the time of the photograph. This post card was taken around 1911 based on the postmark date that was on the back of the postcard.

In dealing with coastal environments, I look at the overall environment not only from the perspective I see as a consultant, who essentially represents my applicant's interest, but also from the perspective that I have gained serving as a member of the Brewster Conservation Commission. So in regards to environments like this, the strand line or wrack line seen in the slide is important from a wildlife habitat standpoint. Although it's not usually referenced or reviewed, you want to ensure that prior to, or at the completion of the restoration project, that you are not permitting the proponent to maintain a sterile beach by sweeping or raking the beach. There are certain permitted instances in recreation areas where beach raking may be appropriate. But environments like this in natural areas, where you're working along the shoreline, the wrack line is an important resource for shorebirds **(Figure 40)**. I've also noticed, and I'm sure others in the audience have as you walk the shoreline, not only are shorebirds active, but you also find evidence of raccoons, skunk, fox, and white-tailed deer activity along the beach. Sometimes you find tracks along the shoreline and you'll see them coming out of the sand dunes or down the face of the coastal bank, walk a section of the wrack line and then back up into the coastal dune habitat.

This is a sanderling. This is a semi-palmated plover. I thought it was interesting in the discussions that Joe has been dealing with a federally listed species and the requirement for "no short or long-term impacts" in dealing with state-listed rare species. This is a very difficult hurdle for an individual landowner to get over, the no short or long-term impact requirement. Yet, in a situation like this, it must have taken months of negotiations to come to an agreement and a resolution of the short or long-term impact requirements for a state-listed species, because a taking includes the temporary collection of a species and moving it to another area. Under the Massachusetts Endangered Species Act, that's an impact. You're collecting it, you're holding it temporarily and then you want to put it back in the area after work is completed. Well, that is an impact. It's a short-term impact and the short-term impact is a very difficult hurdle to get over.

The other areas that I've looked at and touched on in other presentations, is in coastal dunes systems which are overly planted or so heavily planted that you're losing potential shore-bird nesting habitat. You risk losing nesting habitat for common terns, least terns, and other coastal species that prefer more open coastal environments. For several years I would assist in the removal of old beach grass material from the dunes at Gray's Beach in Yarmouth. We would go out and actually rake some of the debris and rock materials that collected on the backside of the dunes, so there would be open sandy areas for nesting terns. It's probably the unusual individual property owner that is dealing with a shorebird colony in their front yard. Now, I'm sure that in the town of Duxbury you can look at the habitat restoration on the spit as a primary nesting habitat for shorebirds.

This is a common tern and a least tern. A coastal plant that is not widely recommended for use for dune restoration, it's rare that you find it in the literature as a planting suitable for dune stabilization or bank stabilization, is poison ivy. The rampant growth cascading over the sand dune in this slide is poison ivy. From a wildlife habitat standpoint, it's an ideal species. The literature references a number of bird species that depend upon the fruits of this plant as a food source. The number of bird species is quite high. I've seen tables listing forty to sixty different bird species that feed on the poison ivy berries. However, poison ivy is not a plant that I would recommend to a commission. Can you imagine the reaction that you would get if you said, "I want to restore the bank and dune with poison ivy".

The other vine that I find beneficial — the other vine that does show up in the literature as suitable for coastal environments and does possess wildlife benefits, is known as Virginia Creeper, or Wood-

Fig 41. Artemisia stellerian in flower, Brewster

bine (*Parthenocissus quinquefolia).* You find that this vine is recommended as a suitable species for coastal environments for stabilization. What first comes to mind is that I've seen this vine covering someone's chimney. You know it's selected for homeowner use because it's widely available and it has a handsome leaf pattern and leaf color in the fall.

Here are a few slides of other species that are available for coastal planting to increase species diversity. This is Dusty Miller **(Figure 41)**. The question was raised earlier in the program as to whether or not you should use Salt Spray Rose. Well, the same concern applies to the use of Dusty Miller. If you're a purist and you want only native plants than this plant would not make the cut. Dusty miller was introduced to the United States in the 1880s. The literature indicates that Rugosa Rose or Salt Spray Rose was introduced in the 1860s or 1870s. Well, at some point the plant became naturalized, and it's now presented in the literature as a naturalized plant. Granted, Rugosa rose is not a true native species, but I find that it doesn't tend to be, in my experience, an overly invasive or aggressive species **(Figure 42)**.

