NATIONAL
ESTUARINE
RESEARCH
RESERVE
SYSTEM

Restoration Science Strategy: A Framework

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National Estuarine Research Reserve System
Restoration Science Strategy: A Framework

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INTRODUCTION

Background

Estuaries and coastal ecosystems located along the continental margins of the United States encompass a diverse array of highly productive habitats and important populations of living resources. For example, coastal wetlands and riparian areas provide essential habitat for over 75% of the total commercial landings and 80-90% of the recreational catch of the nation's fish and shellfish (NOAA/NMFS, 1994). The long-term health and sustained productivity of estuarine ecosystems are priority areas of national concern, and particular attention has been focused on the chronic adverse effects of industrial operations, residential development, and recreational activities on the physical structure and ecological functions of estuarine habitats (NOAA/NOS, 1990). Estuaries, embayments, and barrier islands are dynamic coastal ecotones that respond readily to disturbance by natural and anthropogenic events. As a result, resource agencies have been encouraged to place a high premium on the development of cost-effective and reliable methods to assess existing and future habitat values in efforts to guide local land use planning and informed coastal decision-making (NOAA, 1996; NCZMES, 1997).

Academic scientists and agency investigators have put considerable effort into the development of effective restoration and enhancement technologies designed to regain lost ecological functions and natural resource values in estuarine habitats (Thayer, 1992). These efforts include the development of innovative techniques for the re-establishment of salt marshes and seagrass beds (Simenstad and Thom, 1992; Fonseca et al., 1998), specialized requirements for sensitive species and essential fish habitat (NOAA/NMFS 1996), and new monitoring protocols to standardize data collection and evaluations following the implementation of restoration and enhancement activities (Simenstad et al., 1989; PERL, 1990; Simenstad et al., 1991; ACOE, 1996; GPAC, 2000). The technical information available to evaluate alternative design approaches for estuarine restoration projects, implementation protocols and active remediation steps, and the acquisition of standardized monitoring data is substantial. However, there are still pressing needs for additional new research in the field of restoration and improvements in the dissemination and transfer of technical information to appropriate user groups (Josselyn et al., 1989; Thayer, 1992).

The critical need for estuarine habitat restoration has attracted Congressional attention. In October 2000, Congress passed the "Estuary Restoration Act of 2000." This Act authorizes $275 million over five years for local restoration projects to restore one million acres of estuary habitat by 2010. The Act focuses on the importance of sound science and monitoring to achieve restoration success.

The purpose of this document is to describe the current and potential role of the National Estuarine Research Reserve System (NERRS or reserve system) in restoration science and provide a framework for how the reserve system can contribute more fully to the

successful restoration of estuaries through science and education. The document characterizes the reserve system's capability to address national restoration science priorities, identifies partners, and presents the niche that the reserve system believes it can fill to address the Congressional mandate for restoration.

Overview of the National Estuarine Research Reserve System

The reserve system is a network of twenty-five protected areas established to improve the health of the nation's estuaries and coastal habitats by developing and providing information that promotes informed resource management. The reserve system was created by the Coastal Zone Management Act of 1972, as amended, to augment the federal Coastal Zone Management (CZM) Program. The CZM Program is dedicated to comprehensive, sustainable management of the nation's coasts.

The reserve system is a federal-state partnership. A coastal state and the National Oceanic and Atmospheric Administration (NOAA) jointly establish each National Estuarine Research Reserve (reserve). Each reserve is a discrete area containing key habitat within an estuary, protected by state law from significant ecological change. Reserves are selected to represent different types of estuaries and large biogeographic regions within the nation.

NOAA's Estuarine Reserves Division (ERD) administers the overall reserve system. The national office establishes standards for designating and operating reserves, supports the operation of each reserve, undertakes projects that benefit the entire system, and integrates information from individual reserves to support decision-making at the national level.

Each reserve is managed on a daily basis by either a state agency or a university. Reserve staff work with local communities and regional groups to address natural resource management issues. Because reserves are designated to represent large biogeographic regions, they also provide an important source of information to coastal states with similar estuarine ecosystems.

Reserves conduct integrated programs that develop a fundamental understanding of estuaries and how these areas are impacted by human activities. In carrying out these programs, reserve staff and other investigators gather data on the natural and human environment through scientific (natural and social science) research and monitoring. From that data, staff members develop innovative solutions to address resource management needs and translate results into an easily understood format for target audiences such as resource users, managers of coastal resources, and the general public. The individual reserves are at various stages of developing stewardship and restoration plans for their reserves and, in some cases, their estuaries. Many are working with other agencies and organizations to develop mitigation strategies in the event of accidental or natural disasters.

The Reserve System as a Setting for Restoration Science

As living laboratories, the reserves are ideal settings to investigate the restoration and protection of estuarine and coastal habitat. The reserve system offers the habitat, diversity, on-site human and physical infrastructure, educational programming, and, at many sites, experience in restoration science. Additional resources and outside support would increase the capacity of the reserve system to meet restoration science needs on a national basis.

The estuarine areas designated as part of this national network of protected areas range from relatively pristine to significantly disturbed habitat and represent the biogeographic diversity of our nation's coastal ecosystems. Most reserves have extensive areas of undisturbed habitat. These are useful as long-term scientific reference sites for understanding estuarine ecosystems and comparing them with other more disturbed habitats in similar physical settings. Reserves also encompass habitat that has been lost, damaged, or altered over time. Within reserve boundaries and watersheds, one can find wetlands historically converted to agricultural lands; coastal hydrography disrupted by roads, dikes, and other human structures; native forest and meadow species replaced by invasive, non-indigenous species; beaches and dunes used for commercial or recreational purposes; and habitat damaged by accidental spills or groundings. Disturbed areas within the reserve system offer a wide spectrum of opportunities, ranging from scientific investigation to large-scale habitat restoration and enhancement.

Because of their federally protected status, biogeographic diversity, on-site facilities, long-term monitoring programs and data, and professional staff capabilities in science and education, the reserves are excellent platforms for advancing the " science" of restoration**,** staging demonstration restoration projects, and monitoring their long-term response. Long-term monitoring is an integral aspect of reserve operations and is a part of reserve restoration projects at some sites. A number of reserves have research coordinators on their staff who have particular expertise in estuarine ecology. Some have stewardship coordinators with expertise in restoration. This on-site capability allows for long-term monitoring for a range of ecological parameters. The majority of the sites have office, meeting, and laboratory space and dormitory facilities available to house visiting investigators and graduate students. Each reserve has an on-site Geographic Information System (GIS) capability that has the potential to support research and education activities. Moreover, ongoing and proposed restoration science projects usually generate a variety of short-term research projects suitable for graduate level thesis and doctoral dissertation work.

The reserves are already engaged in a number of system-wide activities, such as the System-Wide Monitoring Program, the Coastal Training Program, and the Graduate Research Fellowship Program. These will enhance and, in turn, be enhanced by a NERRS Restoration Science Program. The reserve system is also closely affiliated with the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), a national center that supports a number of projects that apply innovative restoration technologies at the reserves (see below for additional details).

With additional resources, reserves can further develop effective communication tools needed by others involved in restoration and utilize links in their surrounding communities to deliver the information to local audiences. An additional advantage is that the reserves are biogeographically representative and can therefore conduct restoration demonstration and science projects that are regionally relevant and transferable.

To date, the majority of the reserves have engaged in restoration science and have planned or conducted small to medium-scale restoration projects (.5 to 250 acres). They have investigated both engineering and natural approaches to restore areas to approximate natural, unaltered conditions. Several reserves must first address water quality issues and/or restore hydrologic regimes (i.e. sheet flow, tidal exchange, and freshwater drainage) before they can restore terrestrial and aquatic native plant communities and achieve faunal and ecological recovery.

