The South Florida and Caribbean Cooperative Ecosystem Unit
A Strategic Vision for the Future

Updated August 4th, 2003, May 6th, 2006, January 7th, 2008, December 29th, 2009, January 17th, 2010, January 1st, 2015, and October 12th, 2016.

1. Introduction

The South Florida and Caribbean Cooperative Ecosystem Unit (**SFC-CESU)** is part of a nationwide network of biogeographically focused programs which were established to provide research, technical assistance, and education to federal land management, environmental, and research agencies. The **SFC-CESU** is one of the 17 CESUs nationally with a focus area that encompasses Florida south of Lake Okeechobee, Puerto Rico, and the Virgin Islands (Figure 1). Although each CESU has its specific focus area, membership and projects sponsored through each CESU can extend beyond the geographic boundaries. In addition to the general geographic boundaries, topical areas addressed by the CESU include applied scientific and socio-economic issues relevant to the geographic study region. Specifically, the **SFC-CESU** focuses on the marine, coastal, and terrestrial ecosystems of the South Florida and the Caribbean (Fig. 1). The **SFC-CESU** activities will encompass all ecosystems of terrestrial and coastal environments, including estuaries and near-shore oceanic environments, salt and freshwater wetlands and mangroves, terrestrial wetlands (Everglades), and coral reefs.

The **SFC-CESU** is a unique collaboration, which assembles a wealth of technical knowledge and expertise from 19 partner universities and organizations. The technical abilities from these organizations and institutions are made available to federal managers from the 9 cooperating federal organizations which will allow for the development of innovative and creative solutions to the many of social and environmental issues that confront the unique environment of South Florida and the Caribbean.

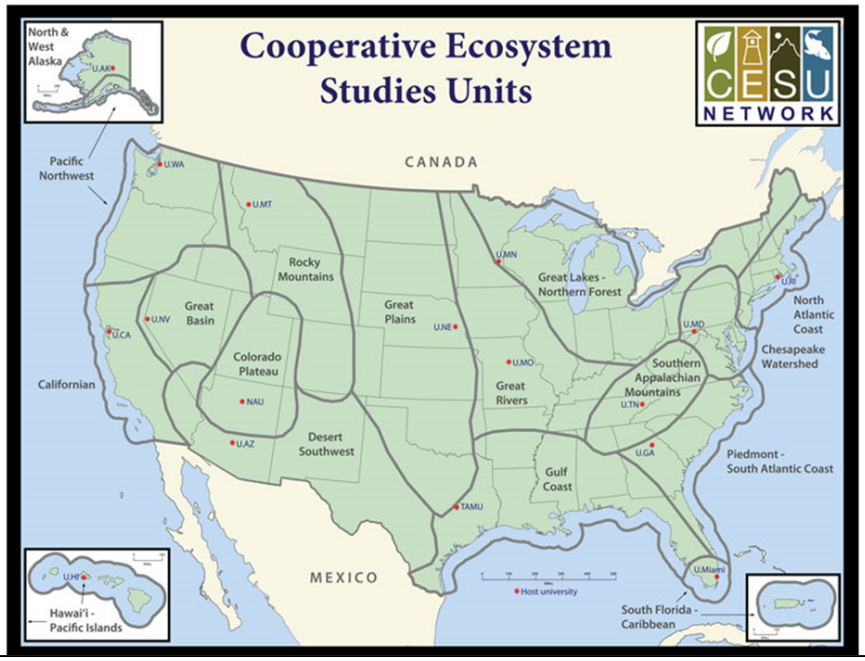


Figure 1: Location of Existing CESUs (Figure from http://www.cesu.psu.edu/default.htm)

2. Timeline and Membership

The **SFC-CESU** was established in October 2000 by agreement between the Department of Interior (National Park Service, US Geological Survey-Biological Resources Division, and the Bureau of Land Management) and the host institution, University of Miami, with its partner institutions, Nova Southeastern University, Barry University, Florida A&M University, University of North Carolina-Wilmington, University of Florida, University of Puerto Rico, University of the Virgin Islands, and the Audubon Society of Florida. In 2002 Florida Atlantic University was added as an academic partner. In 2003, 2004, and 2008 the United States Fish and Wildlife Service (USFWS), the National Resources Conservation Service, and the U.S. Army Corps of Engineers were added as federal partners. In 2005 the **SFC-CESU** was renewed for a further five years. In addition to the existing academic partners, Florida International University was added as an academic partner during the renewal.

In 2007, Florida Institute of Technology (FIT) and the Institute for Regional Conservation (IRC) were added as academic partners. In 2009, the Everglades Foundation and the University of South Florida were added as academic partners. In 2010 the SFC CESU was renewed for a further five years.

In 2012 Florida Gulf Coast University, Cetacean Logic, Ocean Research and Conservation Association, and Fairchild Tropical Gardens joined. In 2013 NOAA and DoD joined as federal partners.

