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EARTH SYSTEM MONITOR

Setting priorities for coastal wetland restoration

A GIS-based tool that combines expert assessments and public values

A guide to NOAA's data and information services

INSIDE

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Over the years, many coastal wetlands have been degraded by filling, ditching, pollution, tidal restrictions, or other human activities. Recently, as the public has become more aware of the ecological importance of coastal wetlands, new programs and funding have been devoted to restoring wetlands.

Within a given region, many wetlands may be candidates for restoration. However, funds are rarely sufficient to restore all possible sites. Thus, difficult choices must be made. Historically, the choice of coastal wetland restoration activities has often been unsystematic and politically driven, with restoration funds often going to sites that have strong community or political support. While community and political support are important, such ad hoc decisions may not lead to the most effective use of public funds.

Recently, there has been a move towards prioritizing potential restoration sites based on ecological goals for a watershed or other region. Scientists have developed a number of tools to assess wetland functions, both before and after restoration (see Bartoldus, 1999 for examples). Many of these methods, however, require detailed, expensive, and time consuming field studies. Thus, these methods are most appropriate for evaluating sites already selected for restoration, or for making fine distinctions once a preliminary set of restoration sites has been selected.

In addition, while current practice often considers ecological goals, social goals have not generally been considered as an integral part of the site selection process, except to the degree that community groups actively lobby for projects in their communities. A method for prioritizing potential restoration actions that considers *both* public values and ecological goals can help policy makers choose ecologically beneficial restoration sites or actions that are more likely to receive public support.

In this project, we are developing a decision-support tool that considers both social and ecological values for prioritizing coastal wetland restoration projects, using an integrated combination of ecological and economic indicators. While, ideally, restoration actions would be evaluated based on site-specific measures of the full range of economic and ecological values for each site, funding and time constraints often do not allow for the required full scale public and ecological field studies. Accordingly, the goal of this project is to develop a method that can be used to evaluate potential restoration sites using existing GIS data. This method should be useful as a "first cut" evaluation of sites for restoration, to select a set of sites that best meet various objectives. Site specific studies can then be conducted to further refine the restoration decisions. This approach can provide a cost-effective method for prioritizing wetland restoration actions, addressing both ecological and economic factors, and can thus help agencies spend public funds for restoration more effectively.

The project consists of three parts: (1) expert assessments of important functions of coastal wetlands, based on characteristics of each site and surrounding area; (2) assessment of public values for a set of coastal wetlands attributes; and (3) development of a computer-based tool that produces geographic information system (GIS) maps to prioritize possible restoration sites based on user-supplied objectives, public values, and expert assessments.

Expert Assessments of Wetland Functions

As restoration science has matured, the primary focus of restoration has shifted from restoring the physical structure of a wetland to restoring ecological functions. There is a significant body of work focused on assessing the results of restoration of coastal wetlands functions, although there is not yet general agreement on how best to define success (Kentula 2000). Most methods focus on a few biological or structural

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Table 1: Expert Survey Variables and Levels

Variable (Wetland features)	*Levels*	*Description*
Size	4	1, 5, 17, or 65 acres
Adjacent water body type	3	Coastal embayment, coastal river, or salt pond
Wetland shape	2	Fringe or "Meadow-like"
Percent of wetland covered by *Spartina* vs. *Phragmites*	3	High *Spartina* (90-100%) & Low *Phrag.* (0-10%), Medium *Spartina* (60-80%) & Medium *Phrag.* (20-35%), or Low *Spartina* (10-30%) & High *Phrag.* (65-90%)
Ratio of high marsh (*S. patens*) to low marsh (*S. alterniflora*)	2	25:1 or 10:1
Brackish marsh (other than *Phragmites*)	2	Absent or Present (3-6%)
Estuarine Scrub-Shrub	2	Absent or Present (3-6%)
Tidal restrictions	3	No significant restriction, Moderately restricted, or Severely restricted
Intertidal creeks in marsh	2	Absent or Present
Subtidal channels in marsh	2	Absent or Present
Percent of marsh covered by pannes	3	1%, 5%, or 15%
Percent of marsh covered by pools	3	1%, 10%, or 20%

Variable (Landscape features)	*Levels*	*Description*
100' surrounding wetland	3	No buffer, Shrub buffer, or Forest buffer
Percent developed land in 500' surrounding wetland	3	High (80+%), Medium (40-50%), or Low (10-20%)
Percent Forested & Agricultural Land in 500' surrounding wetland	3	Medium Forest (38-72%) & Low Ag. (10-15%), Medium Forest (38-72%) & Medium Ag. (45-65%), or Low Forest (10-20%) & Medium Ag. (45-65%)
Freshwater wetlands	3	Contiguous, Within 0.5 mile, or Further than 0.5 mile
Significant tidal flats adjacent	2	Absent or Present (25-30% of size of wetland)
Eelgrass in adjacent waters	2	Absent or Present
Another salt marsh within 0.5 mile of described marsh	2	Absent or Present
Public Access	2	Restricted, or Access not limited

EARTH SYSTEM MONITOR

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Pacific Fisheries Environmental Laboratory provides new web site

A new NOAA web site is available to the public to interpret climate variability and its effects on fisheries. Developed by the Pacific Fisheries Environmental Laboratory of the National Marine Fisheries Service, it provides background information and illustrations to help the public understand the components of climate and the scales of climate variability.

Recent studies relating changes in marine fish populations to patterns of ocean environmental conditions are cited and summarized. Several temporal and spatial scales of environmental variation are included, from interannual variability (including El Ninos) and interdecadal scale regime shifts, to global climate change. The response of pelagic fish to El Ninos, the differing response of salmon in Alaska and Oregon to decadal-scale North Pacific warming, and theories of how global warming may affect fisheries are all discussed.

The web site is designed to provide both basic information to the general public and bibliographies and references to recent research for scientists. Relevant research links are welcome. The Climate and Marine Fisheries theme page can be found at *http://www.pfeg.noaa.gov*.

Climate proxy derived from Spanish galleon voyages

The National Geophysical Data Center's Paleoclimatology Program has archived a 159-year reconstruction of atmospheric circulation changes in the tropical Pacific Ocean, based on the voyages of the Manila galleons from 1590 to 1750. Historical accounts of the voyages of the Manila galleons were gathered from the General Archive of the Indies, in Seville, Spain, which provides the length of the voyages between Acapulco, Mexico and the Philippine Islands.

Trans-Pacific sailing times are proportional to the strength of the trade winds, and suggest that the atmospheric circulation of the western Pacific underwent large, multidecadal fluctuations during the seventeenth century. The data and research summary, published by Garcia *et al.* in the Bulletin of the American Meteorological Society (2001), are available on the NOAA Paleoclimatology Program website at *http://www.ngdc.noaa.gov/paleo/pubs/garcia2001/garcia2001.html*.

News briefs

Sun continues to dazzle

The Sun may actually be aiming for a new higher solar activity peak! The secondary peak of Solar Cycle 23 is proving to be higher than the April 2000 peak in some solar indices. The total magnetic flux index level is comparable to Cycle 21, one of the highest recorded. The 10.7 cm radio flux mimics the magnetic flux with a higher current maximum than in April 2000. The Calcium K line value is also exceptionally high. Sunspots, however, are showing a second maximum, but so far it is not as high as the first one. "The complexity and structure of the CME amazed even experienced solar physicists at the SOHO operations center" says Paul Brekke, Solar and Heliospheric Observatory (SOHO) Satellite Deputy Project Scientist. NGDC maintains the definitive archive of sunspot and other solar activity.

Climate and Cryosphere meeting

An ad hoc meeting to discuss a U.S. program for Climate and Cryosphere (CliC) was held in Washington, D.C. in early January. It was hosted by the Polar Research Board and Climate Research Committee of the National Research Council (NRC). It was attended by some 35 scientists and agencies, including representatives of NOAA (NESDIS, OGP and the Arctic Research Office).

