FAU CLIMATE CHANGE INITIATIVE PRIORITY THEME:

RESEARCH, ENGINEERING, AND ADAPTATION TO A CHANGING CLIMATE

"I am persuaded that global climate change is one of the most important issues that we will face this century…" Florida Governor Charlie Crist

"Let me state what the official IPCC prediction is: It (sea levels) could go up as much as three-quarters of a meter in this century, but there is a reasonable probability it could be much higher than that." "A rise in levels of one meter, coastal areas around Florida around Louisiana would move much farther inland" "Lots of areas in Florida will go under…" U.S. Secretary of Energy Dr. Steven Chu

"Ocean acidification, along with thermal heating of the oceans from climate change, is the most important threat to fisheries worldwide" U.S. National Oceanographic and Atmospheric Administration (NOAA) chief scientist Dr. Jane Lubchenco

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ADCP - Acoustic Doppler Current Profiling
ArcGIS – Arc Geographic Information System
CAUPA - FAU College of Architecture, Urban and Public Affairs
CEDD - Council of Environmental Deans and Directors
CES - Center for Environmental Studies
CIMAS - Cooperative Institute of Marine and Atmospheric Science
CIOERT - Cooperative Institute of Ocean Exploration, Research and Technology
COE - FAU College of Education
COET - Coastal Ocean Energy Technology
CTD - Conductivity, Temperature, Density Sensor
DOI - US Department of the Interior
DWBC - Deep Western Boundary Current
EM - Electromagnetic
FACE - Florida Area Coastal Environment
FDOT - Florida Department of Transportation
FGCU - Florida Gulf Coast University
FIU - Florida International University
FVLS - Florida Virtual Schools
GIS - Geographic Information System
HBOI - Harbor Branch Oceanographic institute
HEC-RAS - Hydrologic Engineering Center- River Analysis System
IPCC - Intergovernmental Panel on Climate Change
IRL - Indian River Lagoon
LABEES - FAU Laboratories for Engineered Environmental Soultions
LIDAR - Light Detection and Ranging
MAPCO2 – CO_2 Mapping/Monitoring System
NASA - National Aeronautics and Space Administration
NCSE - National Council for Science and the Environment
NOAA - National Oceanic and Atmospheric Administration
PMEL - Pacific Marine Environmental Lab
NPS - National Park Service
OA - Ocean Acidification
PAM - Passive Acoustic Monitoring
RSMAS - Rosenstiel School of Marine and Atmospheric Science (University of Miami)
SASMAE - Situationally Adapted Simulations for Mitigation and Adaptation Education
SeaTech - Institute for Ocean and Systems Engineering (FAU)
SEAWAT - Program Simulation of Three-Dimensional Variable-Density Ground-Water Flow
SFWMD - South Florida Water Management District
SLR - Sea level rise
TOC - Thermohaline Overturning Circulation
UM - University of Miami
USACE - United States Army Corps of Engineers
USFWS - United States Fish and Wildlife Service
USGS - United States Geological Service
WRAC - Water Resources Advisory Committee

EXECUTIVE SUMMARY

Globally, sea level rise has the potential to impact two billion people living along coastlines. In South Florida, sea level rise is already a threat to coastal infrastructure and will continue to require new engineering solutions. Research universities, particularly those with strengths in hydrology, engineering, and ocean sciences, will play a major role in human adaptation to a rapidly changing climate; FAU can be one of these institutions with its current interdisciplinary climate change research. FAU's premier engineering program provides opportunities to develop and apply new technologies to ascertain climate change impacts and develop solutions to assist in adaptation. FAU Civil Engineers are on the front lines of developing sea level rise adaptation strategies for water utilities and counties in South Florida. Faculty in the Geosciences Department are developing models and applying GIS to assess sea level rise and saltwater intrusion into South Florida's aquifer, and measuring greenhouse gas fluxes from wetlands. The College of Architecture, Urban and Public Affairs is running models to evaluate/visualize sea level rise impacts to urban populations for planning. Harbor Branch Oceanographic Institution (HBOI) and SeaTech are developing new tools to assess ocean acidification on marine ecosystems and acoustics for the U.S. Navy. Biologists from the College of Science and HBOI are using genetics, ecological models and molecular indicators of stress to identify thresholds of ecosystems and species resilience to climate change. FAU is developing climate change curriculum (K-graduate) applying unique computer gaming approaches. These examples highlight the depth and breadth of expertise and research at FAU addressing climate change, which if coalesced into a collaborative program, would put FAU on the map for climate change research and education. FAU climate change program is organized into three themes: Human System Problem Assessment and Sustainability through Re-Engineering and Adaptation, Natural System Assessment and Education and Outreach.

I. RESEARCH PROPOSAL

1.0 BACKGROUND AND SIGNIFICANCE

There is a new saying in water management: "stationarity is dead" (Milly et al., 2008; Obeysekera, 2009)! While engineers over the last century have planned for extreme flood or drought events, they have relied on the frequency and intensity of weather events and fluctuations to be somewhat predictable. So, what has changed? If we consider South Florida's climate as a ball in a tea cup, its variance is explained by the ball rolling around within a defined, moderately predictable boundary-the edge of the cup. If the ball is pushed too far, it can spill into an adjacent cup with a different set of boundaries. If the Earth's climate shifts, people will find that adaption to climatic changes requires new resource management, urban planning strategies, and other challenges not currently being considered.

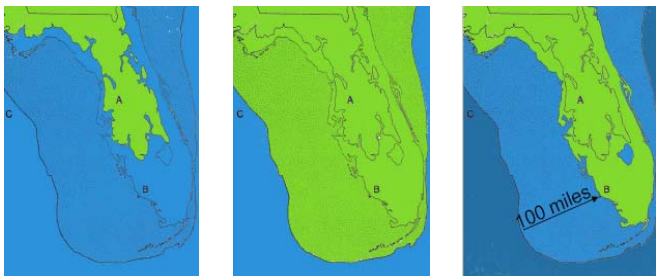


Figure 1. Florida sea levels at 120,000 and 18,000 years before present (ybp) and 2010.

The Earth's climate cycle has been fairly consistent over the past several hundred thousand years with approximately 100,000 year periodic cycles linked to orbital shifts of the Earth (Hays et al., 1976). During these cycles, the formation or thaw of polar ice sheets in response to global climate trends has lowered or raised the oceans by hundreds of meters, exerting a dramatic influence on the size of the Florida peninsula (Fig. 1). Furthermore, geologic records indicate sea level rise is non-linear, meaning abrupt changes are the norm rather than the exception (NAS, 2002). While ice dynamics are currently not well understood, there is evidence the global rate of sea level rise is accelerating (3.36 ± 0.41 mm/yr from 1993 to 2007; Beckley et al., 2007), primarily resulting from ocean expansion due to thermal heating (Domingues et al., 2008). Melting of the ice sheets may further increase these rates, placing coastal regions in jeopardy in a warming climate.