Many of the reserves are already demonstrating leadership in restoration science. They serve as important local and regional catalysts for the planning, design, and implementation of restoration projects. For example, the research, education, and stewardship staff at the Rookery Bay (Florida) Reserve is involved in various small to large-scale hydrologic alterations and science based coastal habitat restoration projects within and beyond reserve boundaries in Southwest Florida. The Wells (Maine) Reserve is playing a lead role in salt marsh restoration in the Gulf of Maine (GPAC 2000). After twenty years of estuarine research and monitoring, the Tijuana River (California) Reserve has completed the first two phases of a science-based inter-tidal salt marsh restoration project. The reserves have also coordinated and facilitated investigations by academic and agency scientists to restore degraded areas. For example, the South Slough (Oregon) Reserve is investigating both natural and engineering approaches to reestablish tidal circulation and restore its heavily diked estuary. Implementation of a system-wide Restoration Science Strategy can increase the capacity of the reserves to accomplish restoration research and monitoring and deliver results to the appropriate local, regional and national audiences. Properly undertaken, it can lead to national recognition of expertise in the reserve system. With adequate funding, reserve restoration science and education capacity can spread system-wide to cover a range of habitats.

Inventory Results

To better understand the reserve system's involvement in the field of restoration and, more specifically, restoration science, a NERRS Habitat Restoration Inventory was conducted during the fall of 1999. It was designed to collect general but significant information about historic and ongoing restoration activities and the direction of future restoration at the reserves. The findings provided a foundation for the NERRS Restoration Science Framework document. A table presenting each reserve's restoration priorities and current restoration projects is provided in Attachment 1 (the information is based the inventory results and a 2001 update).

The results of the inventory demonstrate that restoration and restoration science are widespread throughout the reserve system. Three quarters of the reserves are currently engaged in restoration activities, including both physical restoration and restoration science. The reserves estimate that to date they have physically restored or enhanced approximately 8,000 acres within site boundaries and approximately 100,000 acres outside their boundaries. Activities can be categorized as assessment and planning, restoration of hydrologic regimes, restoration of native plant communities, elimination/control of invasive species, monitoring, and faunal/ecological response. The most common types of on-the-ground projects include salt marsh restoration, hydrologic restoration, riparian restoration/enhancement, and controlled burning in fire-dependent habitat.

Reserves are primarily engaged in restoration science related to project design, physical restoration, and monitoring restoration response. Project design has included site identification and prioritization, development of assessment models, and pilot studies. For example, the Elkhorn Slough (California) Reserve is developing a comprehensive Vegetation Management and Restoration Plan, and the Narragansett Bay (Rhode Island) Reserve is involved in eelgrass restoration research and pilot studies. Two examples of restoration science related to on-the-ground restoration projects are the experimentation with controlled burning techniques in fire-dependent habitat at the Weeks Bay (Alabama) Reserve and research related to salt marsh restoration at the Jacques Cousteau (New Jersey) Reserve. The assessment of water quality improvements resulting from oyster reef restoration at the Great Bay (New Hampshire) Reserve; pre- and post-restoration bio-monitoring of community structure at the Rookery Bay (Florida) Reserve; and analysis of vegetative succession and the use of restoration sites by fish at the South Slough (Oregon) Reserve are examples of monitoring for restoration response.

The majority of the reserves expressed interest in increasing the reserve system's capacity to undertake restoration science. The reserves identified activities in the following categories as their chief restoration science priorities in the future: project design, restoration, and monitoring restoration response. The areas of restoration science cited most often were the identification and prioritization of areas needing restoration, and the development of effective, standardized tools and methodologies for restoration and evaluation of restoration success.

Because a number of sites reported that they are currently addressing water quality issues in their watersheds, the scope of the NERRS Restoration Science Strategy needs to be broad enough to encompass the science linking water quality to habitat.

Based on inventory responses, there are also significant opportunities for "on-the-ground" restoration in the reserve system. The inventory provided very rough estimates of additional acreage needing restoration or enhancement in the future: more than 30,000 acres within reserve boundaries and 200,000 acres outside reserve boundaries to reduce impacts that directly affect reserve resources.

There is strong interest in undertaking the science and information transfer related to these restoration projects, but less universal interest in reserve staff actually "shoveling the dirt." However, reserve restoration needs provide opportunities for outside researchers to undertake science-based restoration projects in a protected environment.

Few reserves have restoration plans separate from the reserve management plan. All but two respondents expressed interest in developing restoration plans.

It is clear from the responses that it will take additional resources in order to accomplish a successful NERRS Restoration Science Program. Nearly every site emphasized the need for additional funding and most would require additional expertise and resources (e.g. equipment, personnel).

Inventory respondents overwhelmingly expressed the importance of an integrated research, education, and stewardship approach. This would be critical in garnering the necessary support and translating and disseminating the research findings to the appropriate audiences.

The National Context for a NERRS Restoration Science Strategy

A national Restoration Science Program for the reserve system will support a number of national activities underway inside and outside NOAA. A brief overview of the national context indicates the timeliness and appropriateness of the NERRS Restoration Science Strategy.

The NERRS FY 02-04 Action Plan

The reserve system's national restoration planning appears in the NERRS FY 02-04 Action Plan, a blueprint for the national direction that the reserve system is heading. The relevant objectives and actions are as follows:

> OBJECTIVE 4. Protect reserve habitats and resources to minimize accidental, cumulative, and chronic damage and improve degraded habitats and resources where necessary.
>
> > Action. Complete a restoration science strategy (framework document) to increase the reserve system's capacity to provide scientific information and technical expertise to restore, enhance, and maintain estuarine ecosystems.
> > COMPLETE BY December 2001
> >
> > Action. Seek funding for habitat restoration science to develop and transfer effective techniques to identify, prioritize, restore, and monitor disturbed or lost estuarine habitat.
> > COMPLETE BY Continual

Action. Develop a system-wide strategy to restore and conduct research and monitoring on disturbed habitats within reserves and those areas that impact the site from outside reserve boundaries.
COMPLETE BY October 2002

Action. Participate in the planning and implementation of the Estuary Restoration Act.
COMPLETED BY Continual

OBJECTIVE 6. Broadly share lessons learned in the National Estuarine Research Reserve System.

Action. Use reserve outreach and training capabilities to translate and transfer restoration results and techniques developed as a result of ongoing restoration science activities.
COMPLETE BY Continual

This Restoration Science Framework document completes the first action and sets the stage for the third action. In accordance with the second action, the reserve system will seek funding to implement the Restoration Science Strategy. It is envisioned that a focus area of the strategy will be the translation and transfer of results and techniques, thus responding to the last action.

Consistency with the NOAA Mission to Sustain Healthy Coasts
Development of a NERRS Restoration Science Strategy is consistent with the 1995-2005 NOAA Strategic Plan (NOAA, 1996). NOAA sees a large part of its environmental stewardship mission as improving the nation's ability to sustain healthy coasts. "Protection, conservation, and restoration of coastal habitats and their biodiversity" is one of three objectives under the "Sustain Healthy Coasts" goal in the plan.

In addition, the NERRS Restoration Science Strategy strongly supports the National Ocean Service Strategic Plan (NOS, 1999) habitat goal to "enhance the preservation and restoration of the U.S. coastal and ocean environments." It also supports the coastal and ocean ecosystems goal in the Office of Ocean and Coastal Resource Management (OCRM) Strategic Plan to " increase the long-term health and economic viability of coastal and ocean ecosystems."

NOAA Restoration Network
In March 2000, NOAA held a meeting of headquarters and field personnel to launch a NOAA Restoration Network. This was envisioned as a network of NOAA resources and expertise organized to focus on and function at a local level to promote grassroots efforts to restore habitat beneficial to NOAA trust resources. The reserve system has a great deal to contribute to this NOAA network as it comes to fruition.

Consistency with ERF/RAE Principles
In 1999, the Estuarine Research Federation (ERF) and Restore America's Estuaries (RAE) sponsored a series of workshops to "assess the current situation with regard to

habitat restoration; clarify what is known about how to effectively restore habitat; and develop a collaborative agenda for the year 2000 and beyond." [1] In their final report (ERF/RAE, 1999), they identify gaps in (1) supporting research and monitoring associated with restoration planning, construction, and evaluating success; and (2) integrating past scientific results into future on-the-ground restoration projects. The reserve system seeks to fill these gaps. A set of guiding principles for restoration was developed as part of the ERF/RAE workshops (Attachment 2). These principles highlight the importance of long-term stewardship, good science, reference sites, scientifically based monitoring, open regional processes, and public involvement and understanding. These principles fully support the direction and activities proposed by the reserves in this Restoration Science Framework document.