I also agree with the statement made that it should be pruned regularly. On many occasions, when you're before a conservation commission at a public hearing and your applicant finally receives the approval permits, he thinks his project is finished. It was nice to hear concerns about the requirement for maintenance of the planted species. If you're looking to maintain wildlife habitat, well, obviously, a plant like this isn't really included here as a major food source, nor would be the *Arenaria*, which is known as Sea Beach Sandwort, which is a perennial plant acclimated to the beach strand. These are perennial plants that grow successfully in exposed marine environments. These species are not all commercially available, but Dusty Miller is, but you usually end up finding a cultivated variety, more suitable for horticultural purposes.

I like the inclusion of native plantings in coastal environments. This is a slide of Beach Heather; there's a little cluster of Broom Crowberry in the slide also. Both species of *Hudsonia* are referred to as the Beach Heather or Poverty Grass (*Hudsonia ericoides* and *H. tomentosa*).

In the research work that I have been doing out at the Cape Cod National Seashore

Fig 42. Salt spray or Rugosa rose (Rosa rugosa), Brewster

in South Wellfleet, MA, I have found that small coastal habitats, like this, form their own microhabitats. And within the small microhabitats, there's available shade. You'll also find evidence of wildlife use within these unique community structures that are no more than a few feet across, if you're there early in the morning you can find small rodent trails that lead into these little plant clusters. Time is spent there and then the small mammals move off.

I like the use of the Rugosa Rose or salt spray rose in coastal restoration projects. It's been my experience when I've been surveying coastal environments that when you're flushing up American Goldfinch or other small songbirds common to coastal shrublands that the birds tend to move from one population cluster of shrubs into another and on to another as you wander across the site. In the landscape design for a proposed development from a wildlife standpoint, it's nice to have the plant populations staggered so there's a random clustering of plants. And I agree, you will find, for whatever the reason, the use of odd numbers in restoration plant seems to give you a better chance of getting your project approved than plans using even numbers of plants. So there is something there in the numbers. There is some unknown reason behind this perception. You say you're going to plant nine specimens, for some reason that sounds a lot better than eight specimens. I think what the odd number permits is that it allows you to work with a more random arrangement in the design or planting pattern.

Now, I know from studies that I've conducted under power line easements and transmission line corridors, where they've maintained isolated corridors of shrubs, that the level of predation on nesting birds, at least along the power lines, is reduced because when a predator gets into one of the isolated shrub habitats, they might just go through that first population cluster they find and decimate the eggs or young birds. But the other isolated shrub clusters, which do not form a continuum of plants, remain undisturbed and allow resident birds to reproduce successfully. So from a wildlife standpoint, I'd rather see the clustering or the location of these shrub clusters placed with some distance between them so you're not planting them as continuous band of vegetation. Many times you'll see a whole band of shrubs that will run unbroken along a hundred-foot or a two hundred-foot distance. So it means a predator is able to start at one end where it has shelter and protective cover and it can just follow the shrub community down the line like you're walking down a Band-aid, and just work through the shrub community feeding along the way.

You know, I'm interested in reptiles. It's been in environments like this, a coastal sand dune that I've encountered the eastern hognose snake. It's always been usually very droughty conditions, coarser sands, high summer temperatures, and generally a plentiful source of food, such as toads.

But an environment like this is also a suitable environment for hognose snakes, which is a state-listed rare species in Massachusetts. So you're able to bring preservation of rare species habitat into your request for that permit — the more you can generate habitat for some wildlife benefit, the more I think it establishes your case for the project that you're proposing to do.

It's a handsome plant, too. Naturalized, yes.

This is the type of habitat that I find again and again is really quite beneficial to wildlife. You may be able to see that most of these areas are covered in poison ivy. The other plant cover is a mix of bayberry and arrowwood. I'm not adverse, in appropriate situations, to the use of highbush blueberry as a planting on coastal banks. I have found in situations where you see freshwater seeps American hazelnut and other woody shrubs surviving in coastal environments. Almost all of the oaks can occur on coastal banks, but once again, I encourage keeping them in low protected environments. You'll see scrub oak specimens commonly on the face of exposed coastal banks. Inkberry and common winterberry or black alder may also be found on exposed coastal banks. But the actual — not all of these are common on exposed coastal banks, but all of these species can grow in the coastal bank environment, and it does give you a chance for increasing the variety or diversity of species within the coastal community.

Obviously, salt spray is a major influence on coastal plants. Here is a slide of seaside goldenrod, which is a common species in coastal environments.