The current trends of increasing atmospheric carbon dioxide (CO_2) concentrations are unprecedented in the geologic or measurement record (Fig. 2). The accumulation of CO_2 and other greenhouse gases in the Earth's atmosphere has the potential to significantly alter global climate patterns of temperature and precipitation as well as regional weather events like hurricanes, flooding, and drought (IPCC 2008). Increased atmospheric CO_2 concentrations also result in greater sequestration of CO_2 by the oceans (approximately 30%, Feely et al. 2004, Millero 2007; Tyrell 2007). This is currently driving down ocean pH resulting in "ocean acidification" (Schulz et al. 2009). Low ocean pH influences the availability of calcium carbonate ($CaCO_3$) with adverse effects on marine organisms that utilize $CaCO_3$ for skeletal development. Acidification also affects ocean acoustics with potential consequences for marine mammal communication and navigation, as well as for the U.S. Navy's sonar program. As noted by Fabry et al. (2008) and others, present levels of atmospheric CO_2 concentration are rising at a rate of approximately 0.5% per year, 100 times faster than any other rate of change in the past 650,000 years and at this rate may exceed the ability of ocean sediments to neutralize the acidification process.

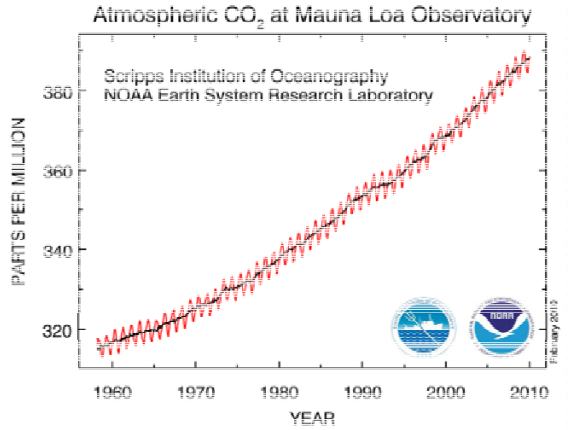


Figure 2. Carbon dioxide (CO_2) levels over time, including long-term trends and seasonality.

Recent research also suggests climate change will induce shifts in precipitation patterns and tropical storm frequency and intensity (Emanuel, 2007; Karl et al. 2009; USCCSP, 2009). Current projections for the South Florida region estimate the climate will be drier overall, but with more intense precipitation

events, potentially leading to episodic flooding. Tropical storms are also predicted to be less frequent, as a result of high altitude wind shear (Vecchi1 and Soden, 2007), but may have greater intensity due to increased ocean temperatures. Greater intensity storms will result in storm surges that would likely cause flooding, salinisation of aquifers and/or erosion in low-lying, hurricane-prone regions such as southern Florida (Heimlich et al., 2009).

Sea level rise has the potential to impact two billion people globally or 30% of the human population that live along coastlines. In South Florida, sea level rise has already been identified as a threat to coastal infrastructure and will continue to require new engineering solutions (Heimlich et al., 2009). Already few canal structures need re-engineering due to current sea level change and additional structures are going to be at risk over the next two decades (Obeysekera, 2010); pump stations will have to be installed to replace gravity-driven weirs bringing new regulatory, management, and engineering challenges. Research universities, particularly those with strengths in hydrology, engineering, and ocean sciences, can play a major role in human adaptation to a rapidly changing climate; FAU can be one of these institutions.

2.0 FAU'S CLIMATE CHANGE RESEARCH PROGRAM GOALS AND SPECIFIC AIMS

FAU's climate change research program has seven overarching goals under the rubric of outreach and technology development:.

- To achieve our outreach goal the aims are to: (1) synthesize current information on climate change impacts to natural systems and human-dominated built environments, (2) organize forums for communicating synthesized data, (3) develop collaborative relationships amongst governmental, non-governmental, business and academic organizations to set climate change research priorities based on consensus, and finally, (4) develop natural system and human-dominated environment adaptation solutions that can be applied at the local, regional and international level.
- To achieve our research and technology goal we start with the tenant that new technologies will have to be developed to monitor, assess and provide creative solutions to climate change impacts over the next few decades. Our aim will be to develop the infrastructure to (1) apply FAU strengths in engineering, geosciences and biological technology, as well as social and economic research strengths, to assess climate change impacts, including sea level rise and ocean acidification, (2) provide new science, engineering and planning solutions to assist in adaptation to climate change with economic considerations, and (3) apply urban planning and social sciences to assess human impacts and responses to a changing climate and to guide policymakers to ensure the future sustainability of South Florida.

3.0 FAU RESEARCH OPPORTUNITIES AND UNIQUE CAPABILITIES

The most recent textbook on climate change (Bloom, 2010) allocates 11 chapters and 336 pages to the reasons for climate change and mitigation strategies and one chapter and 12 pages to the human response to unavoidable consequences of climate change. Yet here in South Florida, in low-lying countries such as Bangladash, and in many small-island states a primary concern must be adaptation. In order for humans to adapt to a changing climate, we need to understand the science, through monitoring and research, and be able to plan and implement strategies using contemporary research and planning tools. Finally, the adaptation process needs to be iterative in an adaptive management framework as the science is better understood. This requires coordination and collaboration amongst scientists, planners, economists and engineers; we also need to include stakeholders such as the business community, governments, non-government agencies, and the public on adaptation strategies and planning.

FAU's current climate change research program is interdisciplinary, spanning disciplines as diverse as engineering, molecular biology and urban planning. Thus, this contemporary research topic is scripted for FAU's initiative to find a few overarching interdisciplinary themes for research initiatives. FAU's premier engineering program provides immense opportunities to apply new technologies to ascertain climate change impacts, as well as develop solutions and new technologies to assist in climate change adaptation. For example, Engineers in the Civil Engineering Department are on the front lines of assessing impacts and developing sea level rise adaptation strategies for water utilities in South Florida. Faculty in the Geosciences Department are developing models and applying GIS to assess sea level rise,

greenhouse gas fluxes from wetlands, and potential saltwater intrusion into South Florida's aquifer. The College of Architecture, Urban and Public Affairs are applying GIS and running model scenarios to evaluate sea level rise impacts on urban populations and addressing design needs for resilient buildings and infrastructure. Biologists from the College of Science and HBOI are using genetics, ecological models and molecular indicators of stress to identify thresholds of species, populations and ecosystems, including tolerances of important species, such as sea turtles and marine mammals, to climate change impacts. HBOI and SeaTech are developing new tools to assess ocean acidification on corals and marine mammals, as well as effects on U.S. Naval communications; they and their collaborators are on the cutting edge of this research on an international level. Archaeologists in the College of Arts and Letters are developing paleoclimate models to evaluate the long-term impact of climate change on ancient societies. Several FAU departments are also offering and developing education courses on climate change (K-graduate), including unique computer gaming approaches. A major focus is also education of the business community.

These examples highlight the depth and breadth of expertise and ongoing research projects at FAU addressing climate change impacts, which if coalesced into a collaborative and cohesive program, through modest FAU funding, could put FAU on the map for climate change research and bring in substantial funding to the University across several colleges. Finally, and perhaps most importantly, FAU could assist the South Florida population in its efforts to adapt to a changing climate. This would be a long-term commitment, but a critically important research and outreach opportunity.

4.0 BUILDING SYNERGIES BY DEVELOPING PARTNERSHIPS

Internal Collaborations - FAU has several research initiatives that would be enhanced as part of a climate change program and vice versa: (1) College of Engineering's Coastal Ocean Energy Technology (COET) program, (2) UM-FAU partnership in the Cooperative Institute of Marine and Atmospheric Science (CIMAS; pending), (3) College of Engineering's Ocean upwelling, Sewage Outfall, Water Quality program (FACE), (4) Harbor Branch Oceanographic Institution's Cooperative Institute of Ocean Exploration, Research and Technology (CIOERT), (5) College of Science's Environmental Science Program, (6) College of Engineering and Computer Science's Institute for Ocean and Systems Engineering (SeaTech), (7) College of Science's Center for Environmental Studies (CES), (8) College of Architecture, Urban and Public Affairs' Urban and Regional Planning Visual Planning Technology Lab, (9) The College of Science's Center for Geo-Information Science. (10) College of Business's Executive Programs Center.