National Legislation

There is currently legislation that offers tremendous opportunities to draw upon and advance the reserve system's restoration science capabilities. In November 2000, President Clinton signed the "Estuaries and Clean Waters Act of 2000." Title I, the "Estuary Restoration Act of 2000" (ERA), promotes the restoration of one million acres of estuary habitat by 2010. It directs the U.S. Army Corps of Engineers (USACE) and a federal interagency council to prepare a National Strategy for Coastal Habitat Restoration. The ERA authorizes $275 million over five years for matching funds for local restoration projects. It singles out the contribution that the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) and the reserve system can make. One of four purposes of the ERA is " to develop and enhance monitoring and research capabilities through the use of the environmental technology innovation program associated with the National Estuarine Research Reserve System … to ensure that estuarine habitat restoration efforts are based on sound scientific understanding and innovative technologies."[2]

NOAA has a seat on the Estuary Habitat Restoration Council established by the ERA. The agency is also responsible for a database of restoration project information and the establishment of monitoring data standards. It is authorized to receive $1.5 million annually for FY 2001-2005 to implement these monitoring provisions. The reserve system is uniquely positioned to contribute to these efforts.

National Strategy for Estuarine Habitat Restoration

Under contract with NOAA, RAE (principal sponsor of the ERA) has collaborated with various federal agencies and non-governmental organizations to prepare a "National Strategy for Estuarine Habitat Restoration." In partnership with the organizations preparing this document, the reserve system played a national role in developing this strategy. The strategy provides a valuable foundation for future ERA activities.

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[1] ERF/RAE. Principles of Estuarine Habitat Restoration (1999), page 1.
[2] Estuaries and Clean Waters Act of 2000, Title I, Section 102.

THE NERRS RESTORATION SCIENCE FRAMEWORK

Introduction: Approach and Focus of the NERRS Restoration Science Strategy

In August 1999, a NERRS Restoration Science Workgroup consisting of ERD and field staff was formed to develop the NERRS Restoration Science Strategy (see Attachment 3 for current workgroup members). Based upon input at the 1999 NERRS annual meeting; the 2000 Education Coordinators, Research Coordinators, and Program Managers meetings; the 1999 NERRS Restoration Inventory results; workgroup meetings and conference calls; and an external review meeting in July 2001, the workgroup developed the approach and focus of the NERRS Restoration Science Strategy.

The goal of the NERRS Restoration Science Strategy is as follows:

> To provide the scientific basis and technical expertise to restore, enhance and maintain estuarine ecosystems by developing and transferring effective approaches to identify, prioritize, restore, and monitor degraded or lost coastal habitat. Success will require a partnered approach, education and community involvement, regional coordination, and additional resources.

The Reserve System will undertake an adaptive management approach in the restoration science strategy. "Adaptive management" is a process that enables an organization to make adjustments in its management actions based upon the results and evaluation of monitoring. This is particularly advantageous for restoration plans because, typically, there are gaps in preliminary information about the consequences of actions on complex estuarine ecosystems. Adaptive management can become a powerful method to systematically assess and improve the performance of restored systems as well as contribute to the technology of restoration.[3]

Reserves can develop the scientific information necessary to support adaptive management strategies for restoration. They can identify areas of scientific uncertainty, plan and conduct field experiments to test hypotheses, evaluate the information gathered, and make recommendations based on the results of these experiments. Reserves are uniquely situated to undertake experimental investigations that are prohibitive at other restoration sites.

Under consideration is a coordinated, multi-site project to tackle an issue important to the development of restoration science. The reserve system could conduct a collection of experiments at all reserves to answer a question that crosses ecosystem types and benefits from the multi-site approach that the reserve system can provide.

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[3]**Thom, R.M. Adaptive Management of Coastal Ecosystem Restoration Projects (2000), p. 366.**

The following are overarching questions that are under consideration:

- Once habitats and functions that we value in estuaries are degraded, is this reversible and how? Can you get back to a pre-existing state at a particular point in time? When is rehabilitation to some other habitat more appropriate than restoration?
- What is the importance of topographical complexity to restoration?
- What is the relationship between topographical complexity and biodiversity?
- What is the relationship between habitat structure and function?
- What is the importance of species interaction and the maintenance of diversity?
- What do you monitor at an individual reserve that would help measure the cumulative benefit of many restoration projects?
- How long do you monitor a restoration site in order to predict the long-term success of a project?
- How do you go about restoration? What level of effort is appropriate? What are the tradeoffs between tremendous effort up front and small efforts over a longer period of time?
- When and how is restoration possible? Looking at estuaries affected by eutrophication, sedimentation, or subsidence, are these reversible?
- How large does a restoration site need to be?

The chief areas in which the reserve system proposes to play a national role are:

- Project planning
- Developing effective approaches to and testing innovative technology for restoration and evaluation of restoration performance
- Monitoring restoration response
- Serving as local reference or control sites
- Translation/transfer of restoration information
- Scientific and technological advice to support policy and regulatory decisions
- Constituency building for support of restoration science
- Regional science coordination

These focus areas are described in greater detail below. They fully support the Estuary Restoration Act of 2000 and serve as an enhancing complement to the National Strategy for Estuarine Habitat Restoration described above.

Assumptions and Definition of Critical Terms

Reserve staff agrees upon a set of underlying assumptions and working definitions for the NERRS Restoration Science Strategy. The working assumptions are as follows:

- Preservation and conservation of existing coastal and estuarine habitat must occur along with restoration. Reserves seek to accomplish preservation and conservation in their priority setting for acquisition and in their long-term protection and maintenance of pristine and restored sites. The reserve system recognizes that preservation and

conservation are essential; however, they are not within the scope of this Restoration Science Strategy.

- Reserve participation is voluntary rather than system-wide.
- Additional funding is required for implementation of a NERRS Restoration Science Strategy.
- The scope of the NERRS Restoration Science Strategy will be broad enough to encompass the science linking water quality to habitat.
- Reserves will not support habitat manipulation that causes adverse impacts on unaltered site habitat and resources, compromising the representative character and integrity of a site.
- The Strategy will require a partnered approach among established science and management entities.
- The Strategy will require an integrated research, education, and stewardship approach.
- Future revisions of the reserve system regulations will articulate and support a stronger role for the reserve system in restoration and restoration science.
- There will be crossover between the NERRS Restoration Science Strategy and the System-Wide Monitoring Program (SWMP) and Coastal Training Program.
- Science activities conducted as part of the NERRS Restoration Science Strategy will be subject to a peer review process.

In the NERRS Restoration Science Strategy, *restoration science* will be defined as:

> a rigorous and experimental scientific inquiry that applies theoretical and practical considerations to the design, implementation, and evaluation of activities and manipulative steps undertaken to restore, improve, and enhance the habitat structure and ecological function of degraded estuaries and estuarine ecosystems.[4]

For the purposes of the Restoration Science Strategy and conformance with federal efforts to adopt consistent definitions and categories of wetland conservation activities, the reserve system will adopt the Clean Water Action Plan definitions for *establishment, restoration, re-establishment, rehabilitation, enhancement,* and *protection/maintenance* (Attachment 4). These definitions can be adapted to track and compare reserve restoration efforts in coastal habitats that are not wetlands.

Focus Areas of the NERRS Restoration Science Strategy

Project planning

The focus area "project planning" includes site selection and design. The reserve system plans to undertake site selection based on historical information and desired outcome. A key consideration for reserves is the development of a landscape level "framework" to guide project selection. The landscape is a geographic area distinguished by a repeated pattern of components, including both natural communities and human-altered areas. Technical considerations related to the

[4] Rumrill, personal communication (2000).

landscape scale include political, economic, historical, and/or cultural values; natural resource management concerns; and biodiversity (Landin, 1995). The reserve system acknowledges that there can be constraints associated with operating outside reserve boundaries. However, it believes that it can make a valuable contribution to the landscape view by developing principles and criteria, not actually setting priorities or making selections. Reserves may also undertake restoration in a watershed framework, thereby increasing the connection among the upstream habitat, the estuary, and the ocean or gulf. They also foresee some investment in spatial scale at the biogeographic region (e.g., reserves serving as reference sites, mapping of land use/habitat change).