The purpose of the meeting, coordinated by R.G. Barry, Director, National Snow and Ice Data Center and co-Vice Chair of the World Climate Research Program (WCRP) CliC project, was to consider an item in an NRC report encouraging U.S. members of the CliC scientific community to develop a coordinated U.S. CliC component to catalyze and integrate the diverse U.S. expertise in this area. Two topics were addressed: the need to designate a U.S. focal point for WCRP and any U.S. CliC activities, and the potential role and representation of a U.S. CliC Science and Coordination Committee. It was agreed that the North American members of the CliC Steering Group and Panels would take up the various suggestions and prepare a short report and recommendatons to be submitted to potential Agency sponsors of these activities.

Airport approach designations

The Federal Aviation Administration (FAA) is responsible for maintaining and updating runway approach designations, which are based on magnetic declination. The current method for updating the approach designation is to determine the declination in a published text which is updated every five to seven years. This procedure is causing some confusion with pilots, most of whom are flying airplanes equipped with Flight Management Systems which provide the real-time magnetic declination. Approach designations, which are several years old, may differ from the real-time magnetic declination by as much as a degree. To avoid confusion, a new recommended policy is for FAA employees to visit the NGDC Geomagnetic Data web when updating airport approaches and obtain the current magnetic declination.

Automobile testing

An engineer with Ford Motor Company will use hourly temperature and pressure data from key United States cities as the primary input in a modeled simulation environment. The analysis will show how fluctuations in these parameters affect the performance on different systems operating in their recently manufactured automobiles. In a previous simulation, the *Hourly United States Weather Observations* CD-ROM was used which contains data from 1990 to 1995, but now more recent surface data will be applied to perform the analysis on newer vehicle systems.

Drought Monitor Forum workshop

The National Climatic Data Center has begun the process of setting the dates and agenda for the April 2002 Drought Monitor Forum workshop that will be held at the Center. NCDC Meteorologist Richard Heim analyzed drought indicators and field observations from several dozen experts to prepare the January 8 *Drought Monitor* map and text discussion. The *Drought Monitor* is an interagency monitoring tool which is rotated among the U.S. Department of Agriculture, the National Drought Mitigation Center, and the Natonal Oceanic and Atmospheric Administration's National Climatic Data Center and Climate Prediction Center.

Wetland restoration, *from page 1*

indicators, but still require significant and costly fieldwork. When funds are constrained, as is usually the case, initial choices must be made as to which wetlands to evaluate in detail. However, these choices already embody implicit decisions regarding the desirability or feasibility of a site.

The focus of the first component of this work has been to develop a system that allows wetlands to be categorized based on their potential to provide functions, using existing GIS data. The intent is to identify wetland characteristics that can be used as indicators of a wetland's potential to provide specific functions. Four functions of salt marshes are considered – storm buffering, nutrient transformation, bird habitat and fish habitat. The first two will be assessed using existing models to measure potential, while the two habitat functions are assessed through a survey of wetland scientists.

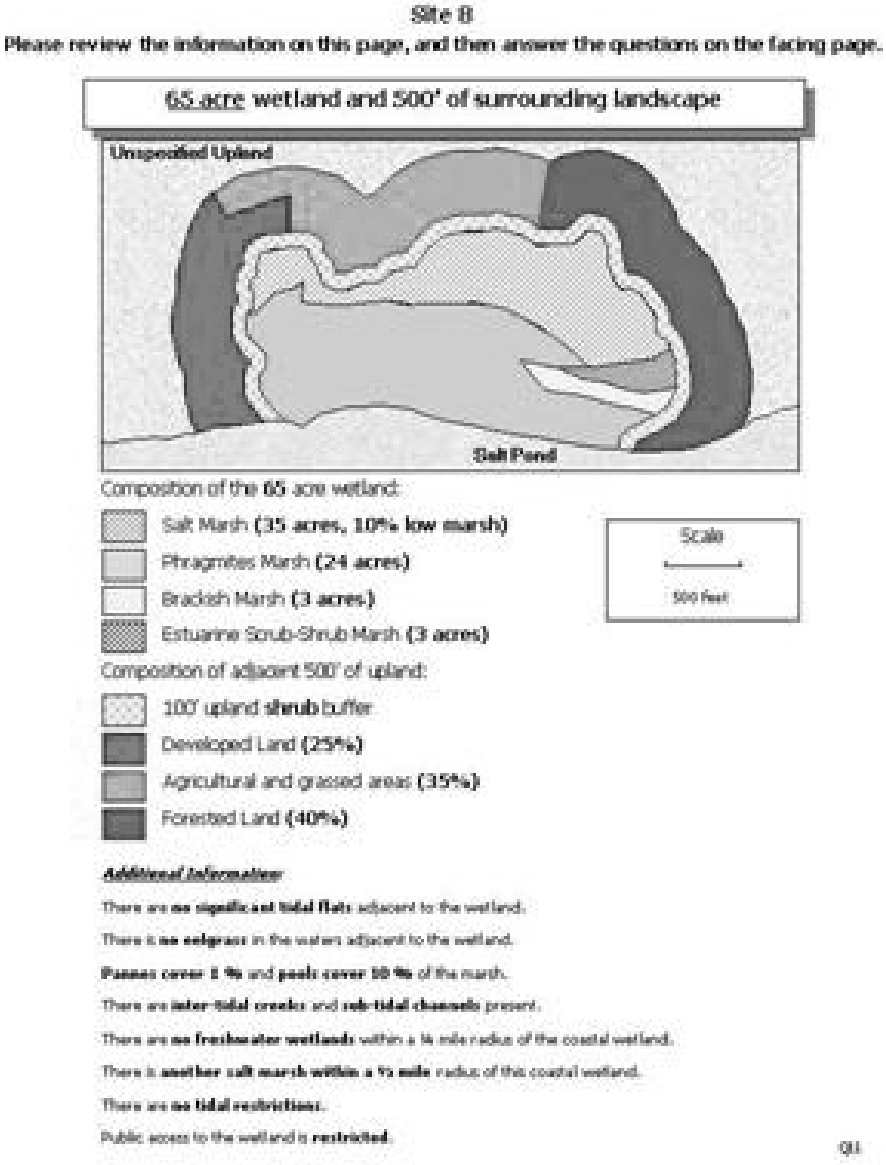
The goal of the survey is to assess the potential of hypothetical wetlands to provide habitat for four groups of birds (wading birds, waterfowl, songbirds and shorebirds), two groups of fish (resident and non-resident) and shellfish. In the survey, experts are asked to look at stylized GIS maps and descriptions of several hypothetical coastal wetlands, and to judge their potential to provide habitat for each category of birds and fish, on a scale of 0 to 4. See Figures 1a and 1b for example questions.

Experts' responses to the survey will be used to determine which combinations of characteristics of wetlands, on average, provide the best indicators of habitat quality for these species. Variables for the survey (shown in Table 1, *on page 2*) were selected based on a review of the literature, and interviews with over 20 technical experts. Variable levels were based on ranges existing for salt marsh wetlands within the Narragansett Bay watershed, the case study area. The survey is currently being administrated to wetland professionals in the New England area.

Public Values

The second component of the project uses a contingent choice survey to identify public values and priorities for improvements in services provided by coastal wetland restoration. The survey focuses on bird and fish habitat, in addition to recreational access and mosquito control. Habitat is described in terms of ecological benefits provided by the same four bird groups included in the functional survey (wading birds, waterfowl, songbirds and shorebirds), as well as fish and shellfish.

Before filling out the survey, respondents watch a 7-minute video presentation on a notebook computer. The presentation was developed through a series of focus group meetings with members of the public, designed to elicit the types of information potential respondents require to understand and answer survey questions. The presentation describes and defines salt marshes in common terms, and provides background information on marshes in Rhode Island, causes of degradation of salt marshes, and actions to restore salt marshes. It then provides basic survey instructions.



▲ **Figure 1 a.** Information page for review.

In the first section of the survey, respondents are asked to choose among alternative restoration options, described in terms of their impact on habitat, recreation and costs. Figure 2, *page 6*, shows an example question from the first section of the survey. The second section of the survey asks about preferences for restoring different types of bird habitat. Figure 3, *page 6*, shows an example page from this section.

The survey also addresses issues related to variations in public preferences for access to restored wetlands. In focus groups, we discovered that there is a wide range of preferences for recreational access to restored wetlands, where some people desire public access and others want access to be restricted.