External Collaborations - Most research institutions, both academic and governmental, are gearing up for climate change research by developing new centers or refocusing current research efforts. The governmental institutions are looking for academic partners; FAU is in discussions with USGS to establish a climate change center at FAU. We have partnerships with Florida Sea Grant, USGS, USACE, USFWS, NPS, NOAA, FIU, UM, FGCU and SFWMD on issues of climate change and have jointly hosted climate change workshops. We have worked with the Southeast Florida regional Climate Change Compact (Monroe, Dade, Broward and Palm Beach counties) and the Florida Institute of Public Health on climate change issues. FAU (CES) is also working closely with the National Council for Science and the Environment to develop national climate change curriculum at the undergraduate and graduate level.

FAU faculty in six colleges with their internal and external collaborators have unique expertise that, if coordinated and strategically developed, could contribute significantly to climate change research at the local, national and international level. Based on our collective expertise, the proposed climate change research program is organized into three primary themes: (1) Human System Problem Assessment and Sustainability through Re-Engineering and Adaptation, (2) Natural System Assessment and Technology Development, and (3) Climate Change Coordination, Education (K-Graduate) and Outreach. These three themes are detailed in the following section.

5.0 PROPOSED AND ONGOING CLIMATE CHANGE RESEARCH

THEME #1:
HUMAN SYSTEM PROBLEM ASSESSMENT AND SUSTAINABILITY- RE-ENGINEERING AND ADAPTATION

Topic 1: Integrated Hydrological Model Development for Risk Assessment of Climate Change

Project Team: *L. Berry, F. Bloetscher, B. Heimlich, H. Kalva, J. Restrepo, and R. Shankar (External: SFWMD, Miami-Dade County Climate Change Task Force, National Park Service).*

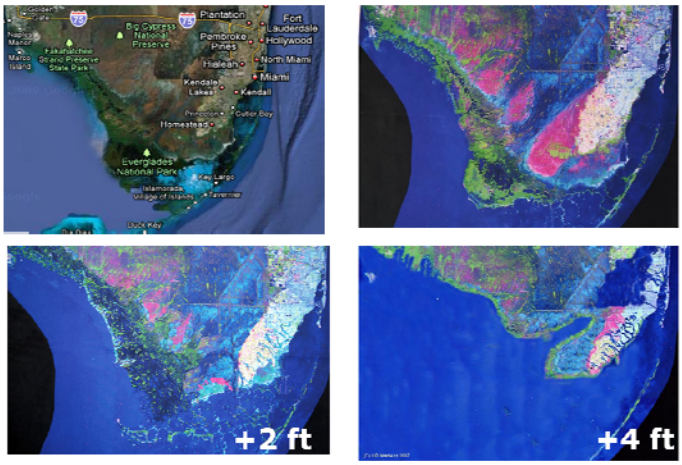


Figure 3. Impact of Sea Level Rise on Southern Florida.

Research Needs and Priorities: Based on current climate change data and projections, the low-lying South Florida Peninsula is one of the most vulnerable developed regions around the world (Fig. 3). Major human populations, vast economic assets, and natural resources of national significance, including the Everglades, are at risk. Of major concern is the impact of climate change on the hydrologic infrastructure of Southeast Florida with a population of approximately 5.4 million (Heimlich et al. 2009).

Research Proposed and Ongoing: The proposed modeling and risk assessment project will advance the science related to the hydrological consequences of climate change in SE Florida in collaboration with regional water agencies. The project seeks to: a) more accurately determine the extent and rate at which projected effects of climate change impacts on water resources will occur using integrated hydrologic models, and b) project the effects of sea level rise on flooding during heavy rainfall events through the development and application of integrated hydrological models and topographical mapping. The project will estimate reliable water budgets for representative areas of the region, developing a robust methodology for estimating water budget components that cannot be fully measured directly. For this purpose, a coupled density dependent flow, SEAWAT2005 (2010) and a surface water routing model, (e.g., Surface-Water Routing (SWR1) Package (2010) or HEC-RAS (2000)) are proposed to investigate the surface and groundwater flow to tide and the effects due to the rise of seawater level. The results of the project will provide a framework for guiding adaptation programs of climate change task forces established in Broward and Miami-Dade Counties and other local, state, and federal agencies.

Topic 2: Water Resources, Utilities and Flood Protection/Supply under a Changing Climate

Project Team*: F. Bloetscher, B. Heimlich, J. Jolley, D. Meeroff, T. Root, P. Scarlatos, and R. Teegavarapu (External: SFWMD, USGS,USACE, University of Miami, Florida Gulf Coast University, Colombia University, Florida Public Health Institute, Broward and Miami-Dade Counties).*

Research Needs and Priorities*:* Sea level rise will diminish the amount of soil storage capacity, which will directly impact the amount of rainfall that filters into the soil (Fig. 4). As a result, flooding will worsen as sea level rises. Rainy season precipitation will cause more frequent flooding since the stormwater system will have limited ability to move water to the sea or evaporate. Hence, more pump stations will be required. Another question is where to discharge the stormwater so that water quality and environmental impacts are minimized. Additional water will be needed during the dry season to retard saltwater intrusion in the open coastal aquifer and migration of saltwater in the lower Everglades as a result of sea level rise. Extra pumping will be needed in the wet season to limit flooding, with no current storage to accept it. The cost of hydrological infrastructure adaptation is a concern and needs to be addressed. There are also water

quality and contamination issues with flooding of landfills and the release of other anthropogenic contaminants.

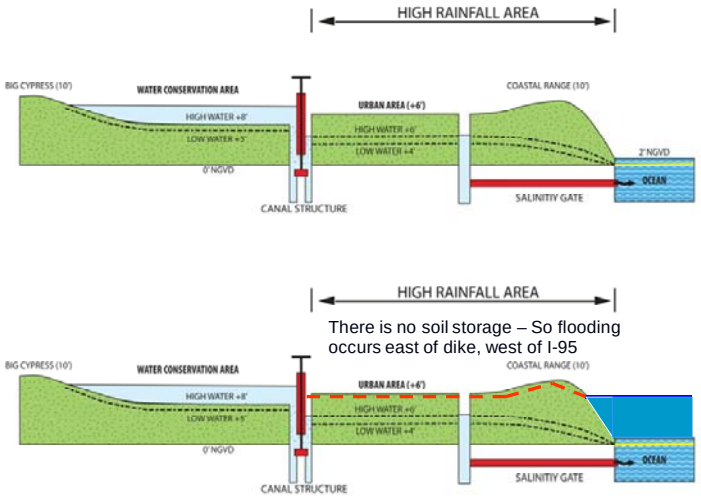


Figure 4. Soil water storage capacity loss with sea level rise in South Florida in cross section.