Restoration project design identifies the reasons why restoration is needed and the general strategies for conducting it.[5] Restoration project design includes selecting and characterizing the actual site to be restored; identifying anthropogenic stressors and the need for restoration; comparing existing conditions with desired conditions or a reference condition; identifying the desired future conditions (recognizing that there may be multiple alternatives and associated habitat tradeoffs); prioritizing restoration sites; identifying restoration constraints and issues; conducting cost analyses; addressing scale considerations; developing performance criteria; and planning for implementation, monitoring, evaluation, and adaptive management. In all cases, restoration project design includes data collection and analysis, and in some cases, it involves the development of assessment models and pilot studies.

Individual reserves have already engaged in project planning. The reserve system proposes to expand its capacity to undertake project planning in order to ensure that sound science and restoration principles are applied. More specifically, the reserve system can address the following problems in the current practice of coastal habitat restoration:

- Haphazard selection of restoration sites
- Inadequate or erroneous understanding/justification of proposed restoration projects
- Inappropriate project design
- Inadequate and/or inappropriate success criteria
- Inadequate and/or inappropriate evaluative pre- and post-restoration monitoring.

Developing effective approaches to and testing innovative technology for restoration and evaluation of restoration success

Restoration efforts in the U.S. tend to be *ad hoc* and often driven by either regulatory compliance or community interest without full consideration of the underlying science. As a result, approaches to various types of restoration -- from the design phase to the evaluation of restoration response -- have been inconsistent. Efforts to transfer techniques and methodologies from one project to another have generally been minimal.

[5] Society for Ecological Restoration. Guidelines for Developing and Managing Ecological Restoration Projects (2000), p. 1.

With additional resources, the reserve system can assist in the development of scientifically defensible approaches to restoration and the evaluation of restoration performance. Reserves are well-suited for experimentation and can develop and test techniques and methodologies for effectiveness. This focus area is also enhanced by the affiliation of the reserve system with CICEET. One of CICEET's major goals is the development and application of innovative and cost-effective restoration technologies in support of the reserve system restoration science. Innovative technology is defined as new processes, techniques, or materials or the use of existing processes, techniques, or materials in a new application. It is applied to solve a problem. Additional resources can expand the capacity of CICEET to support and the reserve system to test innovative technologies for restoring our nation's coastal and estuarine habitats.

Monitoring restoration response

One of the ERF/RAE principles of estuarine habitat restoration states, "Scientifically-based monitoring is essential to the improvement of restoration techniques and over-all estuarine restoration." Pre- and post-monitoring is necessary to provide baseline information and to evaluate restoration performance and success. However, it is usually under-funded, often inadequate or inappropriate, and sometimes omitted from restoration projects. Monitoring protocols are rarely based on a set of core variables within broad categories of habitat structural and functional responses to restoration.

The reserve system has experience in developing and implementing the monitoring methods and protocols associated with SWMP and individual site monitoring programs. This places it in a uniquely qualified position to develop monitoring protocols and methods and provide baseline information to monitor restoration response. Additional resources can increase reserve capacity to design and implement monitoring programs associated with estuarine restoration projects. This can contribute greatly to our understanding of the long-term ecological response to restoration projects, since many post-restoration monitoring activities outside the reserves are limited to a few years. More subtle but no less important ecological responses to a restoration project take longer to detect.

Serving as local reference or control sites

The eighth ERF/RAE principle of estuarine habitat restoration states, "Success criteria for projects need to include both functional and structural elements and *be linked to suitable reference sites*." (emphasis added). A reference site is a habitat minimally impacted by natural or human-caused disturbances that is believed to be indicative of the natural potential of a disturbed site. The selection of appropriate long-term reference sites is critical for effective design and evaluation of restoration response. Because all of the reserves encompass relatively undisturbed areas, they are able to provide suitable and, in some cases, well-studied local reference sites for comparison with restoration projects in similar physical settings. Moreover, SWMP provides valuable baseline and predictive information that increases the reserves' value as reference sites.

Translation/transfer of restoration information

One of the chief weaknesses in the field of estuarine restoration is the translation and transfer of restoration information. Scientific findings – both the successes and failures -- need to be interpreted and disseminated to coastal decision-makers so that they can make better decisions about estuarine resources, and to other restoration scientists and practitioners so that they can learn from previous experiences as they undertake future restoration. The primary role that the reserve system education program can play in the NERRS Restoration Science Strategy is to translate and deliver information about restoration science and technology. Reserves already provide training in various facets of restoration through their coastal decision-maker workshops. The NERRS Coastal Training Program is intended to deliver relevant science-based information, including restoration findings, to targeted coastal decision-maker audiences. In addition, CICEET can support innovative information transfer technology.

Scientific and technological advice to support policy and regulatory decisions

The majority of the reserves have programs and products that target coastal decision-maker and advocacy audiences (i.e. non-governmental organizations [NGO's]). In addition, reserve staff members have established one-on-one communications and relationships with local, state, and regional decision-makers. They are often asked to serve on scientific advisory committees, review permit applications, and consult on coastal projects. They are reputed for their scientific and technical expertise to provide sound advice to support policy and regulatory decisions. It is proposed that the reserves, coastal decision-makers, and NGO's engage in a proactive dialogue to determine and then undertake the science needed to support policy related to estuarine restoration. Reserves can also assist by advocating for a better rules system for restoration at the state and local level, one that streamlines the permitting process and improves mitigation practices.

Constituency building for support of restoration science

Two of the ERF/RAE principles of estuarine habitat restoration address the importance of public involvement and constituency building. Principle 2 states, "Estuaries can be restored only by using a long-term stewardship approach and developing the constituencies, policies and funding needed to support this." Principle 4 states, " Greater public awareness, understanding and involvement in estuarine habitat restoration are necessary to the success of individual projects and to achieve national restoration goals."

Stakeholder participation can build ownership in and support for restoration science. Reserves are in a position to offer various opportunities for involvement with guidance and oversight from appropriate stewardship/resource management staff (e.g. student and volunteer programs, on-site access and interpretation, seminar series, interpretive materials). Certain types of involvement have the additional benefit of attracting media coverage that helps to build community awareness, understanding, and support for the concept of restoration. Additional resources can expand this capacity for constituency-building throughout the reserve system.

Regional science coordination
The sixth ERF/RAE principle of estuarine habitat restoration states, "Estuarine restoration plans should be developed through *open regional processes* that incorporate all key stakeholders and *the best scientific thinking available*"(emphasis added). Scientists need to be involved as core participants in restoration planning activities. Likewise, restoration plans need to incorporate up-to-date scientific information.

The reserve system proposes to play a larger role in regional science coordination. With additional resources, reserves can serve as clearinghouses for relevant scientific information to enhance restoration activities taking place in their bioregion. They can bring together researchers in various disciplines to plan and implement a project. Existing relationships with academic and agency scientists can be leveraged to promote regional science coordination. Moreover, reserve facilities can be used to convene scientists and practitioners at appropriate phases of a restoration project.

RELATIONSHIP OF THE PROPOSED NERRS RESTORATION SCIENCE PROGRAM TO OTHER RESERVE SYSTEM PROGRAMS

Reserve headquarters and field staff have articulated the relationship between the proposed Restoration Science Program and other reserve system programs and initiatives.

Relationship of the Restoration Science Strategy to Research and Monitoring
The reserve system plays an important national role in the realm of coastal habitat research and long-term monitoring. Through the Restoration Science Strategy, the reserve system can apply its research/monitoring expertise and research field site support to improve the science and practice of coastal habitat restoration.