The survey is currently being administered to a sample of Rhode Island residents in public places throughout the state. The goal is to obtain a representative sample of citizens, in order to discover the preferences of the "average" taxpayer. Very preliminary results, based on the first 200 surveys returned, show that people have strong preferences for improved mosquito control and improvements in shellfish habitat, with moderately strong preferences for improved bird and fish habitat. Size of the restored wetland is less important to the public. As expected, the preliminary results indicate that there are heterogeneous preferences for access. We will be conducting further analysis of economic values for wetlands attributes, and of preferences for recreational access.

Please give your professional judgment of this site's current potential to provide habitat functions, by circling one number in each row below. If you feel there is insufficient information to answer any of the questions, or if certain species are not within your expertise or experience, please answer accordingly.

Habitat Use	Potential for Site #1 to provide functions listed below: No Significant Potential	Limited Potential	Moderate Potential	High Potential	Exceptional Potential	Insufficient Information	I do not feel qualified to answer
Wading Bird	0	1	2	3	4	I.I.	N.Q.
Waterfowl	0	1	2	3	4	I.I.	N.Q.
Shorebird	0	1	2	3	4	I.I.	N.Q.
Marsh Dependent Songbird	0	1	2	3	4	I.I.	N.Q.
Other Songbirds	0	1	2	3	4	I.I.	N.Q.
Overall Bird Habitat	0	1	2	3	4	I.I.	N.Q.
Marsh Resident Fish	0	1	2	3	4	I.I.	N.Q.
Marsh Non-resident Fish	0	1	2	3	4	I.I.	N.Q.
Overall Fish Habitat	0	1	2	3	4	I.I.	N.Q.
Shellfish Habitat	0	1	2	3	4	I.I.	N.Q.

1) If you answered **insufficient information** for any of the above, please let us know what we missed (please be as specific as possible):

2) Additional Comments:

▲ **Figure 1 b**. Answer these questions based on the information provided in Figure 1 a.

GIS-based tool

Once the two surveys are complete, the results of the ecological and economic components of the work will be combined within a GIS framework to provide a tool to help decision-makers prioritize wetland restoration actions. This tool will allow users to explore the impact of alternative restoration objectives on the ranking of potential restoration sites within a watershed.

Users of the tool will start by entering information on restoration actions under consideration, including modifications to the hydrology, vegetation or elevation of sites. Next, the habitat functions for sites will be weighted based on either the typical citizen values from the public survey (the default), or on user inputs. For example, users may want to assess the outcomes if greater importance is given to one particular species. Other parameters, such as invasive species and geographic location, will also be available in the model, but will not have default weights, since they were not included in our public survey.

Once users have entered the information on restoration actions and weights for different functions and other parameters, the model will produce a set of maps showing the prioritization of sites within the area of interest, using different colors to indicate priority levels. The decision tool will thus allow policy makers to examine restoration options in a more formal manner than ad hoc selection, but without the requirement of detailed field studies. Funds can then be allocated for fieldwork on sites with the highest potential to achieve restoration objectives, increasing the benefits received by society given the limited resources available.

— *continued on page 6*

3. NOW, PLEASE COMPARE RESTORATION PLANS 5 AND 6. DO NOT COMPARE THESE PLANS TO PLANS ON OTHER PAGES, AND DO NOT ADD UP THE COSTS. PLEASE VOTE FOR THE PLAN YOU PREFER:

Check one box: →	❑₁ I choose NEITHER PLAN ($0 per year)	❑₂ I choose RESTORATION PLAN 5 ($20 per year)	❑₃ I choose RESTORATION PLAN 6 ($40 per year)
		Restoration Plan #5	Restoration Plan #6
		Improvement: gains from restoration* (0=no improvement, 10=highest):	
Ecological Improvement to RI Bird Populations*		7	1
Ecological Improvement to RI Fish Populations*		4	4
Ecological Improvement to RI Shellfish Populations*		7	2
Potential to Control Mosquito Nuisance*		2	7
Access for Recreation		viewing platforms & trails	viewing platforms & no trails
Size of Salt Marsh		5 Acres	12 Acres
Annual Cost of the Plan to YOUR HOUSEHOLD	$	$20 PER YEAR IN HIGHER STATE TAXES	$40 PER YEAR IN HIGHER STATE TAXES

* As judged by wetland experts, compared to all other potential salt marsh restoration projects in Rhode Island.

Section B: Your Rating of Salt Marsh Bird Habitat

Different restoration choices can have different effects on habitat for various bird species that use salt marshes. For each of the following comparisons, assume that everything is the same, including cost, except for the amount and type of bird habitat restored.

Waterfowl include ducks, geese, and swans.
Wading birds include herons and egrets.
Songbirds include sharp tailed sparrows, seaside sparrows, warblers, and thrushes.
Shore birds include sandpipers, killdeers, and plovers.

Check the box for the option you prefer.

1. ❑ Option **A** will result in **12** additional acres of habitat for **wading birds** **OR** ❑ Option **B** will result in **5** additional acres of habitat for **songbirds**

2. ❑ Option **A** will result in **2** additional acres of habitat for **waterfowl** **OR** ❑ Option **B** will result in **5** additional acres of habitat for **wading birds**

▲ **Figures 2 (above, left) and 3 (below)** are example questions from Expert Survey.

Wetland restoration, from page 5

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Predicting and reducing watershed impacts of coastal storms

The Coastal Storms Initiative (CSI)

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NOAA Coastal Service Center

Currently, more than half of the population of the United States lives in the coastal zone. It is important to ensure the safety of this population, help the coastal economy, and sustain the natural environment. Unfortunately, storms in coastal areas are more severe and are less predictable than in the interior of the country. In particular, forecasts of storms and associated precipitation patterns in coastal areas lag behind those for the rest of the nation, owing to observational deficiencies over adjacent oceans, a poor understanding of the physical and chemical processes near the air-ocean-land interface, and associated deficient modeling systems. Coastal storm losses have an economic as well an environmental impact with damages estimated at between ten billion and fifty billion dollars each year. In fact, the cost per single storm event averages a half billion dollars (Heinz Center, 2000). Scientific and management expertise now exists, both within and outside government, that can help ensure the safety of the coastal population, help the coastal economy, and sustain the coastal environment.

Traditionally, there has been little linkage between researchers who study the science behind storms and coastal managers who must deal with the consequences of such events. Moreover, meteorologists who study the origins of these storms over deep ocean waters do not necessarily share their study results with the coastal oceanographers, hydrologists, chemists, and ecologists who are analyzing other aspects and consequences of coastal storms. Improved coordination could result in a better understanding of the broad consequences of storms as they first perturb the coastal-ocean circulation, including the oceanic mixed layer. These disturbances of the benthos produce sedimentation and resuspension, an important factor in the transport of material by estuarine and coastal currents. Coastal storms also increase precipitation and flooding within aquatic ecosystems and habitats, as well as increasing the transport of contaminants from terrestrial ecosystems to the estuaries and the marine coastal areas. Therefore, the National Oceanic and Atmospheric Administration has recently suggested a cross-disciplinary initiative, called the Coastal Storms Initiative (CSI), to predict and reduce watershed impacts of coastal storms. The Initiative's goal is to achieve an enhanced and seamless interaction among the meteorologist and oceanographer, chemist and ecologist, tool developer and educator, while providing user-friendly access to information, forecasts and planning tools for major storm events.

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Initiative objectives

The intent of CSI is to build upon and advance other programs, such as the U.S. Weather Research Program, the Coastal Global Clean Observing System, and the Clean Water Action Plan. It is also hoped that the Initiative will integrate and enhance coastal observations, improve forecasts, and provide decision tools to state/local coastal decision makers. An implementation plan has been designed around eight main action objectives of the initiative.

These eight areas are (1) collecting and archiving environmental data, (2) integrating the data to improve our understanding of coastal processes and impacts, (3) improving environmental prediction, (4) disseminating the data and forecasts in a timely manner, (5) providing end-user decision support tools, (6) doing outreach and extension to form new links with the local community, (7) building capacity to prepare and respond to storms, and (8) providing guidance through a national framework of policies, standards, and practices to ensure knowledge-based, environmentally sound development.