Proposed and Ongoing Research: Heimlich *et al.* (2009) assessed climate change impacts on local water utilities and other infrastructure. This was an engineering evaluation of the SE Florida area defining the general geophysical and hydrologic characteristics aided by the use of USGS-based groundwater modeling of NE Broward County (Zygnerski & Langevin, 2007; Zygnerski, 2008). In longer term projections, the complexities of the surface/groundwater interface were evaluated. The next step was an evaluation of the utility's vulnerabilities to climate change. The adaptation plan included an assessment of specific threats, potential solutions/tools to counter threats, and prioritization of engineering alternatives. Potential adaptation strategies are presented within the context of the existing regulatory and planning framework. Ultimately, adaptation solutions will involve strategies to protect and supplement existing infrastructure (i.e. water distribution networks, sewer collection systems, wellfields, pumping stations, etc.). Increased costs associated with alternative water sources, adaptation strategies, infrastructure development and significant increases in energy and water usage are a major concern. Sea level rise may diminish the ability of the drainage systems and coastal flood control structures in Miami-Dade, Broward, and Palm Beach Counties to control flooding (Obeysekera, 2009; Heimlich, *et al*., 2009). When sea level rises so that there is no difference in levels across a sluice gate, water can no longer be released to tide. Regional decision tools are needed since no local community can effectively mitigate the impact of sea level rise. The goal is to achieve a long-term program that allows currently limited financial resources to be spent for purposes that support the longer term water supply goals without compromising South Florida's standard of living. The project team and collaborators have the skills to merge groundwater, surface water and natural systems modeling results and engineering into solutions for decision makers.

Topic 3: Adaptation for Transportation Infrastructure

Project Team*: F. Bloetscher, G. Carvalho, B. Heimlich, E. Kaisar, D. Meeroff, D. Mitsova-Boneva, J. Murley, J. Rodriguez, P. Scarlatos, R. Teegavarapu, and J. Vos (External: FDOT and SFWMD).*

Research Needs and Priorities*:* Flood control, water supply, stormwater and transportation are inter-related. Transportation managers need 1) a comprehensive listing of infrastructure vulnerable to sea level rise and 2) development and implementation of strategies to improve transportation infrastructure resiliency to adverse impacts of climate change. If sea level rises, the streets and surrounding property would be affected by flooding, as houses are typically built on pads, while adjacent streets are lower in elevation. Heavy rainfall on the interstate highway system will create flooding in low areas and may need to be elevated.

Proposed and Ongoing Research*:* FAU has initiated efforts toward evaluation of the climate change impacts to transportation including roadways, railroads and airports. To determine the likelihood of flooding and stormwater impacts, topographic mapping, stormwater routing and transportation data bases must be merged. One method to help with the topographic data is LIDAR. The acquisition of LIDAR mapping data and placement on ArcGIS or other medium is easily accomplished and would be a major part of the evaluation. This tool can be used to model impacts of rising water on transportation infrastructure and evaluate the need to insure transportation systems function.

Topic 4: Coastal Urban Societal Response and Adaptation to Climate Change

***Project Team*:** *R. Alvarez, F. Bloetscher, D. Mitsova-Boneva, D.V. Reddy, and J. Voss (External: FIU).*

***Research Needs and Priorities*:** South Florida is a highly-developed urban coastal region generating economic activity equal to 75% of the state's annual GDP (ECACWF, 2009) and has >$2 trillion in infrastructure. Using data from the U.S. Census Bureau, Bureau of Economic Analysis, and from Enterprise Florida (eFlorida.com) we project growth for Florida's urban coastal region as follows:

URBAN COASTAL FLORIDA PROJECTED GROWTH			
	2008	**2020**	**2030**
Total population/region	16.6 million	21.1 million	25.8 million
Total GDP/region	$558.0 billion	$710.0 billion	$900.0 billion
Replacement value/Built environment	$2.0 trillion	$2.5 trillion	$3.1 trillion

It is clear that adaptation and hazard mitigation measures must be identified and implemented to avoid damages from climate change impacts to the human ecosystem.

***Proposed and Ongoing Research*:** We propose to develop methodology for assessing and characterizing the impact of climate change, or climate change exacerbated hazards, on the built environment including: (1) assessing damage on individual buildings, structures, facilities, infrastructure etc., (2) designing criteria to adapt existing and new buildings during their remaining or anticipated service life, (3) incorporating adaptation design criteria into building codes and standards, (4) developing vulnerability assessment on a regional scale, (5) establishing the "Value at Risk" from climate change impacts, (6) establishing policy alternatives for local governments based on impact scenarios and risk assessment, (7) pursuing urban adaptation to climate change through urban planning options, (8) incorporating climate change adaptation in the comprehensive planning process, and (9) developing engineering/technological approaches for the long-term protection of coastal communities against the impact of climate change e.g., barriers to sea level rise.

Topic 5: Adaptation through Coastal and Marine Spatial Planning

Project Team*: R. Alvarez, M. Escaleras, A. Esnard, F. McAfee, D. Mitsova-Boneva, J. Murley, J. Vos, P. Widener, Z. Xie and C. Yang (External: USGS and FIU).*

Research Needs and Priorities*:* The resilience of coastal areas to the impacts of climate change has been predicated to a large extent on the success or failure of policy commitments and actions/inactions regarding coastal development. Decision-making related to adaptive responses to climate change must address current and future development patterns, land use, the performance and safety of all types of coastal infrastructure, including disaster-prevention facilities, waterworks and power-generating facilities, drainage and sewerage systems, harbors, landfills, transportation, and other forms of public infrastructure (Mimura and Harasawa 2000).

Proposed and Ongoing Research: We propose to develop a conceptual framework for adaptive response to climate change impacts in coastal areas with a focus on the built environment of South Florida. The framework will comprise the following three subcomponents: 1) geodatabase consisting of data layers and policy instruments layers, 2) vulnerability assessment, and 3) scenario development modules. Adaptation requires knowledge of vulnerable areas and sectors, ability to design strategies aimed at moderating the impacts, and capability to increase the adaptive capacity of coastal communities (Mimura and Harasawa 2000). The research will enhance the ability of local communities and regional planning systems to address environmental and socio-economic aspects of climate change and find appropriate adaptation scenarios. The project has three objectives: (1) Develop a conceptual framework that would enable regional authorities, local governments, planning agencies, and citizens to understand complex issues related to climate change impacts and explore the consequences of alternative actions using multidisciplinary knowledge and experience. (2) Integrate state-of-the-art models, knowledge database and visualization capabilities to facilitate the dialogue among agencies and stakeholders. (3) Support and facilitate community participation, outreach and education regarding climate change issues and actions.

THEME #2:
NATURAL SYSTEM ASSESSMENT AND TECHNOLOGY DEVELOPMENT

Topic 1: Carbon Cycling and Sea Level Rise in Peatlands and Coastal Stability

Project Team*: B. Benscoter, X. Comas, M. Koch, and Z. Xie*

Research Needs and Priorities*:* Although peat-forming wetlands like the Everglades or high latitude boreal peatlands occupy less than 3% of Earth's land surface, they comprise a third of the global terrestrial carbon (C) pool (Gorham 1991). Currently, these wetlands are net C sinks, taking up CO_2 and producing peat which increases the magnitude of the terrestrial carbon pool. However, the thin margin between carbon uptake and release is vulnerable to environmental and climatic changes. Furthermore, wetlands are a source of biogenic greenhouse gases, particularly methane, have the potential to accelerate climate shifts. Most studies investigating wetland C cycling dynamics have focused on boreal ecosystems, while high uncertainty remains for sub-tropical and tropical peatlands with estimated C stores ranging between 1% to 32% of total C in the atmosphere (Hooijer et al., 2006). In coastal Florida and other low-lying coastal wetlands, peat stability will also be a major factor in modeling net sea level rise locally.