Note that FAMU was originally a member but failed to complete the required paper work when the **SFC CESU** was renewed in 2015. We are still in communication with FAMU for their re-instatement. However, as of October 2016, FAMU has not yet been re-instated. During the 2015 renewal, Flagler College was added as an academic partner. In 2016, the Bureau of Indian Affairs was added as a federal partner.

Currently the **SFC CESU** has nine federal partners and 19 non-federal partners (13 academic and 6 non-governmental conservation organizations). A consolidated list of the SFC CESU partners is included on the home page of the SFC CESU web-site (sfc-cesu.com).

3. Research Directions

A discussion of research directions and needs for the **SFC-CESU** came about through a workshop held in April 2001 at the Rosenstiel School of the University of Miami. Present at the workshop were representatives from the National Park Service and USGS Biological Resources Division as well as representative of the host and partner institutions.

Discussions from the workshop were used to develop a strategic vision for South Florida and Caribbean Cooperative Ecosystem Unit. This document identifies the components of

a CESU research project or activity, identifies priority directions for research and technical assistance activities, and discusses specific activities and programs to be sponsored by the CESU.

Research Project or Activity

The philosophy of the **SFC-CESU** is to provide both services and research capabilities to the federal research partners both on a long term and opportunistic basis. These services will be made available through the coordination efforts of the on-site coordinator funded by the National Park service as well as a comprehensive and interactive web site which will allow the federal research partners to easily access and locate the necessary expertise in order to solve problems relevant to the **SFC-CESU**.

In particular, the **SFC-CESU** should provide:

- Necessary abilities and technical assistance in a range of expertise, to provide research and management solutions for environmental and scientific problems within the geographic region of South Florida and the Caribbean.
- Take full advantage of the research and educational expertise of the host institution (University of Miami) and its partner institutions, and include the participation of federal research partners.
- Provide abilities to develop long-term research programs as well as to react to short term requests for assistance from federal partners.
- Be interdisciplinary in nature.
- Provide opportunities for undergraduate and graduate students from diverse backgrounds.
- Provide educational opportunities for the Federal partners.

Research Foci of the SFC-CESU

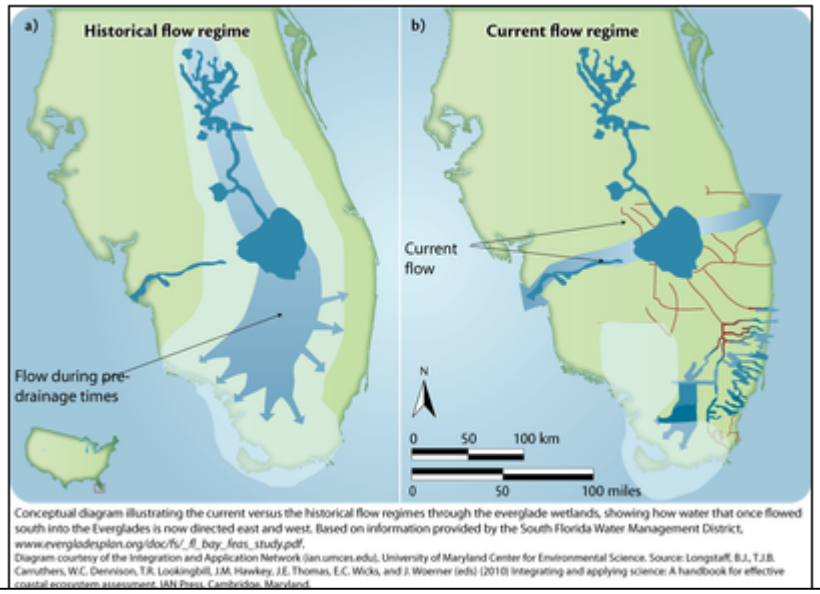
The South Florida and Caribbean Region (Fig. 1) is an ecologically and geographically diverse area encompassing a range of different environments that are of interest to the federal partners. These environments ranges from deep marine environments, off shore corals reefs, near-shore shallow water hyper-saline to hypo-saline bays, coastal marshes and mangroves, freshwater marshes, and sub-tropical forests. The connection between these environments is expressed in the flow of water from the land to the sea and it is this interconnection and its geological, hydrological, biological, and ecological manifestations, which serves as the principal focus for the **SFC-CESU**. In addition the natural environment coexists with an ever increasing human population which places demands. In the following section we include a brief outline of outstanding issues in each of our environments and outline how the **SFC-CESU** can contribute to a greater understanding of these issues.

As a result of the geographically diverse nature of the **SFC-CESU** region certain problems are unique to the individual components of the CESU. In particular issues dealing with the terrestrial ecology of peninsular Florida are different to those of the islands of the Caribbean. In contrast the majority of issues concerned with the marine resources are

common to all areas of the CESU. The following narrative attempts to deal with all portions of the **SFC-CESU** in a equitable manner. The order in which these areas are discussed does not imply a priority within the **SFC-CESU**.