The reserve system has a unique structure that places research, monitoring and, in many cases, stewardship staff on-site at 25 representative areas throughout the coastal United States. With additional resources, this arrangement can provide a valuable foundation for the development of appropriate, regionally applicable approaches to site selection, design and evaluation of coastal habitat restoration projects. Reserve technical capabilities can support both restoration science and its translation for users and coastal managers. For example, each reserve now has a dedicated GIS computer, base data layers, and staff trained in the use of GIS software. Enhancing this GIS capability will contribute to restoration science endeavors, such as mapping and tracking invasive species. To date, the NERRS Graduate Research Fellowship Program has supported nine fellowships addressing restoration issues at the reserves. Funding for additional fellows can increase graduate-level support during the implementation phase of the Restoration Science Strategy. Moreover, on-site facilities (e.g. wet and dry laboratories, dormitories, docks and ramps) and equipment (e.g. research vessels, lab equipment, vehicles) make the reserves attractive platforms for restoration science for collaborating investigators.

Relationship to the NERRS System-Wide Monitoring Program. The NERRS System-Wide Monitoring Program (SWMP) is a long-term monitoring program focused on detecting short-term variability and long-term trends in estuarine ecosystem health. This program uses standardized equipment and protocols at all the reserves to provide information about these critical habitats to coastal managers. The primary relationship between SWMP and the NERRS Restoration Science Strategy is that SWMP provides valuable baseline and predictive information that increases the reserves' value as reference sites. Long-term reference sites are critical for effective restoration and are necessary to address natural changes in habitat, track trends, test restoration and monitoring techniques, identify wetlands functions, and provide essential benchmarks for the success of restoration projects. SWMP will provide an important component of restoration science as described in this Restoration Science Framework. SWMP may also help to develop some of the monitoring methods and protocols for reserve system restoration science activities. As the reserve system attains recognition as a national program that addresses restoration science issues, the increased need for SWMP may lead to greater federal support for this program.

Relationship to the Cooperative Institute for Coastal and Estuarine Environmental Technology. The Cooperative Institute for Coastal and Estuarine Environmental Technology is a national center for the development and application of innovative environmental technologies for monitoring, managing, and preventing contamination in estuarine and coastal waters. It is a partnership between NOAA and the University of New Hampshire. CICEET is currently supporting a number of projects that apply innovative technologies toward the restoration of important coastal habitats. These projects include novel restoration and contaminant remediation methodologies, and innovative technologies to rapidly assess habitat quality and restoration success. All CICEET projects involve at least one of the 25 reserves and benefit from CICEET's close association with the reserve system. Habitats of focus for these projects include salt marsh, seagrass, oyster reef, essential fish habitat, and channel bottom sediment remediation.

The reserve system provides a national network for CICEET experimental research and technology. Ideally, the role of CICEET will be to develop and apply innovative restoration technologies and/or methods in support of reserve system estuarine restoration, including information transfer technology. With respect to measures of restoration response, CICEET support would be limited to testing the technologies and methods being developed, not to the more general question of "how do we know habitat restoration is successful?" The latter leads to a host of ecological process-oriented projects that are outside the scope of CICEET.

Relationship of the Restoration Science Strategy to Education

Results from the 1999 NERRS Restoration Inventory indicate that there are two roles for education in the field of restoration science:

- Development of popular support for and understanding of the need for restoration, methods, implications, importance, and costs (programs for academic and public audiences).
- Transfer of improved methods of restoration, technology, and information (programs for coastal decision-makers).

With increased funding, reserves can build upon existing educational and interpretive activities and provide new opportunities in the following ways:

- Public involvement in restoration and monitoring with the guidance and oversight from appropriate stewardship/resource management staff. This may take the form of graduate and undergraduate level student participation (possibly fellowships), volunteers with an interest in the activities of the reserve, or even middle and high school classes assisting with removal of exotic species, restoration of biotic communities, or long-term restoration monitoring. Opportunities for such involvement are important not only for the participating individuals, in terms of the educational experience, but also the potential for successful media coverage of such activities as an effective means of building community awareness, understanding, and support of the concept of habitat restoration. Public involvement in these activities is particularly valuable because it reinforces the relevance of healthy ecosystems to a populace that does not necessarily see itself as a part of the problem or the solution.

- Provision of tours, information, and public programs for academic and non-academic audiences with a focus on habitat restoration and restoration science will better serve to bolster public understanding of the value of the reserves as places that provide valuable applied science to real world problems. In particular, habitat restoration and manipulation, which can be linked to restoring functions and values that are seen as important to the public good, will help further establish the reserves as important resources in the community.

The value of on-site interpretation is particularly great for the reserves, which represent long-term investments in ecological restoration with protection ensured through acquisition and other types of conservation arrangements. The development of appropriate access to these sites for educational audiences as well as providing a means for non-impact monitoring access is important.

Relationship to the NERRS Coastal Training Program. The other primary role of the reserve system in education related to restoration science is to transfer improved methods of restoration, technology and information. There are a variety of mechanisms to accomplish this. Currently, all of the reserves are conducting coastal decision-maker workshops. These workshops provide science-based information on key coastal management issues to decision makers such as state and local officials, planners, farmers, and real estate agents. Over the past several years, approximately 25 of these workshops have addressed restoration issues. In addition, the majority of the reserves have established communications and relationships with local resource users and local and

regional decision-makers. Many of the reserves have programs and products that target these audiences.

An additional mechanism is the proposed Coastal Training Program (CTP). CTP is intended to deliver relevant, science-based information, including restoration findings, to targeted coastal decision-maker audiences. Each reserve that implements a CTP is expected to develop knowledge and skill-based training programs that target key audiences relevant to reserve priority issue areas. Each reserve will have a program strategy and implementation plan in place that may include restoration science as a priority area. The goal of the program is to improve decision-making related to coastal resource management. CTP objectives are: to transfer information, tools and techniques; to increase networking and collaboration; and to increase understanding of the environmental, social and economic impact of human activity in the coastal landscape among target audiences.

Assuming that restoration science is a priority focus area for a reserve, relevant audiences will be identified for targeted outreach and program development. As a part of the program development process, messages, issues, and needs for skill training in restoration-related areas will be identified; then research results will be "translated" for those groups. The role of reserve staff will be to design and implement programs relevant to priority issues and targeted to audiences that can most benefit from training, education and outreach.

Reserves can conduct workshops to share findings, provide first hand review of case studies, and interpret information derived from restoration work conducted at the reserves. Reserves also can act as clearinghouses for information developed to enhance restoration projects taking place in similar settings at other sites within a reserve's scope and bioregion.

Relationship of Restoration Science Strategy to Stewardship

Approximately half of the reserves currently have stewardship or resource management programs under the direction of a stewardship coordinator. The vast majority of the reserves carry out some stewardship functions even if there is no stewardship coordinator position. Stewards can play a role in the NERRS Restoration Science Program and function as support for the research and education aspects of the Program. Stewardship coordinators in the reserve system carry out a wide range of on-site functions, including land acquisition, restoration plan development, restoration activities, and restoration monitoring. They can identify sites within the reserves that might be candidates for restoration or reference sites, perform science-based restoration activities, and monitor those sites to determine the effectiveness of restoration activities. They can work with researchers to determine the best methods to use for restoration and support educational activities such as on-site interpretation and CTP workshops.

PARTNERSHIPS

A successful NERRS Restoration Science Program requires a partnered approach. Respondents to the 1999 NERRS Restoration Inventory overwhelmingly viewed partnerships as critical in augmenting reserve efforts and complementing restoration activities undertaken by other organizations. Existing partnerships with academic institutions, government agencies, and local interest groups – a key element of the reserve system structure – will be leveraged to advance the Restoration Science Strategy. The reserve system has also identified several NOAA offices and outside organizations as key national partners.

Partnerships within NOAA
The following NOAA offices and programs will be key national partners:

- Office of Ocean and Coastal Resource Management/Coastal Zone Management Program
- National Marine Fisheries Service/Restoration Center
- National Centers for Coastal Ocean Science/Beaufort Laboratory
- National Sea Grant College Program
- Coastal Services Center
- Office of Response and Restoration

The Office of Ocean and Coastal Resource Management/Coastal Zone Management Program. The Coastal Zone Management Program is a state-federal partnership to promote the conservation and responsible management of our nation's coasts. It consists of a national office and 34 state and territorial CZM programs. Direct habitat restoration activities are carried out primarily by the state and territorial CZM programs. The national office provides policy and technical support on various coastal issues, including habitat restoration.