Key actions for the collect and archive objective will be to inventory existing observation capabilities, install additional instrumentation on existing and some new platforms, and create a unified, long-term, readily accessible archive for coastal data sets. The integrate and understand objective focuses on our incomplete understanding of the physical and chemical processes in the coastal environment. Therefore, the Initiative proposes detailed theoretical analysis and field studies of the nature of the coastal air-sea-land interaction, including studies of wet and dry deposition in coastal waters. This work would be performed by both NOAA researchers and by other scientists funded by applied research grants. Since current storm warning and forecast services in coastal regions lag behind those for the interior of the country, CSI recommends developing an ensemble of coupled meteorological and hydrodynamic models to provide improved forecasts for wind, precipitation, currents, wave fields, inland storm surge and flooding, and bio-geochemical events.

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Quiksilver Circumnavigation of the World

Quiksilver, the international boardriding company, in September 2001, announced a further four-year commitment to the United Nations-supported Reef Check program.

The Quiksilver Crossing is presently circumnavigating the world and its duration has been extended until November 2005, making the entire voyage nearly seven years. The following web site offers updated information and images: *http://www.quiksilver.com/crossing/red_index.asp*.

The Reef Check program is perhaps the most ambitious ecological survey everundertaken by man and utilizes thousands of volunteer scuba divers, led by marine biologists, to determine the global health of coral reefs. The importance of coral reefs cannot be overstated: they are the breadbaskets of the sea - a vital link in the food chain for numerous marine species.

In a major commendation last fall, the Quiksilver Crossing received strong acclaim from the United Nations Environment Program (UNEP), which supports the Reef Check program.

The managing director of Quiksilver International, Bruce Raymond, said the Quiksilver Crossing, which was originally launched from Cairns, Australia, in March 1999 for a 12-month journey, has three main objectives: to find surf; to respect local cultures; and to contribute to the scientific knowledge of the world's coral reefs through the Reef Check global coral reef monitoring program.

Since 1999, the Crossing has hosted nearly 300 surfers, scientists and media on board, and has covered 46,944 nautical miles - north from Australia through the Coral Sea, east across the South Pacific Ocean to French Polynesia, then returning along a different South Pacific route and across to Indonesia, then north-west through the Indian Ocean to the Maldives.

"While searching for new surfing locations, the Quiksilver Crossing's 72-foot exploratory vessel has served as a floating research station, allowing Reef Check scientists to survey reefs that would otherwise be inaccessible," Bruce said.

The Director of Reef Check, Dr Gregor Hodgson, said that coral reefs, which are the rainforests of the sea, are facing an unprecedented crisis due to pollution, over-fishing and global warming. "The announcement of the extension of the Quiksilver Crossing for four more years is a huge event, from a scientific point of view, and a public education/public awareness and conservation point of view," Dr Hodgson said.

"The Quiksilver Crossing is vitally important because not since Charles Darwin sailed around the world on the Beagle in the 1800s has there been such an unprecedented opportunity for marine scientists to study remote reefs and evaluate their health. Since the launch of the Crossing, thirteen Reef Check marine scientists have surveyed nearly fifty remote coral reefs that hadn't previously been assessed by scientists, and most reefs show some signs of human impacts. By getting the local communities involved in reef management, Reef Check is one solution to the problems. The collaboration between Reef Check and Quiksilver has served as a bright spot of corporate environmental vision at numerous UN workshops, at World Bank and scientific meetings," Dr Hodgson added.

The United Nations Environment Program (UNEP) provided a major push for the project this past September. "The Quiksilver Crossing's recent discovery of some remaining high coral cover areas in the Maldives is a significant scientific finding and a validation of the scientific value of the Crossing," said Dr Hugh Kirkman, Ph D, the Coordinator of UNEP's East Asian Seas Regional Coordinating Unit (EAS/RCU). "These healthy corals could help re-seed reefs on neighboring islands which were killed during the 1997-98 global bleaching event that was linked to global warming." Dr Kirkman said that on behalf of UNEP, they would like to thank Quiksilver for its valuable support of the Reef Check program. "This support has proved highly effective in allowing Reef Check scientists to reach reefs in remote corners of the globe. No doubt additional valuable observations will be made and data collected over the coming years of the expedition," Dr Kirkman said.

Dr Gregor Hodgson said that at the meetings of the United Nations Environment Program, the Quiksilver Crossing has been highlighted as one of the major contributions of the private sector. "Without the private sector the reefs are going to die, there's just no question whatsoever," Dr Hodgson said. "We can't rely on governments and the United Nations to solve the reef problems, it has to come from the community level."

The Reef Check program has two overall goals: to obtain a reliable scientific, rigorous assessment of the status of the world's coral reefs on a continuing basis year after year; and, secondly, to educate the public and raise public awareness about the coral reef crisis and the value of coral reefs, and to try to involve the general public in actually managing coral reefs. "We've been incredibly impressed with the amount of energy, the amount of effort and enthusiasm of the Quiksilver management team and the surfers involved in the Crossing," Dr Hodgson said. "It's been a tremendously productive collaboration in terms of our scientific as well as our educational goals."

Quiksilver International managing director, Bruce Raymond, said he believed the Quiksilver Crossing ignited a flame in people. "It has beautiful images and a sense of adventure; it takes you out of your world into one that

people may never realise existed. That introduces people to the idea that they can go out and have so much fun in nature, and they don't need much more than a surfboard or a pair of swim fins, or whatever."

Along the route, the crew on board Quiksilver's 72-foot exploration vessel have discovered and surfed nearly 60 new, first-class breaks, with the biggest surf being 12 feet (four metres).

Two-time world champion Tom Carroll said that the Quiksilver Crossing was about the spirit of surfing that he grew up with. "With my surfing, the first thing I did was walk around the headland to the next beach to see what the surf was like around the corner. I was 10 or 12 years old and I was out of the house before light in the morning and around that headland, checking out what the surf was like. Or getting on the bus going a couple of beaches down, just with my surfboard and my mates," Carroll, 39 said. "And it's just going around that corner and checking it out and seeing what it's like, that's the spirit of the Crossing to me, and it's pretty simple and basic. It keeps every cell in your body alive, that spirit."

Six-time world champion, Kelly Slater, who dubbed the Crossing "The Greatest Surf Adventure Ever" when it was launched, agreed with Tom: "The Crossing's about discovery, finding new waves, basically getting away from the world of surfing that we know and discovering something new," Kelly said. "It's getting clean water and checking out different cultures; diving and fishing, just living in the ocean basically, living from the ocean and amongst it and not taking it for granted."

Bruce Raymond said: "The circumnavigation is a huge undertaking and I think that we're trying to achieve something that we have an idea of what the outcome will be, but I think the Quiksilver Crossing will discover things that we didn't even imagine."

The schedule for the Quiksilver Crossing will be:
Maldives to South Africa; September 2001 - April 2002.
Europe; July 2002 - June 2003.
Brazil; July 2003.
East Coast of USA (Caribbean and Central America); September - December 2003.
West Coast of USA and Central America; December 2003 - June 2004.
Pacific Ocean; June 2004 - April 2005.
Indonesia; Indian Ocean. April - November 2005.

The Roxy surfers, including four-time world champion Lisa Andersen (USA), world number two Megan Abubo (Hawaii), Kate Skarratt (Australia), Veronica Kay (USA) and Caroline Sarran (France) have been on board for the past two weeks and have scored incredible three to six foot (one to two metre) surf. Reef Check marine biologist, Craig Shuman, is also on board.

Contacts and links

For highlights of the Quiksilver Crossing to date, and an article on Reef Check and the Quiksilver Crossing, go to: *http://www.quiksilver.com*
http://links.infomail.com.au/redir.asp?uid=340780&id=909

Further information

For further information, photos, or television footage, please contact:
Kirk Willcox
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Fax: (61 2) 9973 4634

Television satellite feed

Reuters Sydney, Australia, will be providing globally via "Media Sat" a 15-minute feed re the Circumnavigation of the Quiksilver Crossing.
The phone number at the Reuters office is (61 2) 9373 1500
The people to contact are:
1. Derek Pascoe
2. Angie Ramos or
3. Nigel Jones. Nigel's mobile is (61) 417 255 817
http://links.infomail.com.au/redir.asp?uid=340780&id=909
http://links.infomail.com.au/redir.asp?uid=340780&id=911
http://www.infomail.com.au/quiksilver/2001-09-05/images/bottom_bar.gif
http://dev.infomail.com.au/stats/152/340780/LIVE/LIVE/ ■

Use of NOAA-AVHRR satellite images as a tool for coastal management

A case study of Ecuador's Bahia de Caraquez barrier spit

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Colombia

The use of modern techniques has been without doubt one of the main factors toward the achievement of serious plans regarding Integrated Coastal Zone Management (ICZM). A multi-temporal analysis of the land-use of one of the most sensitive areas in Ecuador, Bahia de Caraquez, has given interesting results which have been used to update a more complete coastal zone management plan in this area. In this estuary important mangrove reserves are located. Unfortunately, the lack of control of the activities taking place in the area (shrimp farming) has caused the deforestation of most of the mangrove-covered areas.