3.1 Everglades

Southern Peninsular Florida is dominated by a low topographic relief, high rainfall, and a sub-tropical vegetation which has given rise to an extensive ecosystem that is defined by its unique hydrology, vegetation, and wildlife. Within this areally extensive region there is a complex interaction between land managed by State, Federal, and private interests, the conflicting demands of which need to be managed in a manner which reflects the best interests of the ecosystem and its human populations. Regardless of its unique nature, the Everglades is much more than a refuge of biological complexity and intense beauty. The maintenance of the Everglades is vital for the control of water resources supplied to the ever-increasing coastal populations. In the past there was a tendency to destroy the terrestrial wetlands to increase areas under urban and agricultural control. At the present time it is widely recognized that the maintenance of the wetlands is vital to supply clean water for urban, agricultural, and industrial purposes as well as the prevention of salt-water intrusion. Over the past 100 years, the extent of the naturally occurring wetlands has been drastically reduced and the hydrology significantly altered (Figure 2). The changes in management of water flow planned by the Comprehensive Everglades Restoration Plan (CERP) will affect hydroperiods and water depths in many areas, leading to changes in the pattern of plant communities.



Conceptual diagram illustrating the current versus the historical flow regimes through the everglade wetlands, showing how water that once flowed south into the Everglades is now directed east and west. Based on information provided by the South Florida Water Management District, www.evergladesplan.org/doc/fs/_fl_bay_finals_study.pdf.
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Longstaff, B.J., T.J.B. Carruthers, W.C. Dennison, T.R. Lookingbill, J.M. Hawkey, J.E. Thomas, E.C. Wicks, and J. Woerner (eds) (2010) Integrating and applying science: A handbook for effective coastal ecosystem assessment. IAN Press, Cambridge, Maryland.

Figure 2: The historical and man-modified flow of water in the Everglades (Diagram from "Integrating and Applying Science" (pg. 144) - http://ian.umces.edu/press/publications/259/)

Understanding of allogenic succession, due to changing hydroperiods and fire regimes, is essential. Changes in the seasonal patterns of water depths in space and time across the Everglades landscape will have effects the life cycles of many key and endangered species, particularly nesting and foraging during their reproductive periods. These species include the Cape Sable seaside sparrow, the snail kite, the American alligator, the American crocodile, and many species of wading birds. Because of urbanization and agriculture there has been large scale loss and fragmentation of some habitat types, including essential habitat of the Florida panther. It is important to know how these landscape processes are affecting species viability. Population viability analyses need to be done on keystone species. A large number of non-native plants and animals have invaded or have been deliberately introduced to southern Florida over the past century. These include plants such as Melaleuca and Brazilian pepper (*Schinus terebinthifolius*), and aquatic animals such as the Mayan cichlid and the swamp eel. Methods of forecasting the spread of invaders and their effects on the ecosystem are needed. It is not possible to return the system to the condition that existed before anthropogenic influences. The present effort must be to manage the resources in a manner which fulfills the following criteria (i) maintain the existing diversity of flora and fauna, (ii) maintain and increase the availability of freshwater for natural and urban activities, (iii) increase the quality of water available, (iv) supply water in a manner

Some of the specific research areas related to the Terrestrial Ecosystems are:

- The effects of landscape hydrology on the plant community.
- The effects of landscape hydrology on the life cycles of key animal species.
- The effects of landscape loss and fragmentation.
- The effects of invasion of non-native animals and plants.

3.2 Coastal Bays and Estuaries

The large terrestrial ecosystem known as the Everglades interfaces with the marine environment through a broad coastal environment (Figure 3). The major bays and estuaries along this interface include the Indian River Lagoon, Biscayne Bay, Florida Bay, the Ten Thousand Islands, the Caloosahatchee River estuary, Charlotte Harbor, Sarasota Bay and Tampa Bay. These bays typically exhibit spatial and temporal fluctuations in salinity, however, the degree of fluctuation varies greatly among the various estuaries. Within a given estuary, salinity fluctuations are governed by a complex combination of influx of freshwater water (both from rainfall and terrestrial runoff), degree of circulation with marine waters, and evaporation (which can be considerable during dry periods). Most of the estuaries are dominated by seagrasses and fringed on the upland by mangrove forests; plants well adapted to the fluctuating conditions. In some cases the coastal marine environment is very distinct from the terrestrial environment but in many instances the terrestrial hydroscape grades into the marine environment. Consequently, the health of these ecosystems is inextricably linked to terrestrial water quality and hydrology. That estuarine ecosystems make up a significant spatial percentage of southern Florida's two major National Parks (Biscayne Bay and Everglades) is a testament to the intrinsic and esthetic value of these habitats.