Potential Reserve System/CZM Program Relationship:

- The CZM Programs are users of reserve scientific and technical products to support policymaking decisions. The CZM Program and reserve system can engage in a proactive dialogue to determine the science needed to support policy. The reserve system can provide restoration expertise, translation, advocacy, coastal decision-maker workshops, and demonstration projects.
- The CZM Programs engage in planning, policymaking, permitting and enforcement that can be directed to support restoration projects in which reserves participate.
- Some CZM Programs actively support habitat restoration. There are many opportunities for collaboration between the reserve system and CZM Program.

The NMFS Restoration Center. The National Marine Fisheries Service Restoration Center (RC) undertakes restoration pursuant to federal legislation and to improve the state of restoration ecology and habitat management. Its chief programs are the restoration component of the Damage Assessment and Restoration Program (DARP) for injured NOAA trust resources; restoration of Louisiana salt marshes pursuant to the

Coastal Wetlands Planning, Protection, and Restoration Act; and the Community-Based Restoration Program (CBRP) which provides expertise and competitive funding to numerous small, coastal community projects restoring marine and estuarine fishery habitat.

Potential Reserve System/RC Relationship:

- The CBRP can provide funding on a competitive basis for community-based restoration projects at reserves and assign priority to proposed projects occurring within reserve boundaries.
- Reserves can provide restoration science and monitoring expertise and a regional context for existing and proposed CBRP projects.
- Reserves can provide links with local communities and educational opportunities.
- The RC can provide technical support by expanding its national restoration project database to include reserve projects.

National Centers for Coastal Ocean Science/Beaufort Laboratory. The Beaufort Lab in North Carolina is one of four centers comprising the National Centers for Coastal Ocean Science (NCCOS). It is the Center for Coastal Fisheries and Habitat Research and has conducted numerous successful seagrass, oyster and salt marsh restorations throughout the eastern coastal United States.

Potential Reserve System/NCCOS Relationship:

- NCCOS can provide restoration expertise.
- The reserve system and NCCOS can engage in collaborative restoration science activities.

The National Sea Grant College Program. Sea Grant is a partnership between NOAA and 29 universities throughout the United States. It encourages the wise stewardship of marine resources through research, education, outreach, and technology transfer. It supports investigators engaged in restoration research and extension agents assisting communities in restoring habitat.

Potential Reserve System/Sea Grant Relationship

- Sea Grant and reserves can collaborate in restoration science and technical assistance activities.
- Sea Grant and reserves can collaborate on educational/community involvement aspects of restoration, including the Coastal Training Program.

Coastal Services Center. The Coastal Services Center (CSC) in South Carolina works with various branches of NOAA and other federal agencies to bring information, services, and technology to the nation's coastal resource managers. The technologies referred to are primarily geospatial tools such as GIS and remote sensing.

Potential Reserve System/CSC Relationship:

- CSC can provide training as well as technical and financial support for reserve system restoration science activities.

- The reserve system provides a national network for CSC to deliver its information and technology to the communities and coastal decision-makers.

Office of Response and Restoration. The Office of Response and Restoration (ORR) is the steward for NOAA trust resources. Its programs include (1) the Damage Assessment and Restoration Program (DARP) which ensures that injured NOAA trust resources are restored and that the public is compensated and (2) the Coastal Protection and Restoration Program (CPRP), a network of Coastal Resource Coordinators located in the EPA regional offices and a technical support group in Seattle that develop remedies that protect resources at hazardous waste sites. ORR is the NOS lead for the ERA and related activities.

Potential Reserve System/ORR Relationship:

- ORR can provide support for the restoration of reserve resources injured by the release of hazardous materials and oil.
- The reserve system can provide restoration expertise and a regional context for ORR activities.
- ORR may be able to provide funding from recovered damages for reserve restoration science projects (funding to acquire the equivalent of injured resources).
- ORR may be able to provide technical support (e.g. database; mapping).
- ORR can represent reserve system needs and capabilities in the ERA dialogue.

Outside Partnerships

The NERRS Restoration Science Workgroup preliminarily identified the following organizations as high priority partners for a NERRS Restoration Science Program:

- **Estuarine Research Federation.** The Estuarine Research Federation (ERF) is a national organization of research scientists dedicated to promoting research on estuaries and the coastal environment and sharing that knowledge with others. There are opportunities for the reserve system and ERF to collaborate in restoration science and related activities. ERF offers opportunities for the reserve system to communicate its findings to the scientific community.

- **Restore America's Estuaries.** Restore America's Estuaries (RAE) is a coalition of eleven regional community-based organizations that works to preserve estuaries across America by focusing attention on estuarine habitat loss and restoration. They are dedicated to reclaiming one million acres by 2010. The reserve system and RAE can collaborate in the implementation of the ERA. RAE offers opportunities to increase reserve system visibility among constituent groups and Congress. Likewise, the reserve system provides a constituency for RAE and can assist RAE in achieving its restoration goal. There are opportunities for the reserve system to collaborate with RAE member organizations in restoration science activities.

- **The Nature Conservancy.** The Nature Conservancy (TNC) is an international non-profit conservation organization with strengths in acquisition, public-private partnerships, protection and management. TNC has several national programs such

as the "Last Great Places," Bioreserves, and the Coastal and Marine Program that offer opportunities for collaboration.

- **The U.S. Environmental Protection Agency.** The U.S. Environmental Protection Agency (EPA) is the federal agency that administers the National Estuary Program (NEP). There are opportunities for the reserve system and the NEP to collaborate in estuarine restoration, research, education, and demonstration projects. EPA also has various grant programs that are funding sources for NERRS restoration activities, including Wetlands Protection Development Grants, 205j Water Quality Planning Grants, and 319h Water Quality Nonpoint Source Pollution Grants.

- **US Fish and Wildlife Service.** The US Fish and Wildlife Service (FWS) is a federal resource management agency administering a number of restoration programs. They are engaged in activities to prevent and control invasive plant and animal species. FWS personnel work in cooperation with other agencies and organizations to promote habitat rehabilitation and restoration of natural ecosystem functions using native species. FWS administers a number of relevant grant programs, including the National Coastal Wetland Conservation Program (grants for acquisition, restoration, and enhancement of coastal lands or waterways) and Partners for Wildlife (natural habitat restoration on private property).

  The FWS Coastal Program focuses FWS efforts in bays, estuaries, and coastal watersheds. The purpose of the program is to conserve fish and wildlife and their habitat to support healthy ecosystems. The Coastal Program provides funding to fifteen priority coastal ecosystems. Many of the reserves also have FWS National Wildlife Refuges within or adjacent to their boundaries. There are opportunities for the reserve system and FWS to collaborate in estuarine restoration, research, education, and demonstration projects.

- **The US Army Corps of Engineers.** The US Army Corps of Engineers (USACE) is a federal agency with the mission to provide quality, responsive engineering services to the nation. The agency is involved in planning, designing, building and operating water resources and other civil works projects (e.g. navigation, flood control, environmental management and restoration, disaster response). In this capacity, the agency undertakes restoration projects nationwide. These can be associated with individually authorized studies, beneficial use of dredge materials related to the operation of navigation channels, and several programmatic authorities. USACE staff often coordinates its restoration activities with states, nonprofit groups, local towns, and neighborhood associations. The USACE serves as the chair of the federal and state interagency task force implementing the Coastal Wetlands, Planning, Protection, and Restoration Act. In addition, the ERA establishes the USACE as the lead agency for the estuary habitat restoration program. The reserve system and USACE can collaborate in the implementation of the Act. With additional resources, there are also opportunities for the reserve system to provide the research, monitoring, and education for USACE projects.

- **Coastal America.** Coastal America facilitates and coordinates the efforts of twelve federal agencies with state and local governments and private alliances to protect, preserve, and restore wetlands and other aquatic habitats. It has established a national network of " Coastal Ecosystem Learning Centers" at fourteen aquariums and marine museums. These can assist in training and provide a venue for the reserve system to share its restoration findings to develop popular support for and understanding of the need for restoration science. Coastal America also helped to launch the National Corporate Wetlands Restoration Partnership (CWRP) in 2000. CWRP is a voluntary public-private partnership in which corporations join with federal and state agencies, local communities, non-profit organizations, and academia to restore wetlands and other aquatic habitats. Corporations contribute funds for restoration to a participating private foundation or state trust fund. Reserve system projects endorsed by Coastal America would be eligible for CWRP funding.