A serious concern about the future of the estuary is taking place. Consequently, new techniques have been applied with good results and in this way more effective control and coastal management in the area is taking place. The use of NOAA-AVHRR satellite images to study changes in the land-use of the area and its surrounding was very useful to determine new patterns of human behavior.

The multi-temporal analysis done in the area show some interesting results, although most of the images available for that area were too cloudy to consider these results 100% reliable. The comparison and classification of the images (supervised and un-supervised) was completed using as a reference GIS maps where the main activities were identified. Like this, a comparison between the images and the maps was possible and the results were enhanced enormously; although the overall result can not be considered successful, the techniques are quite useful. It is just a matter of quality and resources available in order to do further analysis in this topic.

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Description of the area

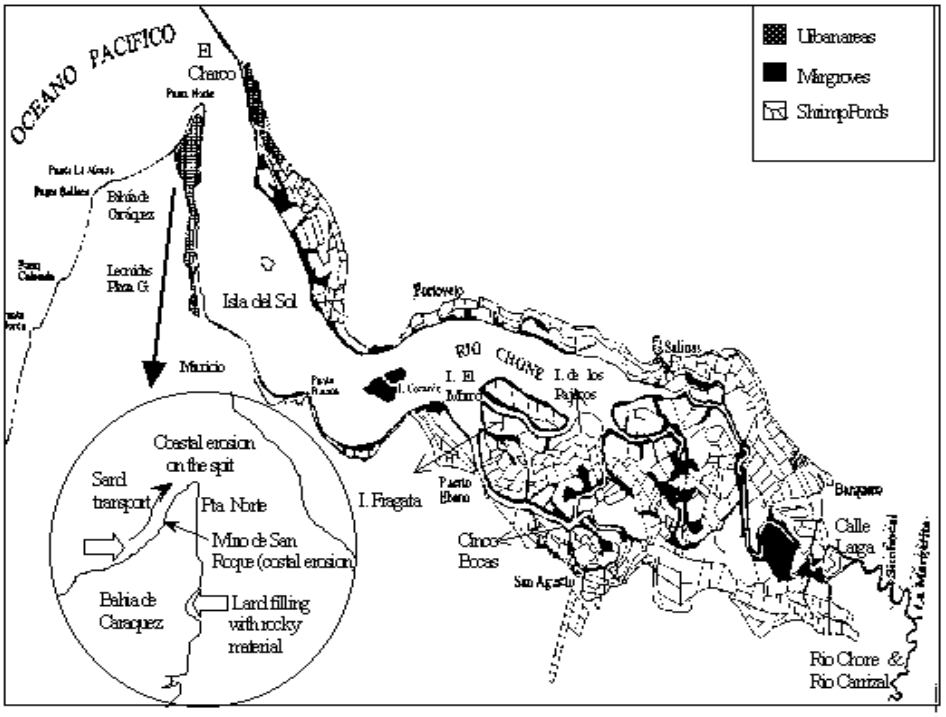
The Estuary of Rio Chone, Manabi, (Figure 1) has been chosen as a representation of the most important processes, events and problems taking place in the Ecuadorian coast. This area is of great interest for the country, due to its tourism, natural landscape and diversity. Its great biodiversity, however, has been severely affected by different factors which are threatening the natural ecological equilibrium of the area.

Bahía de Caráquez (Figure 2) is a large barrier spit of 500 m wide. This spit has grown actively towards the north, since 1950 until 1987 due to natural sand transport to the area. After 1987 severe erosion has taken place mainly because of the felling of mangroves and construction of great walls (related to shrimp farming) in the area.

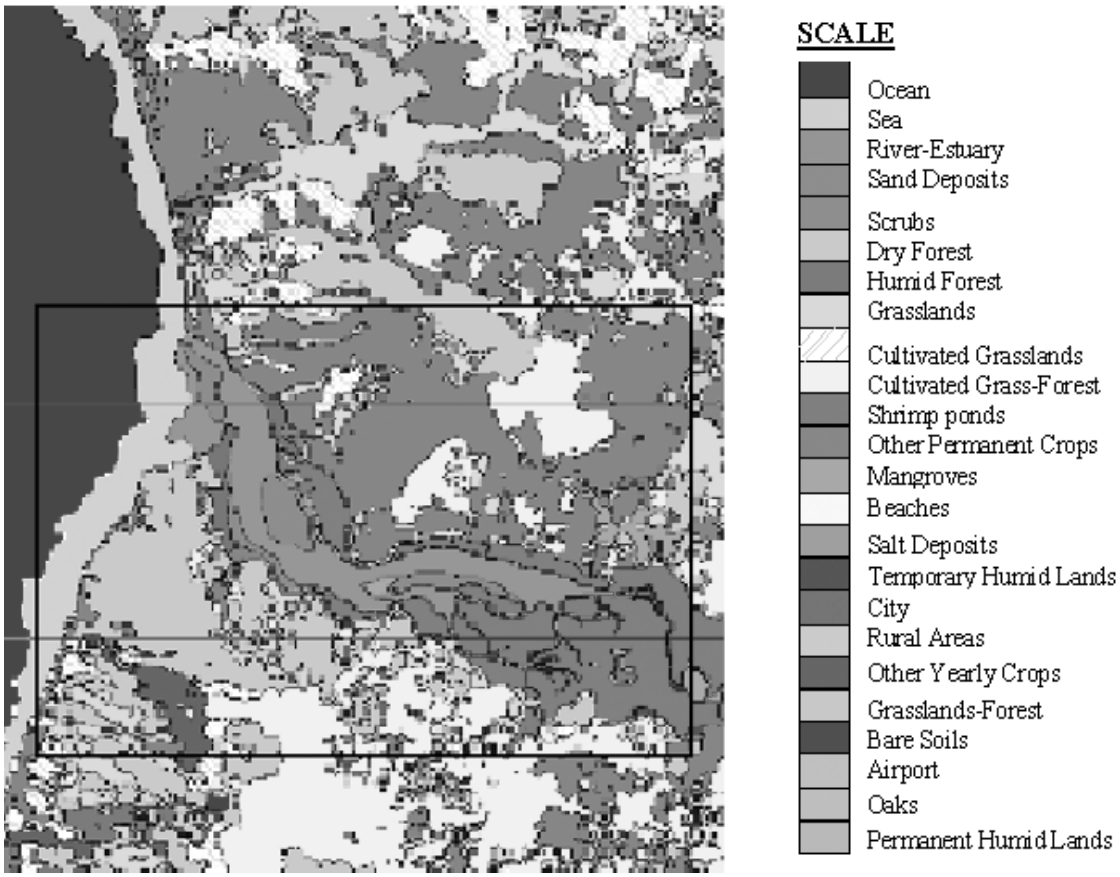
New islands have been formed by the deposition of sediment into the estuary from the Río Chone and formerly covered by mangroves (south of Salinas). They began as extensive intertidal mud flats (600 m wide), which were then gradually covered by mangroves. They fringe the shoreline of the estuary, particularly along the southern margin (Figure 3); PMRC, CRC, USAID, 1994.

Problems and threats of the area

The Rio Chone Estuary has suffered a fast degradation of its ecosystem. The bad condition of the estuary is evident



▲ **Figure 1.** Area map of the Estuary of Rio Chone.



▲ **Figure 2.** Land-use georeferenced map of Bahia de Caraquez and surroundings (GIS).

to the local people, mainly because of two reasons: 1) the high rate of mangrove deforestation (> 90%) for construction of shrimp ponds, and 2) the eutrophication of several bodies of water (e.g. Cinco Bocas-El Ebano, Figure 1), due to the modification in tidal flow (PMRC, 1993).