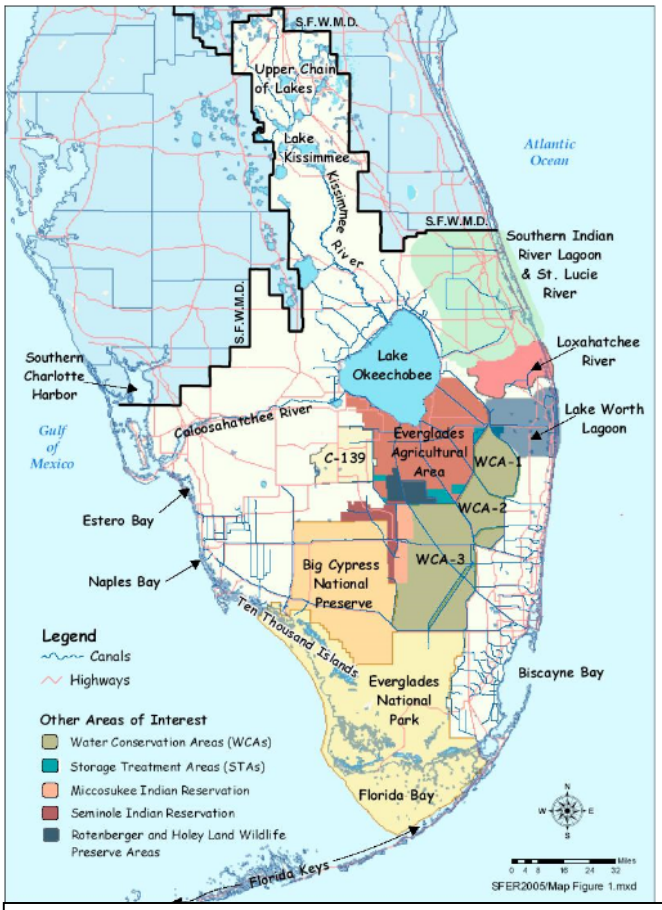


Figure 3: Situation of coastal estuaries and bays surrounding South Florida (from: http://www2.fiu.edu/~sukopm/seminar0405/SFWMD.JPG)

Over the past several decades there has been increasing concern that changes in the water management practices in southern Florida may have had a significant adverse impact on the quantity and quality of the water supply to the adjacent coastal regions. State and Federal agencies developed a system of canals and levies that was primarily designed to meet the flood protection and water supply needs of urban and agricultural areas. However, in most instances, changes were effected without an adequate understanding of the processes involved, thereby resulting in adverse effects on the natural adjacent estuarine systems.

Changes in the distribution of freshwater deliveries and overall reductions in water quantity and quality dramatically changed the hydrology and hydrography of the estuaries. A consequence was that benthic and wetland plant communities were altered and, in some drastic cases, entirely lost. The advent of large agribusiness and the exponential increase in the human population caused further problems for the estuaries. Runoff from farms and urban areas was channeled into the canal system where contaminants were swept downstream into the estuaries thereby changing the nutrient balance and raising the incidence of environmental toxicants such methyl-mercury. Construction of causeways across the shallow areas (e.g. the Overseas Highway in the Florida Keys, Rickenbacker Causeway in Biscayne Bay, Sanibel Causeway in the Caloosahatchee) and the dredging of

the Intracoastal Waterway through all of the estuaries had a dramatic impact on circulation patterns within the bays. Dredge and fill operations converted vast acres of bay bottom and adjacent wetlands into urban centers. With the increase in population also came direct effects such as increased fishing and boating impacts (e.g. overfishing and groundings). Finally, these estuaries are also subjected to global-scale perturbations such as hurricanes and sea-level rise. The **SFC-CESU** provides the expertise to its federal partners to assist in making scientifically informed decisions regarding sound management for the sustainability of these treasured resources.

Some of the specific research areas related to the Coastal Ecosystems are:

- Conduct functional assessments and develop predictive models for coastal ecosystems and habitats.
- Develop and test best management practices to minimize adverse effects of water management on the estuarine ecosystems.
- Identify and develop biotic indicators of ecosystem stress related to changes in water delivery patterns including hydrology, hydrography and water quality.
- Evaluate the response of estuaries to changes in the magnitudes of nutrient enrichment and/or contaminant inputs.
- Assess and monitor the condition of critical habitats (e.g. seagrass beds and mangrove forests) and animal population (e.g. fishery species, water birds, protected species).
- Develop paleoecological techniques in order to best understand historic conditions in an effort to recreate those conditions.
- Evaluate the loss of adjacent wetlands to the coastal environments.
- Examine the impact of changes in circulation patterns within the coastal areas caused by establishment of roads and waterways.
- Monitor and evaluate direct impacts caused by human utilization of the estuaries (i.e., fishing and boating impacts) such that the best management strategies can be developed.
- Assess societal values such that the resources can be managed for high quality recreational and commercial activities.