- **Society for Ecological Restoration**. The Society for Ecological Restoration (SER) is a non-profit organization promoting international ecological restoration. Its mission is to serve the growing field of ecological restoration by facilitating dialogue among "restorationists"; encouraging research; promoting awareness of and public support for restoration and restorative management; contributing to public policy discussions; and recognizing those who have made outstanding contributions to the field of restoration (SER itself does not engage in restoration projects). Members include scientists, planners, administrators, ecological consultants, first peoples, landscape architects, philosophers, teachers, engineers, natural areas managers, writers, growers, community activists, and volunteers. The reserve system and SER can collaborate on restoration science and education activities.

FUNDING AND RESOURCES

Funds to support the planning, implementation, and monitoring of estuarine habitat restoration projects at the reserves have generally been derived from external sources. During 1995-96, however, the reserve system supported a series of sixteen competitive research grants that focused on new techniques for the restoration of degraded estuarine habitat. This core group of restoration science investigations forms a nucleus for future scientific studies that build on the ongoing reserve case histories and supplemental data sets derived from the SWMP.

Funding to date has limited the extent to which the reserves have engaged in restoration and restoration science activities. For example, the Narragansett Bay (Rhode Island) Reserve is poised to lead a large-scale eelgrass restoration project based on years of preparatory research developing a scientific basis for such an undertaking. Currently, the lack of sufficient funding is delaying full implementation of this project. Additional funding would allow the reserve system to satisfy restoration science, education, and management agendas on national, regional, and local scales. Restoration science, demonstration projects, and education programs conducted by a particular reserve could be designed not only to improve the health of that reserve's ecosystem and the practices

of targeted audiences locally, but also to be transferred to other estuarine areas with similar conditions.

Once the NERRS Restoration Science Strategy is finalized, the reserve system will seek funding from a variety of sources to implement the strategy.

FUTURE PLANNING AND IMPLEMENTATION

The following are the proposed steps and timetable for planning and implementing the Restoration Science Strategy:

2002	
February	Finalize Restoration Science Framework document
March-May	Prepare preliminary draft implementation plan
June-July	Hold NERRS Restoration Science Workgroup meeting
August-September	Incorporate workgroup comments into draft implementation plan
October	Present draft implementation plan at annual meeting
December	Hold partners meeting to review draft implementation plan
2003	
January-February	Incorporate partners and reserve system comments into final implementation plan

State and Regional Coordination. Once the reserve system has incorporated national input, it will be incumbent upon the individual reserves to coordinate their restoration science activities with ongoing restoration programs in their states and regions. State and regional input will help to identify and prioritize the focus areas for a particular reserve. For example, the Rhode Island Coastal Resources Management Council has already indicated that the Narragansett Bay Reserve could be most helpful if it focused on monitoring, measurements of restoration success, coastal decision maker workshops for monitoring restoration projects, and teaching educators and students about the benefits of restoration.

CONCLUSION

In conclusion, healthy estuarine ecosystems and the livelihoods associated with them are at risk in the United States. In reaction, Congress has made restoring America's estuaries a national priority. The National Estuarine Research Reserve System stands poised to respond to the critical need for better restoration science and education in coastal and estuarine habitat. The majority of the individual reserves are currently engaged in restoration in their regions. Acting collectively, the reserve system can serve as the

national network of protected areas to address key scientific questions related to restoration. In turn, this can improve coastal decision-making throughout the United States.

In the coming year, the reserve system will complete its strategic planning process with an implementation plan that capitalizes on system-wide strengths and offer a wide spectrum of opportunities, ranging from scientific investigation, to training programs, to regional science coordination. Future implementation will require additional resources, but these may prove to be one of the best investments our nation can make to restore vitality, diversity and productivity to our estuaries.

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Attachment 1

NERRS Restoration Profiles 2001

Reserve	Established	Acres	Mgt Plan Approved	Important Habitats	Restoration Priorities	Current Projects
Apalachicola FL	1979	246,766	1998	forested flood plains, fresh and saltwater marshes, oyster bars, barrier islands	historic hydrology, historic biol. communities, fire regimes	shoreline stabilization, Phragmites removal, marsh restoration, prescribed burning
ACE Basin SC	1992	140,000	1992	forested flood plains; fresh, brackish, and saltwater marshes; oyster reefs; bird keys and banks, maritime forests	restore flow to a salt marsh bisected by a road, native terres-trial plants and shellfish habitat, control invasive species	shellfish habitat and prescribed burning
Chesapeake Bay MD	1985	4,820	1990	fresh water and flooded hardwood marshes, brackish marshes, riverine wetlands	submerged aquatic veg. (SAV) at Otter Point Crk and Jug Bay, wild rice at Jug Bay	SAV monitoring and plantings at Otter Point Crk and Jug Bay, protection of existing wild rice beds and re-establishment of wild rice in previously existing beds at Jug Bay
Chesapeake Bay VA	1991	4,435	1991	upland and forested wetlands; tidal freshwater, brackish, and salt marshes; intertidal sand and mudflats; extensive SAV beds.		riparian revegetation and development of stream drainages based on natural stability concepts
Delaware	1993	8,600	1993	forests, freshwater marshes and ponds, salt marshes, mud flats	tidal wetlands, Phragmites control, shoreline restoration, reforestation of disturbed upland, purple loosestrife control	shellfish habitat restoration, prescribed burning of Phragmites
Elkhorn Slough CA	1980	1,385	1985	coastal prairie, oak woodland, coastal scrub, freshwater wetlands and ponds, salt marshes, mud flats	monitor for new invasive sp.; exotic weed control, aquatic habitat rest.; replant grasslands, oak under-stories, and marsh-to-upland transition zones w/ native species	development of a comprehensive vegetation restoration and mgt. plan, coastal prairie and oak woodland rest., invasion detection, exotic sp. control
Grand Bay MS	1999	18,000	1998	wet pine savannah, coastal swamp, estuarine tidal marsh, shallow water open bay	exotic sp. control, shoal & salt marsh, oyster reef, re-establish of flood water flow, hydrological rest., prescribed burning in wet pine savannah and pine flatwoods	prescribed burning
Great Bay NH	1989	5,280	1989	upland fields and mixed wood, salt marshes, mud flats, rocky intertidal areas, shellfish reefs, eelgrass beds	oyster reef & soft shell clam rest, anadromous fish hab. rest.	eelgrass & salt marsh rest., Phragmites control, preparation of a rest. plan for coastal NH
Guana Tolomato Matanzas FL	1999	76,000	1998	estuarine lagoons, oyster bars, tidal creeks, wetlands, maritime hammock, pine flatwoods, coastal scrub, sand dunes, beaches	treatment of surface runoff, establish buffers to urban develop-ment, restore & stabilize natural shorelines	mitigation activities, conversion of former planted pine plantations to more natural forest and wetland communities
Hudson River NY	1982	4,838	1993	mixed forests, tidal freshwater wetlands, tidal flats & marshes, subtidal meadows	complete a restoration plan for Hudson R. estuary and a functional assessment model for tidal wetlands	serve as a ref. site for freshwater tidal marsh rest., eagle winter roost creation, nutrient load reduction, Phragmites control
Jacques Cousteau NJ	1998	114,665	1998	lowland forests, salt marshes, barrier island/dunes		serve as a ref. site for rest. of former salt hay production areas, salt marsh rest.
Jobos Bay PR	1981	2,883	2001	subtropical dry forests, man-groves, salt & mud flats, sea-grass beds, coral reefs	shoreline erosion on offshore cays, hydrological rest., mangrove & coral reef	dike removal; channel filling; studies of soil condition, water quality, and mangrove productivity for hydrological rest. and mangrove rest.
Kachemak Bay AK	1999	365,000	1999	upland forests, glaciers & glacial streams, tidal flats, brackish marshes, rocky inter-tidal areas		