This is an example of a black cherry planted in a coastal environment. You can see all of the prior year's growth has died back, due to salt deposition. So in selecting your species, you want species that will withstand desiccating winds and that are tolerant of droughty conditions, tolerant of high winds, and full solar radiation. The growth that comes up this year will come up to about the same height and then the salt spray will just shear it off and hold the tree to a low-growing growth form. It's within clusters like this that one finds the eastern tent caterpillar. Maybe they're not a desirable creature, but black cherry certainly serves as a primary host plant for tent caterpillars, and tent caterpillars serve as a food source for birds. And I think the most important time of the year for these coastal shrub or maritime shrub communities, which are relatively uncommon habitats or environments, is the fall of the year. The maritime shrub communities along the coast are important resting stops during the fall bird migration and also in the spring. Migratory birds coming up in the spring following the coast will use this habitat as they move up the coast. In the fall, and late summer, as they're moving back to southern environments, the maritime shrub communities provide food sources in the seeds and fruits that have developed. Serving as feeding and resting station, birds are able to continue on their southern migration.

It was mentioned, I agree with what Dennis said, a fifty percent success rate for beach plum sounded pretty good to me. But when you're the homeowner and you buy ten plants and five of them die, well, you're not very happy. But from the standpoint of what you've actually accomplished, in time, the results will be apparent. Beach plum is a plant that grows to a height of three to four feet in an exposed coastal environment. In protected environments, you're going to see this species growing to a height of six to eight feet with almost a small tree-like form.

Beach plum is an important plant in the early part of the year as a source of pollen for honeybees. I find that the temperature in late April and early May, and also if there's a series of heavy rains, has a strong bearing on whether or not you will see a good beach plum crop in the fall. Cold spring temperatures and heavy rains keep the bees from being out and around, they're not getting to the flowers and fertilizing them. Also, severe rains can strip the blossoms right off the stem, so you never get any fruit. But it's a plant species that once again serves as a small sanctuary or refuge within a coastal community. You can see from the way that the shrubs are staggered here that a bird could hop from one shrub cluster to another and make it up across the sand dune and up into the shrub cover on the coastal bank above the dune.

Just a nice slide of the random assortment of plants in what a more typical planting scheme might look like. This slide was taken in the Cape Cod National Seashore. You can see a nice species transition from the back of an old dune field, moving into a more arboresent or tree-like coverage in the background.

Up in the Province Lands in the Cape Cod National Seashore, this is a slide of willow. There was some discussion earlier that it is not unusual to see facultative wetland and even obligate wetland plants growing on the face of an exposed coastal bank, where a groundwater seepage or a seasonal discharge of freshwater is present on the bank. My experience has been, I agree with the other presenters, that these are very difficult situations to resolve where you have a freshwater seepage, or as you saw, a freshwater breakout over the face of the coastal bank. It's difficult to address bank erosion in these situations.

This will give you a feeling for what the natural communities might have looked like in the past before the coastal environment was commercially developed. This is a slide of groundsel-tree or sea-myrtle (*Baccharis halimifolia*). I see the shrub commonly in coastal environments in areas where the sand dunes transition into moist thickets or wet shrub environments.

And again, a slide of a mixture of community types in a coastal environment showing low shrubs and modest tree and shrubs. The taller shrubs in the slide are approximately twelve to fourteen feet high.

And once you've created the scrub and grassland habitat, bam, you're going to get northern harriers, or marsh hawks, hunting the open scrubland or grassland for small prey species, such as meadow voles and white-footed mice.

I have seen in the references for bank restoration works that you can buy artificial formed nest cavities made of plastic for belted kingfishers. I've also seen in the literature artificial nesting cavities for bank swallows.

Now, I'm thinking, is this what you have to do to put that nest in? You need to dig a hole in the face of the coastal bank. You know, the outside opening of a bank swallows nest is only about an inch to an inch and a half wide, and the average depth is usually twenty four to twenty-eight inches. So you're digging a hole as thick as your arm, as deep as your arm can reach, so you can put in and artificial nest. I have not had any experience with them and I have never requested a permit to install one. I know that they're available and it would be one of those cute little mitigation actions that might get five members voting in favor of your project and two voting in opposition to your project.

I know that while wildlife habitat is an important interest under the Wetlands Protection Act, it shouldn't be used as the only interest to justify approval of a project.

It is as important as the other interests and concerns that you look at when you evaluate a project and look for conformance to the performance standards. As to any of you that serve as agents or commission members, you know that you're bound to review projects based on the ability to meet the performance standards. If you were looking for site mitigation, I'd like to know if anybody has been success in permitting an artificial bank swallow or kingfisher nest.