3.3 Caribbean Forested Ecosystems

Subtropical forests of Puerto Rico and the Virgin Islands reflect the full spectrum of a moisture gradient. Semi-arid life zones occur in southwestern Puerto Rico and exposed headlands among the Virgin Islands. Subtropical dry forests once dominated the Virgin Islands (remaining plentiful only on St. John), and were found abundantly in parts of Puerto Rico. Subtropical moist, wet and cloud forests are well represented in El Yunque National Forest (Formerly known as the Luquillo National Forest), and in several Territorial Forest Reserves in Puerto Rico.

The major anthropogenic threats to forest integrity in the region are: (a) fragmentation and/or conversion to residential and commercial uses, and (b) exotic invasion. Dry forest status in the Virgin Islands varies among the three main islands. St. Croix is an agricultural landscape. Land development on St. Thomas is presently claiming the last of the significant dry forest stands. St. John forests, much of it within the Virgin Islands National Park (VINP), has suffered acute effects of expanding populations of feral farm animals (pigs, goats, donkeys), introduced key deer, mongoose and rats. Alien weeds are less problematic, although a serious threat in certain habitats. The forests of Puerto Rico outside its system of forest reserves and parks, are severely fragmented or extirpated. A key challenge in both territories is aggressive management of the protected forests.

3.4 Coral Reefs

Coral reefs, which fringe much of the coastline of South Florida and the Florida Keys, as well as the of the U.S. Virgin Islands and Puerto Rico, provide a unifying theme and opportunities for partnership among the institutions of the **SFC-CESU** (Figure 4). Coral Reefs are facing a mounting number of threats on local, regional, and global scales, and there is little doubt that they are experiencing a period of decline manifested by loss of coral cover and diversity, in particular in the Caribbean and southern Florida. A major question is how much of this decline is due to natural causes and how much is due to local or regional problems that can be addressed by management action. Coral reefs are sensitive to terrestrial inputs (freshwater, sediments, nutrients and other pollutants) and thus greatly affected by human activity on land, but they also have their own unique problems, including severe responses to climate change and overfishing. Of serious concern is that these multiple factors are interacting synergistically to accelerate the rates of reef decline and make it more difficult to restore and conserve coral reef resources within the region.

Figure 4: Location of Coral Reefs in South Florida, Puerto Rico, and U.S. Virgin Islands (from: http://www.coris.noaa.gov/portals/images/atlantic2.jpg)

Some of the specific research areas related to coral reefs are:

Global

- Increased intensity and frequency of bleaching events (global warming, El Niño)
- Increased problems of disease epidemics and new emerging diseases (physiological stress from global warming, water quality degradation and new pathogens)
- Reduced calcification and growth (potential reduction in the calcium carbonate saturation of seawater due to increasing levels of CO_2 in the atmosphere).

Local/Regional

- Over-fishing (removal of key predators, grazing species, etc.)
- Sedimentation stress (result of poor land use patterns, forest clearing, uncontrolled coastal and inland development)
- Chemical pollution (industrial, agricultural and other human activities)
- Nutrification (sewage, fertilizers and runoff)
- Uncontrolled tourism (coastal development)
- Physical impact (ship groundings, anchor damage, dredging, building of docks, coral extraction, destructive fishing methods, etc.)

In addition, numerous studies are reporting limited coral recruitment and reef recovery years after specific impacts leading to concern about permanent loss of coral reef resources where the above factors are occurring.

Many of these factors (or combinations of them) result in significant reduction of live coral coverage, increased algal cover, increased susceptibility to diseases, and loss of biodiversity. All of these issues urgently need more attention with regard to their impact on coral reef resources within the National Parks and other managed coastal areas. In order to address some of these issues two research institutions have been recently formed in South Florida: the National Coral Reef Institute (NCRI) at Nova Southeastern University (funded by NOAA), and the National Center for Caribbean Coral Reef Research (NCORE) at the University of Miami (funded by EPA). Each of the centers has their particular missions and research mandates, and can provide additional expertise to the **SFC-CESU**.