The main problems in this area among others are: 1) An inadequate use of the coastal zone, like beach invasion for construction of hotels and houses, urban development on unstable cliffs and dynamic beaches, construction of shrimp ponds in mangrove areas, sand extraction; 2) Decrease of the coastal area (beach), because of erosion processes and use of inappropriate methods for shore protection; 3) Lack of effective regulations and a good CZM plan.

This zone is also threatened by the deforestation of the mangroves to build shrimp ponds (Figure 3). Shrimp farming in the coastal zone has had a positive impact on the country's economy, but on the other hand the felling of mangroves has generated a great environmental impact.

The construction of shrimp ponds in the area is the main reason for the felling of mangroves, but also urban development. The ecological alteration on the ecosystem caused by this mangrove felling is quite serious now, for this reason a multitemporal analysis of this area was done in order to compare the changes in landuse and the diminution of mangroves in this zone.

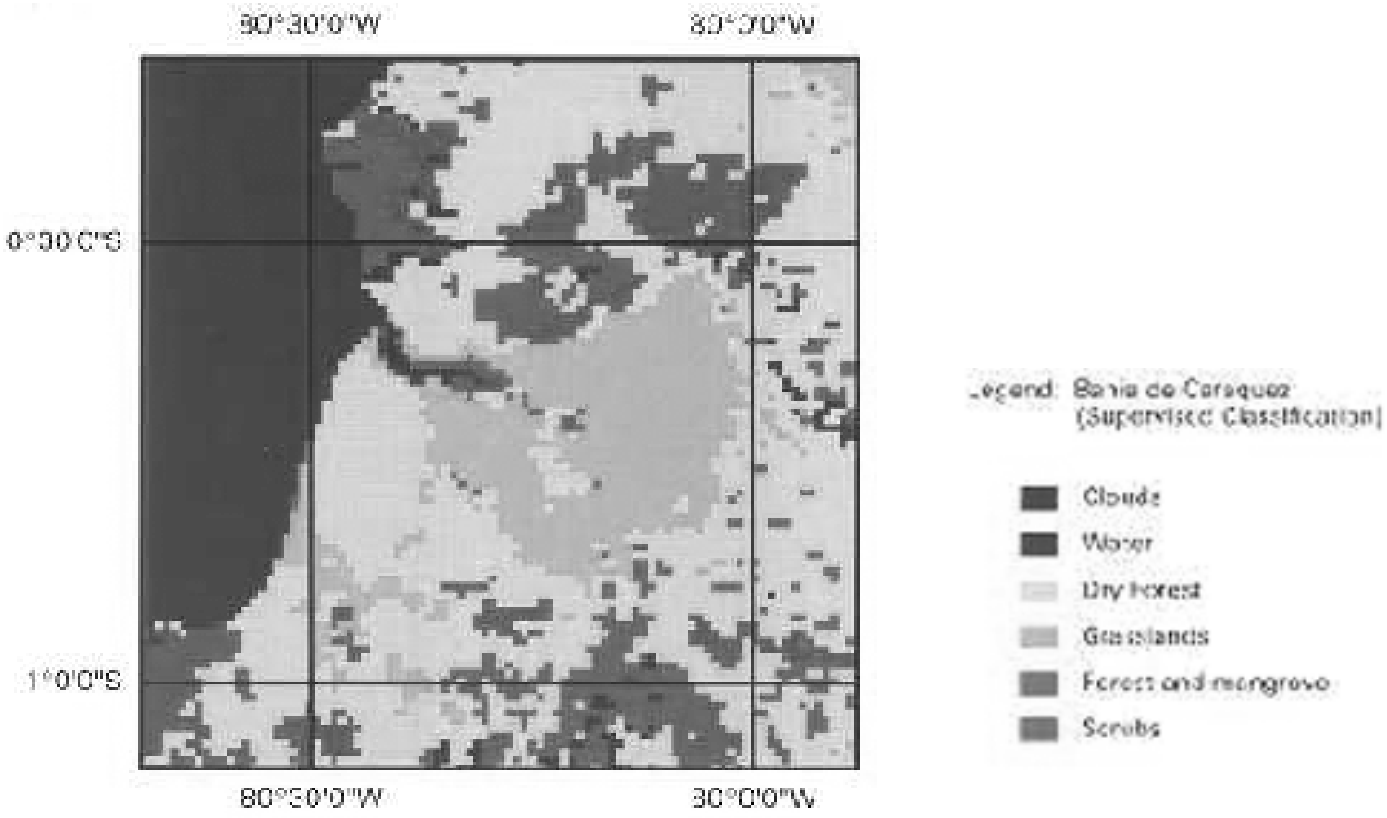
Methodology

Two kinds of classifications were done for the multitemporal analysis, Supervised and Unsupervised, as well as the determination of NDVI. Special emphasis is shown in the Supervised Classification and its results. The NOAA/AVHRR images used for this classification have a 1.1 km of resolution, were composite images of 10 days (3 per month), 5-channel and NDVI (band 6) and were downloaded from internet (*http://edcwww.cr.usgs.gov/landdaac/1KM/*). The images were collected continuously from 01/April/92 - 30/Sept./96 including some missing information.

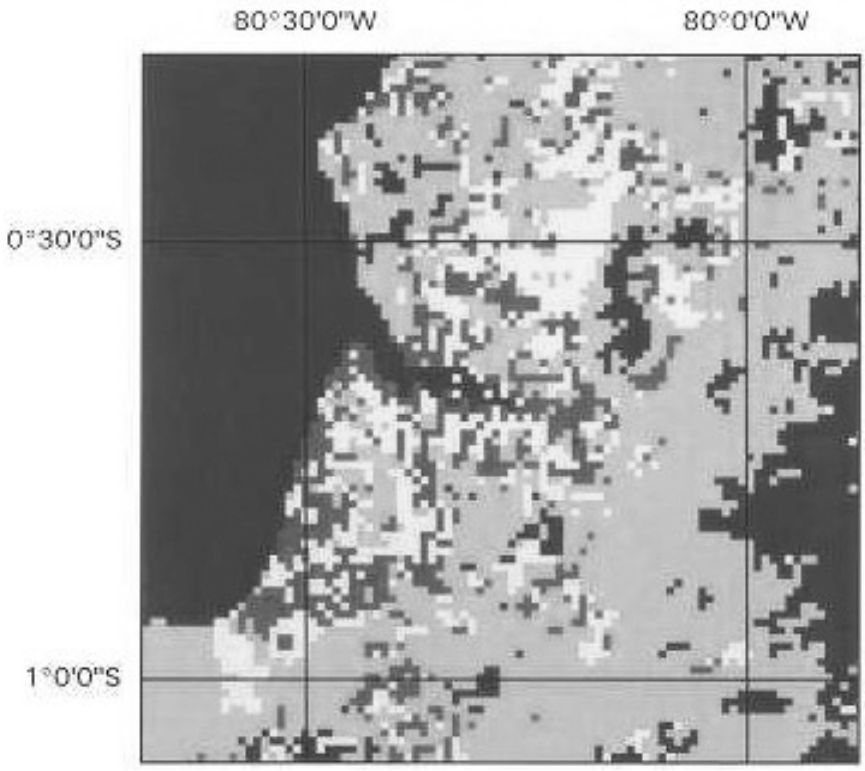
In this case some basic steps were followed in order to obtain the information and for the process and treatment of the images: 1) Selection of the study area (coordinates); 2) Selection of month and year; 3) Download of data (each band separately, NDVI-band 6); 4) Import of data (Erdas Imagine); 5) Distinguish of good images (< clouds); 6) Selection of images (May); 7) Georeferenciation of the images; 8) Classification (Supervised/Unsupervised) and 9) Multi-temporal analysis. Also, an analysis of the NDVI were done on the selected images.

The selection of training sites for this classification was based on the land use map of the area and previous visits to the area. The pixels were identified and selected by polygons located in

— continued on page 12



▲ **Figure 3.** Supervised Classification, May 1992.



▲ **Figure 4.** Supervised Classification, May 1993.