I wouldn't be reluctant to propose it to a commission, but it's — well, in my experience, it's sort of like offering tree swallow nests. Cute, but if no one is going to go out there every spring and remove the house sparrows and their eggs, then why put the nest boxes up. If the nest boxes are there, they're there for some higher purpose — whatever the decision of the commission – for some other more noteworthy bird and the applicant should maintain them as such. If you're not going to maintain them then don't offer them as mitigation and don't put them up. You're just doing more damage than good.

I think that was it.

But as I said earlier in the presentation, I wanted to bring a few of the more valuable references to your attention. These are a few of the guides and references that I've gone to and that I've found to be useful. Although the plants in this particular one are not generally common in our region, it's an introduction to planting and maintaining selected common coastal plants in Florida, a few of them do occur here in the Northeast. Nonetheless, I like what they did and it's suitable for a consultant to use as a guide, it runs through several features that should be noted if you're justifying use of a particular plant in a coastal restoration plan. One point is the make a clear statement on its ecological function and proposed use. The authors then talk about its resistance to erosion and they discuss the potential growth rate and its availability both from nursery sources and natural sources. And finally they then give you planting guidelines and they finish up with suggested maintenance guidelines.

Many of the grass species you will see repeatedly that there's a recommendation for mowing or cutting the grass to increase the vegetative vigor and force the plant to spread. So it's not just that one has the approval from a conservation commission to put the plants into the ground and you walk away from them and hope they survive. It's requires going back to replace specimens and, in some cases, re-cutting them to force more vigorous growth or to force the development of lateral branches resulting in crown spread. That's what I like about this particular guide – use the format to justify the plants that you're proposing to install in a coastal restoration project.

Cornell University has two booklets on plantings for wildlife that I recommend. One is entitled "Enhancement of Wildlife Habitat on Private Lands." This is principally for more upland environments, but it does address issues that you could look at within the hundred-foot buffer zone to a coastal bank. Cornell University also published a booklet entitled "Vegetation Use in Coastal Ecosystems." This is a 1988 publication and it was interesting to review. One of the listed plants was autumn olive. It would be a very backward commission that agrees to allow you to plant autumn olive now. Every once in a while you find other plants that were once highly recommended that are now out of favor. Multiflora rose is one that comes to mind, and every once in a while you will still see it as a recommended species for improving wildlife habitat. Yes, it does serve that purpose. It's good for erosion control, extremely tolerant, extremely hardy, and a good food source for wildlife, but you shouldn't be introducing it into native plant communities and natural environments.

The University of Massachusetts published a very useful book entitled "Trees, Shrubs, and Vines for Attracting Birds." Once you've made your selection, if it's a species that's reviewed in the book, you can go down the list of species that use the plant and say these are species that prefer it as a food source. These are species that nest in it. These are species that use it for some other purpose. This information helps to develop the justification for your plant selections.

The State of Minnesota has "Landscaping for Wildlife" and a second nice little booklet, "Woodworking for Wildlife."

The guide shows you how you can build a nest for cormorants. I think that is so great. And then you could also build — why I laugh is that the permitting hurdle you would have to go through to build a cormorant nesting platform, which looks like a little box about the size of this that floats out in the water with twigs on it which your neighbor's going to see as an eyesore and floating debris. Why even offer it? The booklet does, however, cover bat nesting boxes and nest boxes for small mammals. It also has a nesting design for barn swallows.

My handout lists all of the booklets that I have recommended and I believe that they're all still available. I think the most expensive one was probably ten to fifteen dollars.

MR. SCHALL: Yes?

AUDIENCE MEMBER: To go back to when you were talking about *Rosa rugosa* and you said that in your experience you have seen them with some birds that use them as a wildlife habitat?

MR. SCHALL: Oh, yes. Maybe not necessarily a nest, but it certainly forms shelter habitat and screening in coastal environments. They'll work their way through. I agree the drawback is that plastic bags and plastic wrappers can become entangled in the thorns and it's extremely difficult to get the plastic out of them. But I've seen situations where homeowners have actually mowed — at a height of no more than six to eight inches, they've mowed the *Rosa rugosa* every few years, or they've cut it back to a lower height and the plants have made a fairly vigorous recovery. I think of the *Rosa rugosa* as more of a vegetative screen. This may not be your purpose, but the plant is highly useful where you wish to control pedestrian traffic or control walking patterns in a coastal environment, but yes, it is useful for this purpose.