Reserve	Established	Acres	Mgt Plan Approved	Important Habitats	Restoration Priorities	Current Projects
Narragansett RI	1980	4,369	1999	upland fields & forests, fresh-water wetlands & ponds, tidal flats, salt marshes, eelgrass	restore flow to a salt marsh bisected by a road, eelgrass	salt marsh, eelgrass, prescribed burning, meadow rest. by altering mowing practices
North Carolina	1985	10,000	1998	maritime forests; shrub thickets; freshwater, brackish, & saltwater marshes; mud & salt flats; sandy beaches; oyster bars, subtidal vegetation	serve as ref. site, assess invasive sp. control (especially Phragmites)	
North Inlet / Winyah Bay SC	1992	12,327	1992	abandoned rice fields & canals, tidal creeks, brackish & salt-water marshes, mud flats, sand bars, intertidal oyster reefs, shallow sounds	invasive sp. control (especially crustaceans & Phragmites)	*none at this time but staff has participated in oyster reef res-toration outside reserve boundaries*
Old Woman Creek OH	1980	571	2000	upland forests & old-field suc-cession, swamp forests, fresh-water marshes, streams, barrier beach along Lake Erie	stream corridor buffer strips, exclusion of carp from the estuary, serve as a ref. site	stream bank stabilization
Padilla Bay WA	1980	10,700	1984	tidal flats and sloughs, salt marshes, seagrass beds	salmon recovery by means of rest. of riparian zones & estuarine sloughs, removal of fish migration blockages. (Rest. projects may include removal of invasive sp., woody debris, and toxic materials such as creosote logs)	Spartina control
Rookery Bay FL	1978	9,400	1998	tropical hardwood hammocks, xeric scrub, pine flatwoods, salt-water marsh, mangroves, shallow bay waters, barrier islands	hydrologic rest. & native community rest.	hydrological rest. through roadbed removal & Geo Web installation, invasive plant control, mangrove rest., prescribed burning
Sapelo GA	1976	6,111	1999	maritime forests, freshwater ponds, sloughs, salt marshes, barrier islands & dunes	maritime forests & ephemeral wet-lands; rare endemic habitats (long-leaf pine, pond pine); hydrologic, terrestrial, & associated freshwater habitat; wetland reclamation by rest of natural hydrology; dune stabiliz-ation & rest.; invasive plant & sp. control (popcorn trees, feral hogs)	rare & endemic habitats, selective timber harvest, maritime forest rest, prescribed burning *(mapping & monitoring of oyster reef habitat & biology and high marsh plant comm. interactions conducted to identify rest. needs)*
South Slough OR	1974	4,770	1994	upland forests, freshwater wet-lands & ponds, salt marsh, tidal flats, eelgrass	salmon spawning / rearing habitat in the watershed, salt marsh rest., forest / upland habitat enhancement	salt marsh (dike removal, tidal creeks), replanting of disturbed forest, stream channel rest. and enhancement
Tijuana River CA	1982	2,513	1999	uplands, coastal sage, saltwater marsh, mud flats, dunes, beaches	sediment & flood control of upstream areas, salt marsh rest. to increase endangered sp. habitat	large-scale salt marsh, upland, dune, riparian habitats
Waquoit Bay MA	1988	2,600	2001	pine & oak forest, salt ponds, coastal sand plains, salt marsh, barrier beaches & dunes	riverine habitat for sea run fish, eel-grass meadows/water column, coastal sand plain, salt pond wet-lands, coastal dunes	nitrogen loading reduction, endangered plant rest. in a meadow area, controlled burns to maintain a coastal sand plain, salt pond wetlands rest., sea trout run/ herring run/river rest., coastal bird rest. through controlling human impact in habitat area
Weeks Bay AL	1986	3,028	1998	upland forests, fresh & saltwater marshes, forested swamps, pitcher plant bogs, tidal flats	riparian buffers, shorelines, wetlands, bottom lands	prior converted wetland & riparian buffer, pitcher plant bog, salt marsh, prescribed burning
Wells ME	1984	1,600	1996	upland fields & forests, tidal rivers, salt marsh, forested wet-lands, dune forest, beaches	regional rest. of tidal flow in salt marshes, control/elimination of invasive upland plants, rest. of fish passage for migratory fish in coastal watersheds	hydrological rest. of impounded salt marsh, shorebird rest. through monitoring & protec-tion activities for least terns & piping plovers

Attachment 2

Principles of Estuarine Habitat Restoration
Developed by
Restore America's Estuaries and the Estuarine Research Federation

Principle 1. Preservation of existing habitat is critical to the success of estuarine restoration.

Principle 2. Estuaries can be restored only by using a long-term stewardship approach and developing the constituencies, policies and funding needed to support this.

Principle 3. The size, scale and amount of restoration activity must increase substantially to have a significant effect on overall estuarine functioning and health.

Principle 4. Greater public awareness, understanding and involvement in estuarine habitat restoration are necessary to the success of individual projects and to achieve national restoration goals.

Principle 5. Restoration plans should be developed at the estuary and watershed levels to set a broad vision, articulate clear goals and integrate an ecosystem perspective.

Principle 6. Estuarine restoration plans should be developed through open regional processes that incorporate all key stakeholders and the best scientific thinking available.

Principle 7. Project goals should be clearly stated, site specific, measurable and long-term--in many cases greater than twenty years.

Principle 8. Success criteria for projects need to include both functional and structural elements and be linked to suitable, local reference habitats.

Principle 9. Site plans need to address off-site considerations, such as potential flooding and salt-water intrusion into wells, to be sure projects do not have negative impacts on nearby people and property.

Principle 10. Scientifically-based monitoring is essential to the improvement of restoration techniques and over-all estuarine restoration.

Principle 11. Ecological engineering practices should be applied in implementing restoration projects, using all available ecological knowledge and maximizing the use of natural processes to achieve goals.

Principle 12. Adaptive management should be employed at as many restored sites as possible, so they continue to move toward desired endpoints and self-sustainability.

Principle 13. Long-term site protection is essential to effective estuarine habitat restoration.

Principle 14. Public access to restoration sites should be encouraged wherever appropriate, but designed to minimize impacts on the ecological functioning of the site.

Attachment 3

NERRS Restoration Science Workgroup
2/02

Craig Cornu, South Slough
Maurice Crawford, Estuarine Reserves Division
Michele Dionne, Wells (Co-Chair)
Tom Gaskill, South Slough
Roger Greene, Narragansett Bay
Judy Haner, Rookery Bay
Dorset Hurley, Sapelo
Gary Lytton, Rookery Bay
Chuck Nieder, Hudson River
Roy Ogles, Apalachicola
Nathalie Peter, Estuarine Reserves Division (Co-Chair)
Mike Shirley, Rookery Bay
Dwight Trueblood, CICEET
Andrea Woolfolk, Elkhorn Slough
Brooke Vallaster, Sapelo

Attachment 4

Clean Water Action Plan Definitions

1. Establishment - the manipulation of the physical, chemical, or biological characteristics present to develop a wetland on an upland or deepwater site that did not previously exist. Establishment results in a gain in wetland acres.

2. Restoration - the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into:

> **Re-establishment** - the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to former wetland. Re-establishment results in rebuilding a former wetland and results in a gain in wetland acres.
>
> **Rehabilitation** - the manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions of degraded wetland. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres.

3. Enhancement - the manipulation of the physical, chemical, or biological characteristics of a wetland (undisturbed or degraded) site to heighten, intensify, or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for a purpose such as water quality improvement, flood water retention or wildlife habitat. Enhancement results in a change in wetland function(s), but does not result in a gain in wetland acres. This term includes activities commonly associated with the terms enhancement, management, manipulation, directed alteration.

4. Protection/Maintenance - the removal of a threat to, or preventing decline of, wetland conditions by an action in or near a wetland. Includes purchase of land or easements, repairing water control structures or fences, or structural protection such as repairing a barrier island. This term also includes activities commonly associated with the term preservation. Protection/Maintenance does not result in a gain of wetland acres or function.