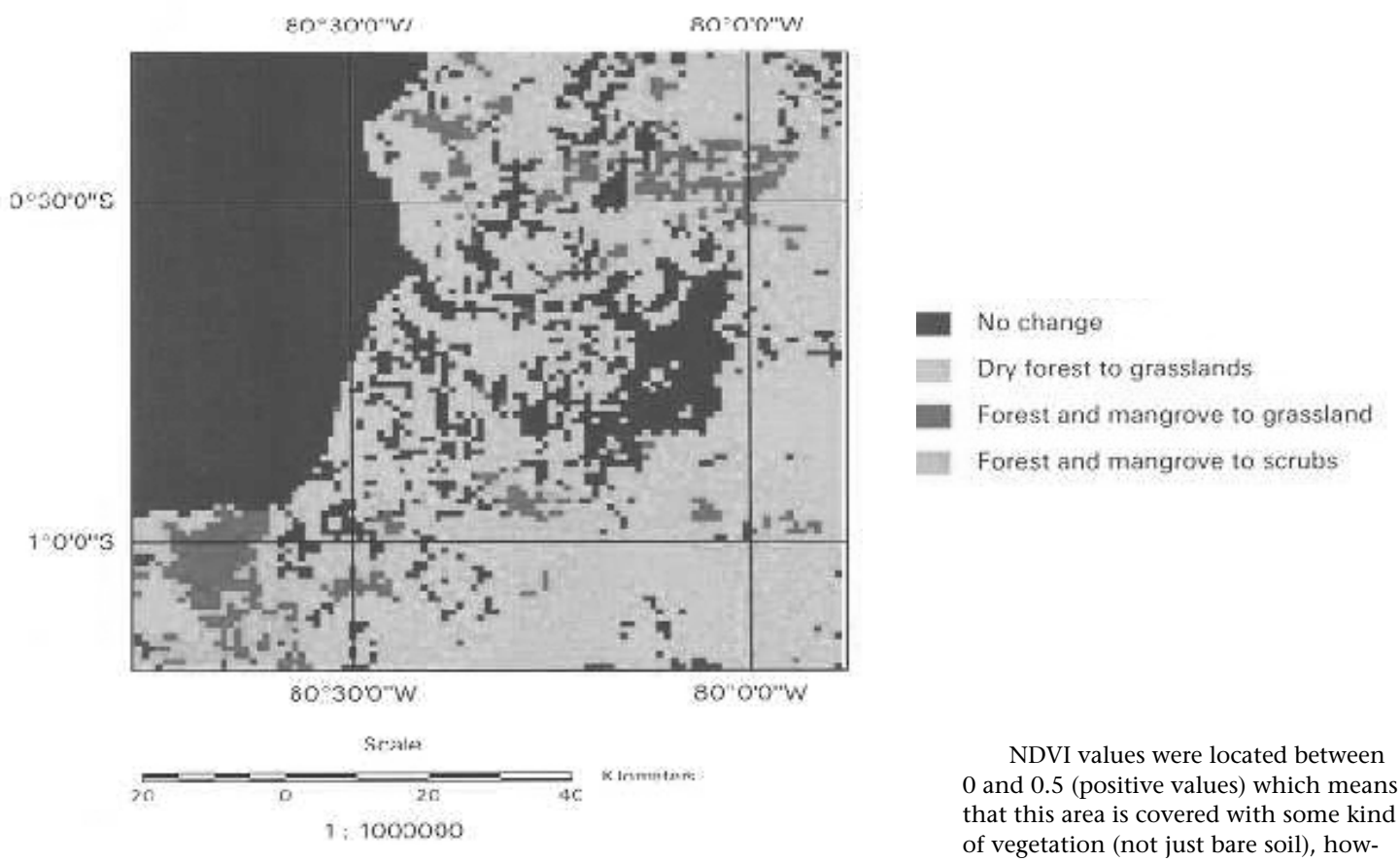
Bahia de Caraquez, *from page 11*

areas previously identified (training sites). Then six different classes were chosen depending on the location of the training sites. The selection of mangrove areas in the image before the classification was a bit difficult due to the small size of them and the low resolution of the images.

For the multitemporal analysis two images were selected, May 92 and 93 (best quality images) and the same procedure and selection was applied in both cases. As part of the supervised classification a different image was created containing the main changes in vegetation cover. For this purpose a specific function using one of the tools of the program was created to automatically compare individual images (e.g. dry forest converted into grasslands).

Results of the Supervised Classification

After the selection of training sites and the classification of the image by



▲ **Figure 5.** Changes in vegetation cover between 1992 and 1993.

the Erdas Imagine some results were obtained: 1) The classification itself was not very precise and reliable due to the cloud coverage of the area and the low resolution of the images; 2) Changes in land use, e.g. dry forest (1992) to grasslands (1993), as shown by Figures 3 and 4 can not be considered 100% true; 3) Some similar results were obtained for both classifications.

The multitemporal analysis between the two images (Figure 5) was not accurate and reliable due to the great differences observed between these two images in only one year. However, some of these differences in the appearance of the images could be real changes in vegetation cover. Unfortunately based on these images and their characteristics (cloud coverage, composites of 10 days and resolution), real changes can´t be differentiated from false o ones.

The NDVI analysis in this area was done with a series of images (Figure 6, *on page 14*) from the same area (time series and seasonal analysis) gave also interesting results which validate, to some extent, the results obtained by the supervised classification and the digital map obtained from our GIS.

For this analysis individual pixels (20), containing NDVI values, were chosen randomly. These pixel values were then transformed to real NDVI values (between 1 and -1) by a simple formula:

$$\frac{X-100}{100}$$

where, X= pixel value.

The average NDVI of the selected pixels (chosen area) for each year was calculated for all the available images in each season (Jan/Feb/May); Figure 7, *see page 14*. The comparison of NDVI values in these images of the time series was not completely reliable due to the cloud coverage in the images. In general NDVI values in this area seem to be uniform (values are similar in every image) and without considerable changes among the years.

NDVI values were located between 0 and 0.5 (positive values) which means that this area is covered with some kind of vegetation (not just bare soil), however the classification of the vegetation is not possible due to the low resolution of the images. Unfortunately, the most recent image for this analysis was from May 1996, so the latest changes in the areas can not be analyzed.

Conclusions

The results of this research after the analysis from the different sources and tools were:

* The main problem of this coastal zone is the great pressure on it (many activities are taking place in the area). This is causing problems as erosion and sedimentation, mainly related to mangrove deforestation and also degradation of soils in the area.

* A detailed vegetation cover classification (supervised classification) was not possible because of the low resolution of the images (1x1 km), cloud coverage, and the areas of interest are not so extensive related to the resolution of the images.

* The multitemporal analysis of the images did not give accurate results

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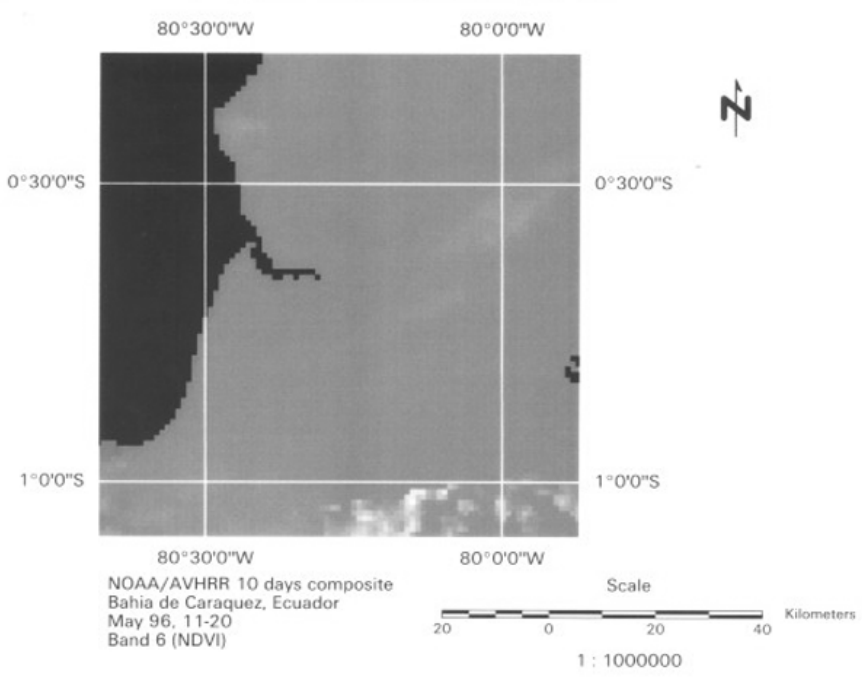

▲ **Figure 6.** NDVI image from the NOAA-AVHRR (band 6).