Thank you.

MR. O'CONNELL: Thank you Don. OK, lets take a 10 to15 minute break. The final session after the break will be an open discussion – a time to discuss any of the issues presented today or ask questions you didn't bring up earlier. Also, offer your own experiences with non-structural erosion methods. There's an enormous amount of talent and experience here today. So, please hang around and we'll reconvene in 10 or 15 minutes.

AFTERNOON BREAK

INTERACTIVE PANEL AND OPEN DISCUSSION: QUESTIONS, ANSWERS, OPINIONS, AND COMMENTS

Jim O'Connell, Facilitator

MR. O'CONNELL: Welcome back. This is a very interesting part of all these types of workshops. Basically, just open it up and discuss whatever you learned today. Ask any more questions that you may have. There's a lot of talent in the audience. So ask any questions you have or offer comments.

When an individual was leaving a moment ago he gave me a question. He said this question has been burning in his mind, and asked that I ask it for him. So, I guess I'll just start it off.

It's a question to anybody really. It was something to the effect — how do you reconcile non-structural stabilization with bio-logs, jute netting, re-grading, and planting, if successful, with the adverse impacts it causes. If it's successful, it's preventing the bank from eroding. If it's preventing the bank from eroding, it's preventing sediment from supplying the beach, downdrift beaches, barrier beaches, and dunes, quote, unquote, from the (state) regulations. Anybody want to try?

Joe?

MR. GRADY: The project should be modified so that during large storm events, coastal banks can in fact provide sediment, and then the applicant or rather the homeowner or landowner will have to go back in and refill some of these areas. They should be designed and permitted so that during the large events, the water can, in fact, reach some of the sediment source, pull it out and use it, pump it downstream.

MR. O'CONNELL: So his answer was that the project should be designed to allow erosion of the bank under major storm conditions.

AUDIENCE MEMBER: The whole thing in that statement is "if" — if it were permanent planting on a bank. All these things, of all these people that talked, none of them have been permanent. Is there such a thing?

MR. GRADY: I saw nothing here that was done before the perfect storm. Every site I saw was post-'93. The next perfect storm, it's all gone. Everything we saw today is gone.

MR. O'CONNELL: That's a good point. All the projects that he saw were apparently —appeared to be after the perfect storm, the October, 1991 storm. So, they're going to provide the sediment at some point anyway.

But what about the ten years intervening between 1991 and now — the small storm, the five-year storm, the ten-year storm, the fifteen-year storm where two hundred to five hundred yards may have eroded from the bank. Incrementally, the beach is probably getting lower due to the lack of these small quantities feeding the fronting beach.

MR. BURGESS: I'm going to comment on your question and then ask another one. Mark Burgess with Coastal Engineering.

In a perfect world, the bank should be stabilized and allowed to erode at the same time. That's an impossible thing to do.

The Town of Eastham allows the use of durabags a lot in high-energy areas. And it's my opinion that that is a well-balanced solution because the bags have to be covered in order to provide proper protection from the elements, so that they don't get punctured and fractured and degraded from the sun. The natural storm wave energy will take the sediment that's on top of the bags and take it away. The owner is then therefore required to keep the bag covered, thereby providing some sort of natural source of sediment. Maybe not perfect for the bank eroding in its natural state, but a very middle of the road balance, and that's what we're all here to do really is to try to balance — achieve a balance.

MR. O'CONNELL: David?

AUDIENCE MEMBER: He had a comment about everything was post-perfect storm, but Joe's point is well taken because I do have a fiber roll project that was pre-perfect storm, and it worked just that way: the sediment above the fiber rolls was removed and taken out into the system, but the fiber roll stayed. So it did work, and it can work. It stabilized the toe and it protected the owner's property.

AUDIENCE MEMBER: So modern erosion control is put in these bio-logs, let the big storm take out all the vegetation and soil, and then bring the soil back and re-vegetate it? Put the sand back, establish a location for the toe of the bank, and then keep replenishing the dune, and let the level of the beach drop, and make the beach smaller and smaller and smaller?

This is what happens. I mean, I observed for forty years, and where I grew up used to be a big, wide beach, and now there's rock walls where high tide comes up five feet on the wall. So where do you go with it now?

AUDIENCE MEMBER: That's the point that he was making. There's going to be maintenance, and the homeowner has to understand they're going to be spending some money, right up front.

AUDIENCE MEMBER: If they stack the rocks higher and higher and higher —

AUDIENCE MEMBER: I'm not talking about rocks.