Potential Cooperative Research Initiatives

Assessment of the State of Coral Reefs in the South Florida and Caribbean Region:

- Inventories (scleractinian corals, algae, fish, other invertebrates)
- Live cover and abundance
- Recruitment levels (Adult/juvenile ratios)
- Studies to examine the impacts of disease in coral reefs:
- Determine current status of incidence of diseases
- Determine spatial and temporal variability in the incidence of diseases B syndromes at the population-species and community levels.
- Determine mortality rates for each disease in each species B spatial and temporal variability.
- Identify disease-causing pathogens (fulfill Koch's principles)

- Identify mechanisms of tissue mortality
- Develop specific diagnostic methods for epidemiological studies

Studies into the processes of coral reef recovery

- Factors affecting or limiting coral recruitment success
- Development of methods to enhance coral recruitment
- Studies to understand factors limiting the recovery of *Diadema antillarum*
- Mariculture of *Diadema* for re-introduction to areas where it is still not returning on it's own
- Examination of the benefits of marine protected areas (no-take zones) to ecological interactions that affect coral reef recovery (abundance of corallivores; algal cover and coral recruitment; coral growth and fecundity)

3.5 Human-Environment Interactions

A central theme of the **SFC-CESU** is the interaction of humans with the terrestrial, marine and coastal environments of South Florida and the Caribbean. An organizing framework for assessing these issues is the integration of socioeconomic and ecological risk assessment frameworks, largely developed by the Rosenstiel School and promulgated by the US Environmental Protection Agency as a way to systematically assess the human environment interactions and effects. The major components of the socioeconomic/ecological risk assessment framework are: a) societal drivers (i.e., what society does, such as land use changes, or energy production); b) anthropogenic environmental stressors that result from those drivers as well as natural stressors, where stressors are defined as physical, chemical, or biological changes that affect people and the environment; and c) socioeconomic and ecological effects manifested on socioeconomic and ecological endpoints, which are defined as those specific attributes across organizational hierarchy (individuals, populations, communities, to landscapes) that can be used to evaluate the health of ecosystems and their human habitants. The risk assessment approach focuses on parallel characterization of the stressor regime, including the spatial and temporal distribution of stressors, and the effects regime, assessed as changes in the ecological and socioeconomic endpoints. The risk assessment process calls first for a problem formulation phase, to define the problem, identify stressors, identify existing and needed databases and analytical tools, and develop an overall conceptual model of the ecosystem and its human interactions. Then the analytical phase is done, in which the data are collected, modeled, analyzed, etc. to perform the stressor-effects assessments. And, finally, the risk characterization is done, integrating the exposure regime and effects regime analyses. This framework has been successfully applied to a number of ecological risk assessments, ranging from scoping exercises on ecotoxicity of chemicals to major assessments, such as for citing power plants or assessing beach renourishment projects.

For the South Florida environment, the history of human-environment interactions is intense and concentrated in a short period of time, in which now more than 6 million people live perched along the coastal ridge of the region, immediately next to some of the most invaluable natural terrestrial and coastal marine ecosystems of the world in the Everglades and the Florida coral reef tract. There are many anthropogenic stressors affecting South

Florida coastal ecological and societal systems, most importantly caused by changes in the hydrological system associated with the massive water management system of the region. The region's hydrological changes and habitat alterations have fundamentally altered the distribution and condition of a diversity of ecosystems. The concerns about the quantity and quality of water are increasingly becoming both ecological and societal issues. Thus, the public wants to know what is in drinking water, what it will do to humans, and how safe and available it is for consumption, recreation, agriculture and industry. Other stressors include major habitat alterations, spread of invasive exotic species, elevated nutrients into a historically oligotrophic system, extensive over-fishing of fish and invertebrate populations, sea-level change, climate change, and xenobiotic chemicals. With the population in the region increasing at a rate of almost 1 million per decade, the stressors can only increase especially competition for the water supply and the over-exploitation of the natural resources. Both the need and the opportunity for significant scientific research in support of environmental decision making about the South Florida environment are extreme, and the CESU offers the tremendous potential for focusing that scientific support to the decision-making process for South Florida.

One element of the ecological risk assessment framework for focusing this research is the identification of ecological endpoints, as discussed above, and the associated societal and ecological indicators or specific measures to monitor in the environment and society.

One aspect of ecosystem management of the region is using an adaptive management approach, making adjustments to societal policies and water management structures as needed to achieve the ecological goals for the region. South Florida is unique in having had an extremely successful process for identifying environmental goals on a spatially explicit basis, as a major accomplishment of the Florida Governor's Commission for a Sustainable South Florida. The challenge in the ecosystem restoration process is to design systems and policies to meet those goals.

To understand and predict natural resource use decisions, we must also track spatial and temporal patterns for socioeconomic variables such as income, land values, and employment. To appreciate the socioeconomic opportunities and hardships created by natural resource usage, we must track the economic performance and social impacts of important economic sectors such as tourism, agriculture and construction. Without a sense of hierarchy of natural resource uses, policy officials have no idea what to do when conflicts arise. Managing the alternative uses of natural resources would be easier if we had a better idea of the socioeconomic values we hold for all potential uses. Socioeconomics enables us to think more clearly about the values that are being taken into account and others that are not. Historically, values that are difficult to measure have often been ignored in the natural resources policy process. Previously, even when decision-makers were aware of the physical harm or benefit that a policy might have on natural

resources, available economic tools did not enable quantification of the effects. Socioeconomic theory can now address natural resource valuation, and federal laws and regulations in some cases stipulate that such valuations be made.