Bahia de Caraquez, *from page 13*

because of the same reason, although some changes can be observed and validated with the digital map from the GIS.

* The use of this modern tools GIS and remote sensing techniques is quite necessary and very useful when analysis like this take place, since most of the information can be integrated into a whole unique system which can be updated as new information becomes available in the case of the GIS and also the remote sensing results in this case of the satellite images are completely compatible as an input source of the GIS. So these two tools can work together and like this facilitate the analysis.

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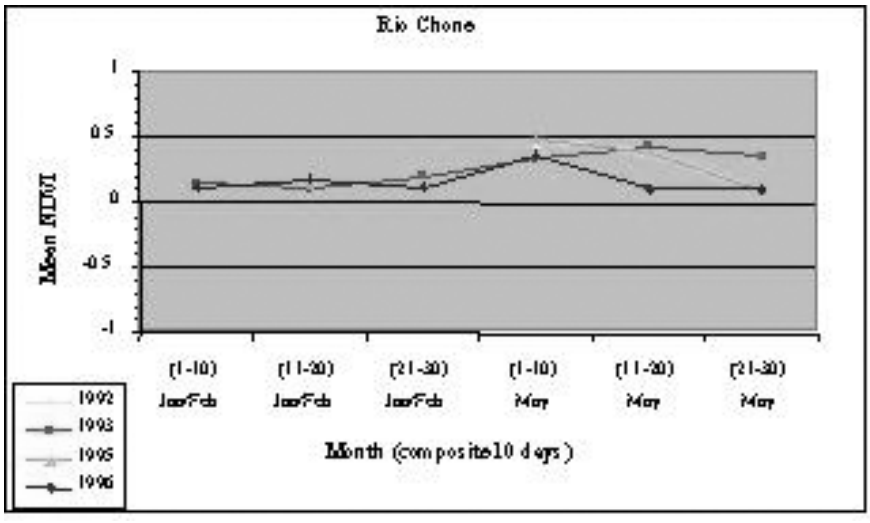

▲ **Figure 7.** Average NDVI of the area for the time seasonal series.

National Geographic requests Doppler radar images

The National Geographic Society contacted the National Climatic Data Center to obtain a unique series of Doppler radar images over central Texas for June 29, 1999. The radar images show several clusters of bats emerging from nearby known bat caves and converging on high densities of insects, their primary food source, near San Angelo, Texas. These images will appear in an upcoming National Geographic magazine article on the habitats of bats in southern and central Texas.
Contact: NCDC

North Atlantic Oscillation

The NOAA Paleoclimatology Program has archived a 555-year multi-proxy reconstruction of the North Atlantic Oscillation (NAO). The NAO is considered to be the dominant mode of winter atmospheric variability in the North Atlantic region.

Published by Glueck and Stockton in the *International Journal of Climatology* (2001), the reconstruction suggests that the recent persistently high phase of the NAO is not unusual over the 555-year record, but that the magnitude of some of the instrumental values may be unique. The data and research summary are available on the NOAA Paleoclimatology Program website at *http://www.ngdc.noaa.gov/paleo/pubs/glueck2001/glueck2001.html*.
Contact: NGDC

Coastal bathymetry from fishing vessels

Carl Wilson, chief lobster biologist for the state of Maine, contacted NGDC soliciting interest in working jointly on a proposal to increase nearshore bathymetric data. Wilson's idea is to outfit commercial fishing vessels with an automatic data recorder to collect bathymetric soundings. Most commercial vessels already use GPS and depth sounders. Data recorded from this venture would be useful to a wide variety of applications and audiences, including scientific models, potential hazards, fisheries researchers, and other commercial fishing companies. Wilson has worked previously with NESDIS/NGDC on the Penobscot Bay project.
Contact: NGDC

Data products and services

North Atlantic and European climate pressure reconstructions

The NOAA Paleoclimatology Program has archived 500-year reconstructions of gridded monthly sea level pressure, based on the combination of early instrumental station series (pressure, temperature and precipitation) and documentary proxy data from Eurasian sites. In press for 2002 publication in *Climate Dynamics* by Luterbacher et al., these reconstructions reveal persistent patterns of North Atlantic climate variability, including a zonal flow pattern with pronounced decadal to centennial time-scale variations, and a pattern modulating the meridional flow component over Europe. The data and research summary, plus custom map graphics, are available on the NOAA Paleoclimatology Program website at *http://www.ngdc.noaa.gov/paleo/pubs/luterbacher2002/luterbacher2002.html*.
Contact: NGDC

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Satellite images for new WMO publication

The World Meteorological Organization (WMO) is publishing a book entitled *Climate: Into the 21st Century*. The National Climatic Data Center provided three high resolution, composite satellite images depicting either a major event or milestone. The images will be included in the new publication expected to be out sometime in 2002. These images include before and after views of the Great Midwest Floods of 1993, Hurricane Mitch, and a comparison image of the first TIROS-1 image in April 1960 and one taken 40 years later by NOAA-15. These historical images can be viewed on the National Climatic Data Center's website, specifically under the Historical Significant Event Imagery page at *http://www5.ncdc.noaa.gov/cgi-bin/hsei/hsei.pl?directive=welcome*.
Contact: NCDC

Bathymetric data provided for Marine Protected Areas (MPAs)

Julia Brownlee of the National Ocean Service (NOAA/NOS) Special Projects Office contacted NGDC and requested bathymetry data for the Great Lakes. The data will be used to generate images of the Great Lakes on the MPA website under the regional maps section of the site (*www.mpa.gov/mpaservices/atlas/composites.html*). NGDC also provided Brownlee with volumes 1-5 of the Coastal Relief Model CDs that contain bathymetric data for the East Coast and Gulf of Mexico.
Contact: NGDC

Great Salt Lake water level study

A former employee of the U.S. Geological Survey (USGS) has noticed that monthly totals of precipitation from Morgan, Utah, correspond with the coincident water level of the Great Salt Lake more than any other reporting facility surrounding the lake. The USGS retiree will closely examine the geographical features near Morgan among other types of information. The National Climatic Data Center will aid in this enthusiast's research by supplying him with monthly precipitation data for Morgan's entire period of record which began in 1903, as well as similar data from other locations in close proximity to the lake.
Contact: NCDC

***Coastal Storms Initiative**, from page 7*

If CSI is to achieve its aims, user needs must be determined at the outset. Therefore, the implementation plan calls for constituent meetings to be held in the pilot regions. It also calls for a network of outreach professionals to provide a link between the user community and the tool developers.

In order to assure that the data and analysis produced by this Initiative receive the widest possible dissemination, CSI proposes to explore new, visionary, distribution mechanisms as well as strengthening existing ones. This means new decision support tools to assist coastal managers in utilizing the data, products, and information generated by this program. These tools will be distributed through traditional media such as manuals and self-help guides or through non-traditional platforms such as dedicated websites. Specialized courses will be created to train local education and extension professionals to ensure that the skills exist to apply the tools to local decision-making.

A final objective of this Initiative is to develop an enhanced national framework for policies, standards, and protocols for data collection, dissemination, and integration, as well as the associated documentation of products and tools. Achieving such an objective helps provide a seamless suite of information, rather than a discordant set of unrelated data, to coastal community decision-makers.

Pilot areas

CSI will end up focusing on three regional pilot areas to demonstrate how improved data, products and services can address specific state/local needs. These three pilot regions are the St. John's Water Management District in Northern Florida, the Southern California Bight, and the Pacific Northwest from Nehalem Bay in Oregon to Gray's Harbor in Washington.

The fiscal year 2002 appropriations process has provided funding for initiation of the first pilot in Florida. Due to recent storm events, the coastal communities in Florida are highly motivated to see improvements in prediction and tracking of storm paths where flooding is a key issue. The project team will be kicking off efforts with the local community in the St. John's Water Management District.

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