AUDIENCE MEMBER: Rocks are the only thing that work. Sand bags are basically rocks. You know, sand put in a bag is basically a rock that you maintain.

AUDIENCE MEMBER: Right. But rocks don't provide any sediment source. They prevent it from entering the beach area a hundred percent. That's why they work, that's why they're permanent and they really don't require maintenance if they're put in properly. But like I said, the bags are middle of the road because the sediment that has to be put on them every year is something. It may not be everything, but it's something.

MR. BURGESS: My question. Now, a lot of the soft solutions that have been presented today have been presented only in instances of low wave energy. And I'd like to know what would be approved in a high-energy condition. There's a lot of banks in Eastham for one. Direct velocity storms are discounted. We've got velocity zones to deal with.

My opinion is these soft solutions, they're just not going to hang in there, not long enough to get the bank stabilized — not long enough to vegetate. So I'd like to hear some comments on when do these things — when is it not appropriate, or when are they appropriate? Up to what levels of wave energy can we accept these solutions, since we don't want to throw our plants or clients money in the middle of ocean either.

MR. O'CONNELL: One comment. The word "solution." Are they really solutions? – they're alternatives. Rich?

MR. POOLE: I think we need to go back to what Wendy was talking about this morning, and look at things more regionally — within the whole town and things like that. Because I've watched Duxbury Beach over the last thirty or thirty-five years and watched the flats behind it. You know what a beach is, okay? And I think one of the most important things we need to talk about, and this may be a topic of a future conference or whatever, is the concept of beach nourishment, which is just beginning to take hold here in Massachusetts. And we're going to see it in Hull and maybe a few other places. But since we're cutting off the source of sand that nourishes beaches and in cases where we've had washover in '78 and '91 and other places, I think it's time to talk about recapturing some of that sand from areas that — the same sand, and getting it back into the system. Put it out there and let it do its thing right around the hook at the Cape.

So that's an observation.

MR. O'CONNELL: Should we get the folks who built the updrift seawalls to all come in collectively and do the beach nourishment at Duxbury Beach? Because we know who built most of the seawalls in Scituate and Marshfield.

AUDIENCE MEMBER: Right, exactly. I think you would agree with me that part of our problem in Duxbury is the fact that we're being starved because of the walls.

MR. O'CONNELL: Most definitely.

AUDIENCE MEMBER: So that's maybe something we need to look at in a future get-together.

MR. O'CONNELL: You've lost a significant amount of sand.

Bill?

MR. CLARK: Well, before my question, to follow up on that. Any recent permitting (of armoring coastal banks) requires beach nourishment. My clients tell me that, I think, at least for five years, maybe ten years, we've been requiring beach nourishment for every revetment.

The question is what's the difference between burying rocks with sand and planting it or burying coconut fiber rolls with sand and planting it? I don't see any difference. The function of a coastal bank is to provide sediment. It's still providing sediment whether it's rocks under there or coconut fiber rolls. We had this conversation during the break, so I'm curious, what's the difference?

You talk about soft solutions. You bring a crane in there, it's an engineered structure, and you start moving things around with the crane, if you put rocks there or whatever, I'm just curious, what's the difference?

MR. O'CONNELL: I'm going to make one comment, Bill, and then I'd like somebody to address that. It gets back to your initial comment. If the IPCC's predictions are correct, and we do get an accelerated rise in sea level in an area that's already half armored, I'll use the eastern shore of Cape Cod Bay in Eastham, for an example. There are a lot of revetments along that shore. It also has sand bags or dura-bags. We know that there's forced high water up against some of the revetments. Eventually, there's going to be forced high water up against the dura-bags. You're not going to be able to maintain that material cover over the bags. So I think your idea of putting material back into the system covering the bags is going to become more temporary. In other words, it's going to be removed more frequently, but you're still going to be putting it back in the system. So there's going to become a point where you're just putting the sand in the water. And that point I don't think is too far in the future. So, if somebody else wants to address that. Leslie?

MS. FIELDS: I know that our firm has done a few large beach nourishment projects around the Cape. We're big proponents of beach nourishment, and I think you're going to see a lot of it in the future.

And in many cases, we've proposed beach nourishment in conjunction with fiber rolls, and almost always in conjunction with revetments or some hardened structure because of the Conservation Commission's requirement, and because we realize that it's a good thing for the sediment supply. And I had mentioned that in one of the slides that I had showed earlier is that we have tried to get our clients to buy into either salt marsh restoration or beach nourishment in conjunction with the fiber rolls. And in that case, it was just a cost issue, and they just didn't want to pay for both solutions.