Proposed and Ongoing Research*:* We intend to investigate C cycle dynamics in peat soils of the Everglades and coastal Florida. We will investigate the role of environmental variables (e.g., water table elevation, atmospheric pressure, climate change, sea level rise, wildfire, urbanization/land development) on wetland C cycling. We will utilize an array of monitoring instruments and techniques (e.g., ground-penetrating radar, infra-red gas analysis systems, etc.) to estimate biogenic C gas flux and C storage. Radiotracer-isotopic methods and soil and water sampling will be used to investigate biogeochemical cycles and estimate how biochemical gradients influence biogenic gas production and emissions. A variety of other observational and experimental research tools, including vegetation mapping, ecosystem manipulation, hydrologic and micrometeorological monitoring and alteration, satellite and aircraft-based remote sensing, and GIS models will be used to enhance our understanding of peat wetland function. This work will assist in developing tropical peat research in the context of disturbance ecology, ecosystem resilience thresholds and global nutrient cycling. Applied management tools will be developed to guide resource management decisions and ecosystem preservation and restoration efforts in these systems including the Everglades.

Topic 2: Coastal and Ocean Ecosystem Responses to Increased *p*CO_2 (Ocean Acidification: OA)

Project Team*: F. Dalgeish, M. Dhanak, G. Frisk, E. Gerstein, D. Hanisak, M. Koch, J. Reed, S. Pomponi, J. Voss, and X. Zhang (External: CIOERT Partners, Scripps, NOVA, UH, NOAA, US Navy)*

Research Needs and Priorities: CO_2 is accumulating in the atmosphere from pre-industrial concentrations of 200-280 ppm to current levels of 385 ppm; it is well-known that the world's oceans are a major sink (30%) for this atmospheric CO_2 (Feely et al. 2004). As more CO_2 enters the oceans, pH and carbonate ion concentrations decrease termed "ocean acidification" or OA (Schulz et al. 2009), resulting in changes to the ocean chemistry with biological impacts and influences on ocean water acoustics.

Proposed and Ongoing Research*:*

Characterization of the electromagnetic fields in the coastal ocean environment - SeaTech: Waves, currents and thermal distributions in the water column lead to anomalies in the electromagnetic (EM) fields in the coastal environment. Changes in the coastal oceanography associated with climate change will have an impact on the EM field characterization. EM signatures have importance for the security of Navy ships and submarines. In a pending Office of Naval Research project, in collaboration with the Navy and Nova Southeastern University, physical features of the coastal oceanography off South FL and their impact on the coastal EM field will be evaluated using AUVs, buoys and fixed sensor systems.

Ocean Acidification Instrumentation Development

Coral Reef Ecosystem Instruments - CIOERT- Coral reef ecosystems are one of the most vulnerable to OA but the most complex to understand in terms of biotic/seawater interactions. Large biomass of organisms on/within coral reefs respire (adding to localized OA), photosynthesize (potentially counteracting OA), and calcify at various rates in various sub-habitats creating complex interactions on a

daily basis; thus, instruments needed to study effects of OA on coral reef systems have different specifications than those needed for oceanic studies. For both reef and oceanic ecosystems, an integrated, autonomous instrument package is needed that measures at least two of the seawater carbonate parameters. HBOI, as part of the CIOERT initiative, is hosting a 3-day workshop to critically review the instrumentation needs and specifications of various types of OA instrumentation for coral reefs, strengths and weaknesses of existing technologies, on-going developments, and funding needs which allow integration into an instrument suite applicable to mid to long-term deployments.

Field CO_2 robotics development and OA monitoring initiative-HBOI/SeaTech - The proposed program will deploy a network of twelve wave-propelled, mobile, autonomous, and persistent unmanned marine vehicles equipped with NOAA Pacific Marine Environmental Laboratory MAPCO2 and Scripps Institute of Oceanography pH sensing payloads to conduct a year-long survey of a 13,000,000 sq-nmi region of the southern Pacific Ocean. This project addresses a severe paucity of the CO_2 and ocean pH observations that are needed to support global climate change and ocean acidification modeling and prediction efforts. The data collected during this project will enable advances in ocean carbon cycle science that will significantly improve our understanding of oceanic carbon dioxide uptake and release and OA processes. The project has broad implications for global climate change policy formulation and impacts upon social and economic activities (fisheries, tourism, etc.) and infrastructures. The Wave Glider CO_2 and OA (WG CO2/OA) Observation Program will be conducted under the program sponsorship and operational guidance of the NOAA PMEL, University of Hawaii, and Harbor Branch/Florida Atlantic University.

Marine Acoustics Monitoring-SeaTech/COS - In recent years, strandings of marine mammals and the association of these events with elevated ocean noise have become topics of concern. OA may lead to decreased acoustic absorption and therefore to increases in ambient noise levels associated with distant shipping. It is therefore critical to establish an OA project assessing ocean noise levels and their effects on marine mammals.

Ocean Acidification affects on Deep and Shallow Reefs - A major research focus in the CIOERT is in situ and mesocosm experiments to examine OA on reefs. Deep-water corals may be one of the first marine organisms affected by OA due to the faster shrinking of the aragonite (calcium carbonate) saturation zone. Few experimental studies have ever been made on deep-water coral to test this hypothesis. HBOI scientists have studied deep water corals for decades and are uniquely positioned to expand this research to OA.

Ocean Acidification on Marine Plants (seagrass and macroalgae) - The resilience and potential consequences of lowered ocean pH and the interaction of higher ocean temperature is being examined on coral reef algae and seagrass at the FAU Marine Lab. A mesocosm system has been constructed to manipulate both pH (by injecting CO_2 into seawater with high precision controllers) and temperature (by using aquaria heaters with thermostats). The principle aim of these studies is to investigate thermal stress tolerance and the effects of OA on tropical macroalgae (coralline and fleshy) and seagrass. Changes in temperature and the partial pressure of CO_2 in marine waters have the potential to fundamentally change the plant community (and potentially coral) dominance in marine ecosystems.

Topic 3: Coastal Monitoring and Ocean Technology Development

Project Team*: E. An, P. Ananthakrishnan, L. Berry, F. Bloetscher, F. Dalgeish, M. Dhanak, K. von Ellenrieder, G. Frisk, D. Meeroff, S. Pomponi, S. Schock, J. Reed and (External: RSMAS, CIOERT).*

Research Needs and Priorities*:* FAU has the opportunity to take advantage of its strategic location along the SE coast of Florida and become more active in the monitoring of physical, biological and chemical aspects of the near-shore environment and Gulfstream Large Marine Ecosystem. There is also a need to more accurately determine the rate of sea level rise for local coastal areas along the SE FL coastline to assist managing risk. There is also a high priority need to understand Gulf Stream processes related to global climate change and interactions with the FL coast. The Gulf Stream represents both the western boundary current for the subtropical wind-driven flow and return pathway for the convective Thermohaline Overturning Cell (TOC), a slow circulation that redistributes the waters of the world's oceans. The TOC has been documented to have strong impacts on the global climate, so variability of the

Gulf Stream represents an important climate signal to be monitored. The straits between South Florida and the Bahamas define a choke point for the Gulf Stream, providing a unique opportunity at SeaTech to study its transport and evaluate its effect on the North Atlantic Circulation. The lower limb of the TOC is typically referred to as the deep western boundary current (DWBC). Off Florida's east coast, the DWBC has been observed east of Abaco Island (Meinen, et al. 2006) in waters deeper than 800 m. In the shallower waters in the Straits of Florida, these waters manifest as upwelling and as convection of upwelled waters at lower latitudes. Numerical models (Drijfhout et al., 2008) suggest enhanced greenhouse effects would lead to weaker and shallower TOC with reduced internal variability. In a warmer ocean, new regions of deepwater formation form further north due to the poleward retreat of the sea-ice boundary and DWBC would become evident in sub-tropical waters in shallower regions, in depths less than 800m, becoming apparent in the Straits of Florida. These changes would likely have impacts on the Gulf Stream waters and associated ecosystems and an important indicator of climate change.