The members of this study unit are interested in the socioeconomic impacts of human environment interactions on the regional human population with a particular interest in low-income and minority populations. Consequently, the FAMU Environmental Sciences Institute's Center for Environmental Equity and Justice will facilitate the integration of environmental justice issues and concerns, specifically the disproportionate impact of environmental stressors on minority and low-income populations. Specific issues of concern include potential exposures and effects of contaminant stressors from subsistence fishing, migrant farm working, and proximity to pollutant sources. The need for appropriate ecological and socioeconomic indicators is to allow the evaluation of the success or failure as time develops of the restoration process, so that we can make those adaptive management adjustments in order to more closely or more quickly achieve the environmental goals for the region. Again, the CESU offers an exceptional opportunity to develop and test-out in a very applied context such ecological indicators. Finally, we have developed a framework for assessing those indicators and evaluating the progress towards achieving the goals, specifically a socioeconomic/ecosystem health report card framework. Again, through the CESU, this framework can be made specific to the South Florida situation and implemented as an important tool to bring science to bear on decision-making through informing policymakers and other stakeholders of the state of our terrestrial, marine, and coastal environments.

Examples of the specific research areas related to human-environment interactions are:

- Identify use and non-use values for various socioeconomic uses within terrestrial, marine and coastal ecosystems;
- Identify the major anthropogenic influences on the natural and human systems and assess and analyze the types of ecological and socioeconomic impacts generated;
- Identify the structure of the various human communities, focusing on social and economic factors;
- Develop and apply an integrated system modeling for ecological, social, economic and cultural resource system components;
- Characterization of the temporal and spatial distributions of environmental stressors affecting terrestrial, marine, and coastal environments;
- Development of an ecological health report card to characterize the state of the regional environment and assess progress towards achieving environmental goals.

Some important research needs in these forests may be grouped under broad headings:

- Reproductive biology and interspecific competition of invasive exotics
- Forest succession and community dynamics
- Systematics of arthropods
- Population biology and ecology of endangered & threatened species
- Effects of erosional processes on terrestrial, wetland, and marine ecosystems

- Effects of global warming (frequency/intensity of hurricanes to sea level rise)

3.6 Hydrological Issues and Sea Level Rise

Hydrological issues are central to all aspects of the ecosystems in the **SFC-CESU**. The most obvious need for hydrological studies is present in the South Florida Everglades system where the immense Kissimmee-Lake Okeechobee watershed is under severe pressures from a burgeoning population and rising sea-level. Increases in population not only mean a loss of wetlands, but also increases in water demand and pollution. These needs must be balanced by the need to maintain a water system, which is consistent with the natural life cycles of organisms living in the Everglades. Another local research need involves the management of storm water and extreme precipitation events in urban areas of South Florida and Puerto Rico, where rainfall-triggered flooding causes significant life and infrastructure losses year after year.

The quantity and quality of water also is suggested to impact the marine resources. A suggestion has been made that increased nutrients from the agricultural areas and from sewage adversely impacts the reefs by promoting algal growth. Alternatively high salinity waters have been proposed to be detrimental to coral growth.

Many important questions regarding the hydrologic balance in South Florida and Puerto Rico remain undetermined. In many regards these questions are inseparable from other issues which influence the Everglades, the Coral Reefs, and the Estuaries. They are also linked to issues such as sea-level rise and global warming and have consequence on human-environmental interactions. Sea-level has been increasing steadily over the past 100 years and is likely to continue to do so as a result of the long term natural and anthropogenic induced changes in the climate of the Earth. The impact of sea-level changes in **SFC-CESU** region is likely to be great as a result of the marine dominated nature of the region. Low lying areas, such as the South Florida peninsula and coastal areas of Puerto Rico and the Virgin Islands, are particularly susceptible to sea-level change. Concerns associated with sea-level rise include the quality and availability of freshwater, the distribution of plant and animal species, and the nature of the coastline. Global warming models predict an increase in the number and intensity of storms for the tropic and subtropical areas. Coincident with an increase in storm intensity comes a concern of flooding of both inland and coastal regions of the **SFC-CESU**. The problems of sea level rise and global warming are inseparable from issues facing the ecology, hydrology, and human-environment interactions of the **SFC-CESU**.

The main objectives of the CERP plan are to increase surface water flow to the Everglades, while maintaining an adequate water supply for agricultural, commercial and residential uses, at the same time providing flood protection for developed areas. There is an additional issue of diverting freshwater runoff from coastal areas to long-term storage areas for future retrieval (aquifer storage and recovery). Under the CERP plan, ecosystems are competing with human issues for a limited supply of fresh water-the availability of which is dominantly climate controlled. It is important to thoroughly understand the consequences of any proposed changes in the water flow in South Florida. Inappropriate

actions taken to remedy perceived problems may eventually produce other consequences which may have been foreseen given adequate opportunity for research.