So I agree, beach nourishment is definitely a good thing in many cases, and if you're going to do a future seminar on beach nourishment, we would love to make a presentation.

MR. O'CONNELL: Well, that's obviously the first suggestion on the next workshop. Al?

AUDIENCE MEMBER: I think Bill actually answered it. A lot of the conservation commissions, when you do these — anything that's going to cut off the sediment source, you have to calculate how much sediment theoretically you might have gotten every year, and as part of the order of conditions there had to be a beach nourishment project each and every year. And so they replace it that way.

MR. O'CONNELL: Yes, most of the commissions that I'm aware of are now requiring that.

MR. O'CONNELL: Dennis?

AUDIENCE MEMBER: Has anyone here had any experience with retroactively having problems as Eastham is — that most of these revetments go back pre-nourishment requirements. We might have a handle on the newer projects; but the vast majority of them are older projects and so far there has not been a mechanism for retroactively requiring nourishment.

MR. O'CONNELL: Actually, that's part of state policy, so it could be considered. But it's only a policy. Whether or not the commissions are doing it, I'm not sure. I believe DEP is unclear about the legality of requiring nourishment for reconstruction of a revetment or just resetting rip-rap when it wasn't required in the original permit. We would have to get that from DEP. Anyone from DEP?

Kevin?

MR. MOONEY: Kevin Mooney, Division of Waterways. I know that when we do projects now, we require a maintenance program. We had a project that we canceled down in Harwich, but it was a very intricate project that we were looking at: rebuilding a jetty, reestablishing the dunes, doing jetty maintenance, doing beach nourishment, and just tying everything together with dredging of the harbor. The maintenance program that we were developing there required you to go out every year and do a survey to see where your erosion is, where your accretion is, and move material back into the eroded area so that you can still feed the whole system, and make sure that your beach plantings are fine.

But everything comes down to maintenance. And that's the one thing no matter what system you're using, whether it's a hard structure or a soft structure, whatever — maintenance. There's going to be different issues with all things, but you have to maintain it. If you don't maintain it, it's not going to be there to protect you when you need it.

Everything that we use on the coast is sacrificial. One good storm, it's gone. But if you maintain it, that's going to go before properties. So the key that we use now is we require the maintenance of these areas. And a lot of the conservation commissions that are requiring nourishment are getting the idea from my office to push this because we work with DEP, and with the Corps, to try to establish things. When you get a license to establish a profile on a beach, that's considered a structure, even though it's sand. You can maintain that profile without going through the whole permitting process again. And that's something that we did down at the Sylvia State Beach. That's where I came across it at Sylvia Beach. That's where we come in and maintain it without going through the process every single time, recognizing that it is a structure and it has to be maintained to get the licenses. So that's what we do.

AUDIENCE MEMBER: Excuse me. When you say "we," who do you mean exactly?

AUDIENCE MEMBER: Commonwealth of Mass. DEM, Waterways.

We're those nice people that dredge all your harbors.

MR. JOYCE: Chris Joyce, Joyce Landscaping. My question is, there's been so many different theories today on nourishment, beach grass, and does it work, does it not work, should it be fertilized, does it all die. And this is for Joe Grady. Obviously you've done a large-scale Cape beach grass planting in Duxbury Beach. Why have you been so successful where others haven't? What's your reason for your success?

MR. GRADY: Plant it early in the season and fertilize it.

MR. JOYCE: You fertilize it once annually?

MR. GRADY: Once a year, with very slow-release nitrogen, twenty pounds per acre.

MR. JOYCE: What do you find the most optimum time to get that beach grass in?

MR. GRADY: We'll be planting March 23rd this year.

MR. JOYCE: And how long will you go for?

MR. GRADY: That's it. It's a one-day event.

MR. JOYCE: You do it in one day?

MR. GRADY: Yeah. I plant it as early as you can.

MR. JOYCE: No later than that day?

MR. GRADY: I wouldn't recommend past April 1st with the weather conditions we're having.

MR. JOYCE: Are you a proponent of spring seeding rather than fall seeding?

MR. GRADY: Yes.

MR. JOYCE: So it doesn't have the whole winter to try to survive.

MR. GRADY: In the southern part of the country, it's traditionally done in the fall. New England traditionally plants in the springtime because traditionally the winter storms cause the most havoc in New England, and you don't want to lose your material by a storm in the wintertime that you just planted.

MR. JOYCE: What percent of dieback do you have?