Ongoing and Proposed Research:

Variability in the Gulf Stream and Deep Western Boundary Current Transport due to Climate Change – We propose long-term monitoring and process studies of the Gulf Stream. These includes assessing its dynamics and variability, including transport as a climate and circulation index, linking currents, temperature and salinity to ongoing NOAA observations east of Abaco Island along 26.5^{o}N. To provide a global picture of the TOC, we would install a cable across the straits between South Florida and the Bahamas that would allow plugging in instruments, such as bottom mounted ADCPs and moored CTD arrays. We would then set up transceivers on both sides of the straits and consider scintillation-type measurements to determine Gulf Stream transport. The proposed process studies include interactions between the Gulf Stream and the coastal zone e.g., the effect of onshore-offshore meandering of the Gulf Stream and its effect on the environment in the littoral zone, near-shore upwelling and consequent changes in temperature and nutrient concentrations in the coastal zone associated with the Gulf Stream eddies. We also plan to characterize eddies of the Gulf Stream and impacts on the diffusivity index and relationship to fish stock variability using acoustic techniques.

CIOERT - The current CIOERT Theme II Exploring Shelf Frontiers is focused on exploration and research on ecosystems within and beyond the eastern Continental Shelf, including Large Marine Ecosystems on the east coast frontiers beyond depths of 40 meters and poorly known habitats; connectivity of deep and shallow ecosystems, in terms of productivity and recruitment; focus on priority locations to promote an ecosystem approach to management; and frontiers of "economic, hazardous, scientific or cultural importance." This program is closely related to the SeaTech project and both of these programs could offer early warning systems for hazardous conditions with more intense tropical storms that may be associated with warmer oceans.

Topic 4: Climate Change and Critical Mega-fauna Profiling and Tracking

Project Team*: G. O'Corry-Crowe, M. Dhanak, G. Frisk, E. R. Gerstein, D. Herzing, S. McCulloch, S. Milton, J. Moore, and J. Wyneken*

Research Need and Priority: Long-term studies provide the necessary perspectives and time-series required to assess effects of climate related changes on long-lived organisms (e.g., marine mammals, turtles and sharks). Currently, FAU scientists are pursuing several multi-decadal studies and are now applying new technologies to expand the spatial and temporal reach to include global spatial scales and centennial and even millennial time frames, respectively. Studies conducted across a range of habitats and geographic locations offer the most powerful approach to assessing global, regional and local impacts of climate change. FAU researchers are conducting research on upper tropic levels across the globe, including species in estuarine and coastal systems in SE Florida, tropical oceanic systems and polar and sub-polar systems in the Arctic and Antarctic.

Research Proposed and Ongoing: Identify climate change stress thresholds across a diversity of organisms in tropical, subtropical and polar habitats through the development and application of indicators using immunogenetics, molecular pathways of physiological stress, as well as identifying changes in organism and population fitness and health over time. Develop multiscale approaches

including novel satellite telemetry and molecular profiling as bases for technology development in the fields of biologging, real-time genetic tracking and potential for bio-ocean and bio-ecosystem observing and assessment (marine mammals, sea turtles, sharks- including endangered/threatened species and apex predators). FAU is uniquely positioned to conduct cutting-edge research on the impacts of climate change on large vertebrates in the upper tropic levels of marine ecosystems. An essential requirement in such endeavors is the investigation of the behavior, ecology, health and population dynamics of marine mega-fauna over spatial and temporal scales sufficient to test hypotheses about the effects of climate change. A second element must be the integration of such research into broader ecosystem-wide studies.

The development and deployment of emerging technologies is a key element of the cutting-edge research required to assess climate effects at the molecular, cellular, individual and population levels. Advances are being made in the development of health and genetic fitness indicators via immunogenetics, in molecular pathways of physiological stress, and in the assessment of individual fitness and population viability via genetic profiling. A new 'Ancient DNA' facility has been established to improve predictive modeling on the impacts of climate change by expanding the time frame of investigation back several thousand years. FAU is poised to play a major role in the development of biotelemetry and biologging technology, where individual animals are not only tracked and sampled but are also employed as 'ocean observers' using satellite-linked computers or acoustic recorders. New insights come from integrating studies where megafauna are used as ocean observing platforms with other systematic ocean monitoring systems. FAU also has extensive expertise in the application of passive acoustic monitoring (PAM) where multiple elements of a marine ecosystem can be monitored simultaneously and continuously. FAU's demonstrated capabilities in scientific research on aquatic mega-fauna are facilitating a new approach to examining the relationship between upper-tropic levels and climate change that is a coordinated research program on multiple upper-level trophic species and developing multivariate models.

Topic 5: Coastal Ecosystem Research, Management and Conservation under Climate Change

Project Team: *L. Berry, D. Devlin, D. Hanisak, J. Jolley, M. Koch, J. Moore, A. Oleinik, E. Proffitt, J. Scarpa (External: Battelle, SFWMD, SJWMD, ENP, NOAA and USFWS).*

Research Need and Priority: FAU has long-term research programs in several major coastal ecosystems, Indian River Lagoon, Florida Bay, SE FL reefs, estuaries and coastal wetlands. Ecosystem processes and critical fish habitat studies have been conducted for over a decade in some systems. Ecosystem-level indicators of system stability are critical to understand the resilience of these habitats with climate variability. The responses of ecosystems to disturbances and environmental variables that will change with sea level rise and warmer oceans are needed to sustain coastal ecosystem health. It will also be important to develop aquaculture and other "intervention" technologies to sustain and conserve important ecosystems and ecosystem services that people value (storm protection, fish nurseries/habitat, water quality, etc.). Modeling and marine spatial planning (marine ecosystem based management) will assist resource managers to anticipate and plan for impacts of climate change on coastal marine resources.

Research Ongoing and Proposed:

Coral Reef Ecosystem Program: The regional coral reef ecosystem program is focused on the factors contributing to environmental stress in corals and macroalgae on reefs in South Florida and the wider Caribbean. This program integrates experimental and field monitoring approaches with advanced molecular techniques to understand the short- and long-term effects of stress and disease on coral and algal physiology and ecology. Specifically, FAU faculty are investigating coral bleaching, disease, thermal stress, ocean acidification and the overall effects of climate change on the sustainability of coral reef ecosystems. Restoration of reef habitats and conservation is also being investigated through genetic studies.