Some of the important issues regarding hydrology in South Florida and Puerto Rico are:

- What is the role of groundwater, surface flow, and precipitation in controlling the salinity of the coastal estuaries.
- What is the impact of horizontal surface flow in controlling water budgets in the
- Everglades.
- What will be the impact of the CERP plan on the delivery of water to estuarine
- systems.
- What will be the impact of the CERP plan on present-day wetlands and their
- Ecosystems?
- What are the consequences on regional and coastal hydrology of projected sea-level rise.
- What have been the impacts on habitat loss and coastal hydrology as a result of sea level which has occurred over the past 100 years.
- What is the impact of quantity and quality of freshwater on marine resources such as coral reefs.
- It is important to thoroughly understand the consequences of any proposed changes in the hydrologic balance in South Florida and Puerto Rico.
- What are the interactions between surface and groundwater system that lead to
- flooding, particularly in densely populated areas of South Florida and Puerto Rico?
- What are the major hydrologic pathways for pollutant transport in these hydrologic systems ? What are the pollutant mass balances and the biotic and abiotic transformations these pollutants undergo in surface and groundwater systems?

4. Data and Information Exchange

A web site, which serves as a data repository and information system, provides a central location where information can be efficiently and rapidly disseminated. The data and information system would facilitate communication among experts from partner institutions and federal scientists and managers. The present system is available at the **SFC-CESU** web site (sfc-cesu.com), which enables members from the partner institutions to search a database of request for proposals and prior funded projects. This system should be designed so that information is available via the internet and is easy to access.

5. Program Activities of the South Florida and Caribbean Cooperative Ecosystem Studies Unit

To complement the research and technical assistance activities of the CESU, programs will be established to encourage education of students and federal managers and scientists, and to facilitate information exchange.

Education

SFC-CESU will develop student fellowships and faculty mentors for undergraduate and graduate students associated with CESU projects. The goals are four-fold:

- Establish a talented and diverse pool of undergraduate and graduate student candidates from within each partner institution for CESU research.
- Obtain stipend support for students involved in CESU lab and field research.
- Obtain stipend support for faculty research mentors at the partner institutions.
- Conversion of research experience into academic credits to be used toward
- graduation.

The development of this talent pool will require attention paid to:

- Recruitment. SCF-CESU will establish methods for on-campus advertisement of research opportunities, including traditional communication networks (flyers, mailers, brochures), web-site information, and faculty contact with students in the classroom. Biology, chemistry, and physics classes in upper-level undergraduate programs, as well as classes in graduate programs are generally low enough in enrollment that effective faculty-student contact can be established. In addition, students enrolled within interdisciplinary coursework (e.g., environmental law, microeconomics) may be easily identified and contacted.
- Selection. Partner Institutions will develop selection criteria, including course grades (GPA), class rankings, knowledge of (and interest in) environmental research, previous research experience, subjective faculty evaluation, and financial need.
- Monitoring. Students placed in SFC-CSEU research projects will require close monitoring by faculty mentors. Undergraduate researchers, in particular, will generally participate in **SFC-CESU** projects during summer months. This is a time when faculty and advisors at many partner institutions tend to be off their academic-year contracts.
- Academic Credits. The number of academic credit hours earned will be based upon number of field and lab hours completed on a project. For example, a conversion might be made of roughly one credit hour for every 100 hours of lab field effort over an eight-week summer experience (roughly 300 hours converted to three undergraduate credit-hours toward graduation. Graduate credit hours will follow traditional accounting methods already in place within graduate programs at the partner institutions.
- Assessment. The outcome for each student's experience in the **SFC-CESU** research will be assessed in several ways. At the conclusion of the research period, the research supervisor will write a letter of evaluation to the academic advisor at the partner institution, and the supervisor will assign a letter grade. In turn, each student will complete a written evaluation of the particular research experience, research supervisor, and faculty mentor.

Federal Resource Managers and Scientists

SFC-CESU will establish an educational exchange program that allows faculty mentors at partner institutions to learn about procedure, management, budget planning, and decision-

making policies within appropriate federal agencies. In reciprocity, the partner institutions will establish part-time (adjunct) teaching opportunities for federal managers within selected academic courses. This reciprocity will allow federal agencies to train academic researchers in the ways of government policy and bureaucracy, while the federal employees will learn the traditional methods of college teaching.

- Distance Learning: Opportunities for distance learning will be available.
- Workshops: Workshops will be held to address immediate management issues, to frame research projects and to provide educational opportunities.
- White Papers: White papers on CESU programs and activities will be published.
- Web Presence: An internet website has been established to facilitate communication between CESU partners. Funding opportunities, proceedings, workshops, white papers and project proposals will be available on this site.