MR. GRADY: The first year, next to none, as long as you continue to fertilize it on a regular basis. You know, we can live with maybe twenty percent. We find that acceptable.

MR. JOYCE: As a conservation agent within your town, as well as being a trustee of the beach, I know in our town, you start talking fertilization on a coastal bank, people start — hair starts standing on end. Today I've heard so many different theories, well, in this town it's okay. Don't you think statewide there should be a theory on that instead of having it all each conservation agency approaching it different?

MR. GRADY: Well, I think that's one of the reasons for processes like this, is to try to spread the word on things that have worked in other places. But in Massachusetts, home rule and individual cities and town decisions are a very strong thing, and it will always be that way. Again, I have to advocate a slow-release nitrogen. Nitrogen is a real problem in a lot of embayments, so they don't want people just pouring nitrogen all over the place next to our coastal waters. You've got to be very careful with nitrogen.

MR. JOYCE: How many pounds per acre?

MR. GRADY: Twenty pounds. For the rest of you, what's traditionally put on a lawn is something around eighty pounds an acre, so twenty or twenty-five percent, which we'd normally apply. And that was work that was done by Carl Rask of the Cape Cod Cooperative Extension, ten, fifteen years ago. They did some experiments to try to find out what the optimal rate was. So it's just a light application.

MR. O'CONNELL: Again, it's coming down to be site specific. If you have an embayment that's not well flushed, use of slow-release seems appropriate, and as little as possible. Tim showed one slide where he used a hundred pounds an acre — that's the open ocean end of the spectrum that's going to flush immediately.

One last comment?

Tim Friary?

MR. FRIARY: I always use quick-release. Right before a storm, in the springtime, in April, I like to get it right to the roots when it rains. I mean, that's the USDA spec too. That's what they experimented with and that's what they came up with that worked. The quick-release is what they fertilize with.

AUDIENCE MEMBER: The common mistake with fertilizer, however, is when you're looking at pounds per acre, you have to remember the percentage of nitrogen. So if you're choosing a hundred pounds per acre at ten percent nitrogen, that's only ten pounds of actual nitrogen per acre.

MR. O'CONNELL: Good point.

AUDIENCE MEMBER: And that's when we had trucked-in soil to deal with, which is very, very sterile.

MR. CLARK: So you have to be careful when you start talking poundage. You have to look at the actual active ingredient.

AUDIENCE MEMBER: And calculate the dosage.

MR. CLARK: Calculate the percentage of active ingredient being applied, and then what percentage of that is actually either slow- or quick-release. So, it makes a difference. So you can't really compare apples and oranges. You have to know all the facts. That's the trouble with using all these numbers.

MR. O'CONNELL: As the Director of Cape Cod Cooperative Extension, Bill gets the final comment.

I want to thank you all for coming. I want to particularly thank the speakers for taking the time to put a presentation together to spark these informative discussions. It can take a great deal of time and effort to put presentations together – so thanks! I hope you enjoyed yourselves and more importantly learned ideas from each other that you can carry into the field. We, and the coastal environment, can all only benefit from sharing our collective experiences.

Thank you all very much. We'll be putting proceedings together to document these important discussions. Continue to share your knowledge.

(Whereupon the proceedings concluded.)

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16. Abstract (Limit: 200 words)

The primary objective of the workshop and these proceedings is to share with a broader audience the valuable information and extensive dialogue that took place amongst over 100 individuals who attended the third in a series of workshops on the science and management of coastal landforms in Massachusetts. The workshop took place at the Woods Hole Oceanographic Institution (WHOI), Woods Hole, MA on February 28, 2002. The individuals who attended the workshop are actively engaged in planning, managing, regulating, engineering, educating, and studying the interaction of human activities with coastal landforms and coastal processes, particularly erosion control related activities. This workshop titled, Stabilizing Dunes and Coastal Banks using Vegetation and Bioengineering, was a natural follow-up to two previous workshops: Can Humans and Coastal Landforms Co-exist, held at WHOI, January 24, 2001 (proceedings published as WHOI Technical Report #WHOI-2001-14), and Coastal Landform Management in Massachusetts, held at WHOI October 9-10, 1997 (proceedings published as WHOI Technical Report #WHOI-98-16). This workshop had a very practical, applied focus, providing state-of-the-art scientific and case history engineering applications of non-structural/bioengineering and coastal vegetation-related erosion control and wildlife habitat enhancement techniques. The history and theory of bioengineering in coastal areas was discussed as well.

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