Florida Bay Ecosystem Program: FAU Florida Bay research is currently focused on climate change impacts including upper temperature and salinity limits of marine plant communities and biogeochemical responses. The research is centered on three major topical questions. (1) What are the upper levels of thermal and salinity tolerance of tropical seagrass in lagoonal systems and what physiological and molecular indicators can be explored to identify the mechanisms by which these species survive at stress-

threshold conditions? (2) What are the multiple-stressor interactions that cause major seagrass mortality events in tropical and temperate seagrass communities that are occurring on a global scale? (3) How will estuarine, coastal lagoon, and bank ecosystems dominated by carbonates be affected by climate change including increases in thermal and salinity stress? In addition to direct plant responses to stress, we are also interested in nutrient cycling and biogeochemical changes at the ecosystem-scale that can destabilize plant communities and influence the sustainability of foundation plant communities that support higher-level organisms. We work directly with modelers actively incorporating our results in models for ecosystem management and decision making in support of policies and best management practices.
Indian River Lagoon Research Program: The Indian River Lagoon Research Initiative (IRLRI) is to acquire and disseminate new data and knowledge on key components of the IRL. This research program will expand and lead to the optimization of ecosystem services provided by the IRL's unique natural resources and their sustainable management, so they can be sustained for generations to come, despite the pressures of human populations and changing climate.
Mangrove-Salt Marsh-Seagrass Ecosystems Program: The FAU coastal wetlands program studies population and community dynamics of natural and restored systems across disturbance and latitudinal environmental gradients which are currently changing. We are interested in the influence of genetic diversity on resilience of foundation plant communities including mangrove, salt marsh and seagrass.
Aquaculture Program - HBOI-FAU has a nationally and internationally recognized research program that investigates technologies for the sustainable production of finfish and shellfish for food; species include Florida pompano, black sea bass, cobia, Southern flounder, hybrid striped bass, tilapia, sunray venus clam, hard clam, queen conch, shrimp, and spiny lobster. The aquaculture facilities are suitable for a wide range of cross-disciplinary research programs including mitigating the effects of climate change by reintroduction of hatchery raised fish and shellfish into ecosystems threatened by a changing climate. FAU scientists have ongoing research programs focusing on production of high quality aquatic animals for stock enhancement of depleted natural populations including red drum, Florida apple snail, queen conch, and oysters. Culture and restoration efforts are enhanced by the on-site disease diagnostics laboratory, which is equipped to provide microbiological, molecular and histological analysis for diagnosis and research concerning reproductive, nutritional and disease health issues for fish and shellfish.

THEME #3
CLIMATE CHANGE COORDINATION, EDUCATION (K-GRADUATE) AND OUTREACH

Topic 1 Climate Change Education through Gaming and Visualization

***Team Members*:** *R. Alvarez, L. Berry, T. Fernandez, F. McAfee, E. Shaw, and G. Thomas (External: Palm Beach School System, Florida Virtual Schools, National Council on Science and the Environment).*
Research Need and Priorities: There is clearly a need for future generations to be well versed in climate science. Computer gaming is an excellent approach to use to reach the younger generation to educate them about climate change. Game simulations have proven to be an effective method to explain complex information and transform inert knowledge into active problem solving (Frye, et. al. 1996).
Research Proposed and Ongoing: In order to address the rapidly growing amount of climate change information FAU and its partners propose a web-based climate change computerized video gaming simulation: Situationally Adapted Simulations for Mitigation and Adaptation Education (SASMAE). We have gathered an interdisciplinary team of educators, computer scientists and climate change experts to create an application that uses and is linked to NASA Earth observing data/NASA Earth system models. The application will also incorporate economic, social and political inputs to model various scenarios. Students from grades 6 to 12 can employ the software to make educated climate change-related technological and policy decisions and evaluate potential outcomes of each. With the collaboration of Palm Beach County schools, FAU will train local teachers to incorporate this tool into the earth science program. After incorporating findings from the pilot implementation, FAU will refine the software and collaborate with state and local governments to introduce this software to policy makers and the broader

community. FAU has established strong connections with the National Council on Science and the Environment (NCSE) and has committed to provide the framework for a nationwide distribution network. We will also collaborate with Florida Virtual School (FLVS), an established leader in developing and providing virtual K-12 education solutions to students all over Florida, the U.S. and the world. FLVS will provide development support, beta testing opportunities, and information dissemination.

Topic 2: Climate Change Education K- University

Project Team: *L. Berry, A. Edwards, G. Hardman, B. Heimlich, T. Hindle, M. Koch, J. Lambert, M. Mehallis, and G. Thomas (External: Palm Beach School System and NCSE).*

Research Needs and Priorities: Several faculty at FAU recognize the importance of climate education and are working towards making students aware of some of the challenges they will face with sea level rise, particularly in South Florida, and other hazards associated with a changing climate. Students today are very interested in the environment compared to preceding generations, and are keen to learn more about climate change processes, assessment, mitigation and adaptation issues. We are organizing ourselves to provide students with climate change information by becoming active at the national level.

Research Proposed and Ongoing*:* We are working with the National Council for Science and the Environment (NCSE) and its Council of Environmental Deans and Directors (CEDD) to develop a multi-institutional, national-scale Climate Science and Solutions Masters degree. FAU has initiated an environmental education master's degree program drawing from every college in the university. The College of Education program which has a unique charge to support both formal and informal education from early childhood through adult in a variety of departments and centers, including three lab schools (serving students ages 6 months through 12th grade, university faculty and researchers) and the Pine Jog Environmental Education Center with programs serving preschool through graduate students as well as educators and the public. The content would address local climate change issues. This program can be expanded across all 8 school districts served by the FIAT students in the schools to which they are assigned. Using this opportunity, informed and trained university students teach grade school students and their teachers principles of science inquiry in the context of climate change. At the university level, FAU currently offers courses in Climate Change Science (graduate level- M. Koch and HBO faculty), Climate Change for Teachers (J. Lambert) and is part of the NCSE team which is creating a national level climate change program at Masters level (M. Mehallis). CES (Alana Edwards) has created workshops for over 1,000 in service teachers on water issues and is developing a program on Ocean Energy for this group. Climate Change in-service training is a goal for 2010-2011.

Topic 3: Focus on Decision Makers and Outreach

Project Team: *L. Berry, M. Escaleras, B. Heimlich, T. Hindle, J. Jolley, M. Mehallis, J. Murley, T. Root (External: FPL, Advanced Green Technologies, CDM and Leonard Townsend Esq.; AIA; LEED®, AP).*

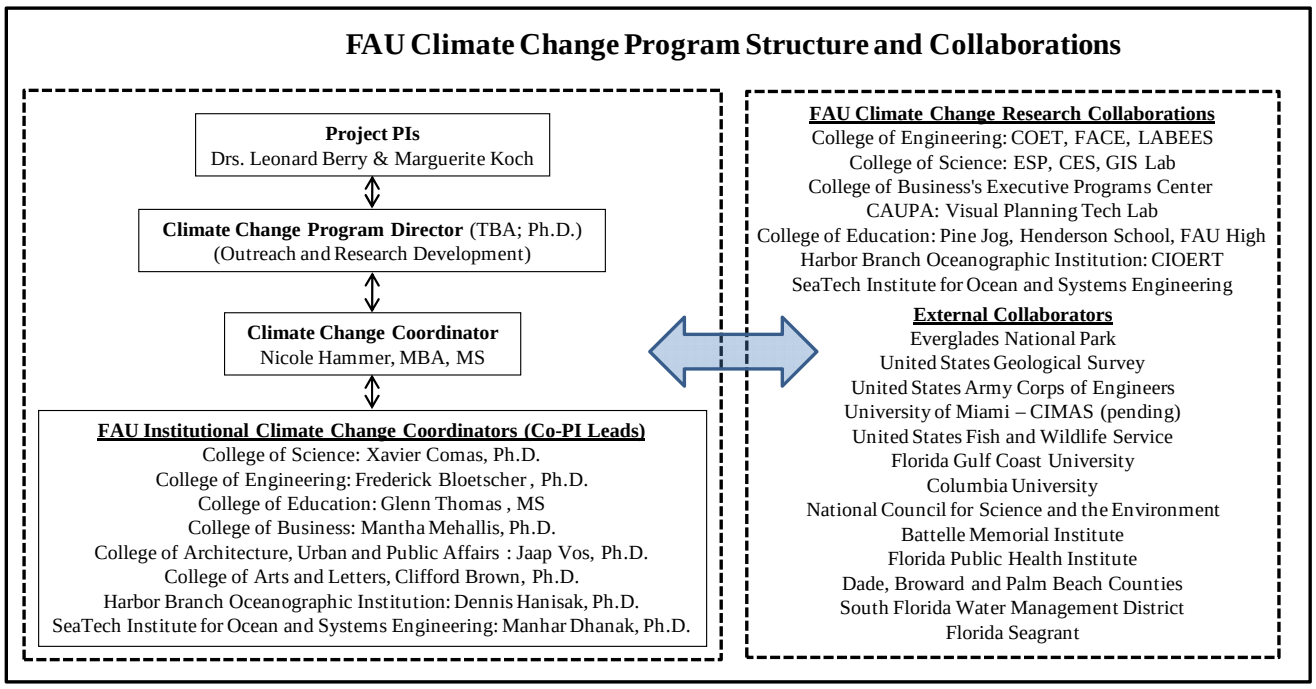
Research Needs and Priorities: The business community, decision makers and the general public need to be educated about climate change to adapt to future changes and incorporate them into long-term plans including budget decisions.

Research Proposed and Ongoing: We propose to develop a sustainable industry/climate change component in the College of Business Executive Program and plan for a course in the regular curriculum. FAU's College of Business's Executive Programs Center has the ability to design, develop, and offer workshops, seminars, certificates, and academic programs both credit and non-credit tailored to meet the needs of the local science, engineering, and business communities with regard to climate change and solutions. We also propose to revise the Environmental MBA to incorporate climate change adaptation issues. We will also continue to engage the business community on climate change initiatives in local counties and cities and the four county coalition (Miami-Dade, Broward, Palm Beach and Monroe), and FPL and other agencies and utilities to develop climate change adaptation strategies. We plan to provide community education and outreach in a coordinated way to diverse publics in the region, and help to integrate climate change into curricula at all levels within the education systems in the region including community colleges. Faculty in the Geosciences have applied for an EPA grant to develop and implement

an Environmental Academic Service Learning (EASL) program at FAU that combines academic instruction with community based, hands-on projects, addressing local environmental issues. In collaboration with FAU's Center for Civic Engagement, local community organizations, businesses, and public agencies will be engaged to develop opportunities for environmentally-focused academic service learning projects. The proposed EASL program will encourage students to apply what they have learned in the classroom to improve the environment of local communities and the southeastern Florida region.

6.0 ORGANIZATIONAL STRUCTURE AND PROJECT LEADS

The major goal of the FAU Climate Change Initiative is to utilize the depth and breadth of current FAU faculty conducting climate change research to build interdisciplinary research teams. To achieve this goal with the research funds available and to sustain this research program for 10-20 years, we see a critical need for a Climate Change Program Director. The Climate Change Program Director would write and develop major interdisciplinary research proposals for FAU with the PIs and Co-PIs (60 in total) on various climate change topics (see 5.0). Proposal development would be coordinated with FAU's ongoing research programs and external partners; thus, a major role of the director will also be outreach and facilitation at the FAU, local, regional, national and international level with a climate change coordinator.



7.0 TASKS AND TIMELINE-GOALS

Year 1 (2010-2011)

- Recruit Climate Change Program director target date 1 January 2011.
- Develop firm partnerships with Sea Grant, USGS, USFWS, SFWMD, NOAA, ENP, and South Florida County initiatives.
- Work with DOI and NOAA to create a Climate Change Center in Davie at FAU campus.
- Write at least four major proposals for research funding.
- Build a strong Education and Outreach component with COE and CES.

Year 2 (2011-2012)

- Build a core team of 3 post-docs and 5 graduate students to work in a co-coordinated way on key climate change issues as set out in research priorities. Funding to come from Fed/Agency matching grants and research proposals.
- Host series of workshops to prioritize research for climate change initiative.

Year 3 (2012-2013)

- Fully functioning Climate Change Center with funding 2-4 million dollars a year including federal, private, and local support.
- Climate change built into curriculum at K-12, University, and teacher training programs.
- Ongoing research results flow to inform agencies and public of climate change adaptation and mitigation.
- FAU recognized as the local South Florida University on climate change issues and coordinates science and engineering input with decision making and climate change educational program development.

8.0 SUSTAINABILITY OF THE PROPOSED PROJECT

Current and Pending Support: Current sponsored research activities for 2008 and 2009 identifies about $1.6 million of ongoing work in the colleges of Engineering Sciences, CAUPA and HBOI on climate change issues with another $1.6 million that could be applied to climate change issues. Thus, there is substantial work already underway developing this research theme at FAU. In addition, at least $6 million is pending from climate change proposals to NSF and NOAA from the recent establishment of a climate change research initiative in CES. FDOT has recently granted FAU $150,000 and is under negotiation for this project.

Sustainability of the Climate Change Initiative After Three Years of Support: Based on the proposed support of $150,000 over the next three years we would anticipate ensuring the long term viability of the project through five potential support streams.

1. Continued active pursuit of federal funds through traditional channels National Science Foundation (NSF), Department of Energy (DOE), Department of Transportation (DOT) etc - There is a new emphasis on interdisciplinary work throughout the federal government and climate issues are an increasing focus and priority.
2. State and Local Support - The South Florida Water Management District (SFWMD) and other water districts, as well as their partners the Corps of Engineers (COE), are becoming deeply concerned about climate change implications for water management and Everglades restoration and we are already working with them to identify ways in which FAU can support their needs. There is already an informal agreement with the Water Resources Advisory Committee (WRAC) and FAU will coordinate university input on this topic (Shannon Estonez per.com.).
3. FAU is working with the federal agencies involved in Greater Everglades Restoration on the possibility of a joint climate change center on the Davie campus. We have available space and there is a good possibility of funding from residual 2010 funds and dedicated support in 2011.
4. We will continue to work with our lobbyists for a dedicated set aside for this important activity.
5. Private Sector Funding will be sought, and as climate change becomes identified as a key S. Florida issue, is likely to be available.

II) BUDGET

Climate Change Program Budget	Year 1	Year 2	Year 3	Total
CC Research Director - FTE 1.0	$ 70,000	$ 90,000	$ 92,700	**$ 252,700**
CC Coordinator - FTE 1.0	$ 55,000	$ 56,650	$ 58,350	**$ 170,000**
Benefits (30.8%)	$ 38,500	$ 45,168	$ 46,523	**$ 130,191**
Conference/Meeting Funds	$ 10,000	$ 10,000	$ 10,000	**$ 30,000**
Travel	$ 5,000	$ 6,000	$ 7,000	**$ 18,000**
Total	$ 178,500	$ 207,818	$ 214,573	**$ 600,891**
Agency Matching	$ 35,000	$ 35,000	$ 35,000	**$ 105,000**
Total	**$ 143,500**	**$ 172,818**	**$ 179,573**	**$ 495,891**

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