

**SUS CLIMATE CHANGE TASK FORCE: SCIENCE ADDRESSING
THE NEEDS OF FLORIDA AGENCIES, INDUSTRY, AND CITIZENRY**

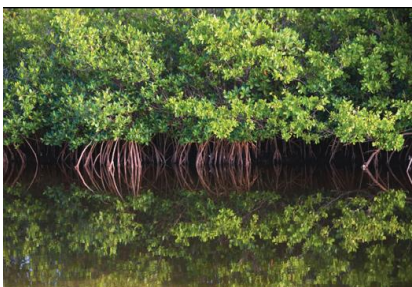


FINAL PROJECT REPORT JANUARY 31, 2012

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AN SUS CLIMATE CHANGE TASK FORCE: SCIENCE ADDRESSING THE NEEDS OF FLORIDA AGENCIES, INDUSTRY, AND CITIZENRY

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I. Introduction

Florida, with its vast and growing coastal communities, increasing population, and changing demography is becoming more vulnerable to weather and climate events. Future projected changes in Florida's climate will progressively impact many elements of life and economy in Florida. These projected changes include higher temperatures, more variable weather with more frequent extreme weather events such as drought and flooding, sea level rise, and possibly increased intensities of tropical storms. Vulnerabilities to changes in climate exist in all of Florida's natural and managed systems as well as to its citizens. The exact nature of these vulnerabilities, impacts, and needs to adapt vary among coastal natural resources, the built environment, marine and terrestrial species, agriculture, forestry, tourism and recreation industries, and other sectors. Climate change issues are highly complex due in part to the uncertainties inherent in future climate projections as well as the broad impacts and responses across all segments of society. Consequently, communicating climate change science to society is challenging; many citizens in the SE USA remain unconvinced that climate change is a problem. However, some real economic and environmental impacts are already occurring in Florida; they require adjustment, investment, and management of change. Federal and State agencies, such as US Army Corps of Engineers (USACE), US Geological Survey (USGS), US Fish and Wildlife Service (USFWS), Florida Fish and Wildlife Conservation Commission (FWC), Water Management Districts (WMDs), Florida Department of Transportation (FDOT), and Regional Planning Organizations, are preparing for significant climate change impacts.

Universities in the State are also responding with pure and applied research, cross disciplinary workshops, and curriculum development to identify threats and opportunities and focusing on the training and education needed to develop the workforce required to address climate-related challenges. Existing SUS initiatives include Florida Atlantic University's (FAU) designation of Climate Change Adaptation as one of three cross-university research priorities, and the joint initiative from University of Florida (UF) and Florida State University (FSU) that created the Florida Climate Institute (www.floridaclimateinstitute.org). The three universities joined together to create an SUS-wide focus on climate change. The project also included contributions by local, State and Federal agencies, water management districts, with whom we already had close working relationships, and representatives from key industries that are centrally involved in these issues and had already formed linkages with one or more of the submitting institutions.

This report summarizes the outcomes of this one-year State University System (SUS) project and presents key conclusions and recommendations. Detailed findings from two workshops and four white papers are available on the project's website (www.floridaclimate.org).

II. Florida Climate Change Task Force Project

a. Background

This project focused on identifying current State University climate change expertise, research and curricula; enhancing cooperation with State and Federal agencies to help bring science into climate change-related decision making; and developing a climate change information system and portal that will connect State University System (SUS) assets with these agencies and other groups to facilitate communication. It was proposed by three SUS universities in response to the SUS Board of Governors call for proposals for the New Florida Clustering Awards Program. This call for proposals was part of the Board of Governors “New Florida 2010” initiative. The overall goal of the New Florida Clustering Program was to enhance teaching, research, and service with a premium placed on collaboration among the universities. The proposal was jointly developed and submitted by three universities (FAU, UF, and FSU), each with major research and education programs.

Leadership from FAU on this project (Dr. Len Berry) was from the Integrative and Collaborative Climate Change Research Initiative. This is a university-wide program creating relevant linkages across disciplines at FAU in order to advance basic and applied research in the area of climate change and adaptation. The initiative has so far included 100 faculty members of seven colleges (Science, Engineering and Computer Science, Education, Honors, Business, Architecture, Urban and Public Affairs) as well as Harbor Branch Oceanographic Institute (HBOI). The initiative has received eighteen letters of support from Federal, State, National, and private sector agencies, and is a widely recognized university program in South Florida.

Project leaders at FSU (Dr. Eric Chassignet) and UF (Dr. James W. Jones) had been collaborating on several projects prior to 2009 when the SUS call for proposals was released, and they had created a joint UF and FSU institute in 2008, The Florida Climate Institute (FCI), that includes researchers from additional organizations and institutions in Florida. The Florida Climate Institute (FCI) fosters multidisciplinary research, education, and outreach to 1) improve understanding of climate variability, climate change, and sea level rise on the economy, ecosystems, and human-built systems; 2) develop technologies and information for creating opportunities and policies that reduce economic and environmental risks; and 3) engage society in research, extension and education programs for enhancing adaptive capacity and responses to associated climatic risks. One goal of the FCI developers was to expand throughout Florida to increase collaboration for more effectively meeting research and education needs of Floridians.

b. Project goals and objectives

Given that climate change and its impacts are going to be different in different parts of the state, but important everywhere, our goals were to develop a clustering project that identified key personnel and programs involved in climate change research and/or education, to engage all SUS universities in preparing information on climate change in Florida, to assemble information on climate change education programs in the SUS universities, and to summarize what is known about vulnerabilities and impacts in selected sectors. Our objectives were to:

- Develop information on university climate change programs (research and education), university climate change institutes and centers, and initiatives state-wide.
- Assess the status of Florida-specific climate change scenarios and develop a strategy for ensuring that users have access to the best science-based climate change scenarios for Florida as they consider options for responding to climate change.

- Support and enhance university cooperation with state and federal agencies in order bring science into decision making and action, improve complementarities, and help avoid redundancies by providing science based white papers on key topics.
- Conduct two workshops to highlight priority climate change adaptation issues in relation to sea level change, agricultural and ecological change, and water management in the different regions in Florida.
- Develop a climate change information system and portal that will connect SUS assets with State and Federal agencies and other groups to facilitate active communication among institutions and agencies and assure that the most current science is used for decision making and action.

III. Approach

a. Coordination

Coordination of this project was accomplished through many routinely scheduled telephone conference calls, each with specific goals and agendas. Leadership for these telephone meetings was shared among the three universities, with FAU being responsible for initial coordination and planning the first workshop that was held at FAU, UF being responsible for planning and hosting the second workshop, and FSU being responsible for coordinating and leading the development of the web site. These meetings, usually held at weekly or bi-weekly intervals, were also used to plan and initiate the development of the four white papers. Lead authors of each white paper were selected along with lists of recommended contributors from universities throughout the state, not just the three universities leading the project. The lead authors followed up on these initial steps, obtaining commitments from faculty from various universities in Florida to help with writing the white papers and additional scientists who would review each one. Coordination for each white paper was assumed by the lead authors for completing the papers and getting them reviewed.

Following the second workshop in November 2011, the three principal investigators met in person to discuss major outcomes and recommendations for the future.

b. Workshops:

Two workshops were held during the project. The overall goals of the first workshop, held at FAU on March 18, 2011, were to bring together faculty from all of the state universities in Florida and from the University of Miami who were involved in research and/or education on climate change and to begin to begin the process of building collaboration among SUS universities to facilitate more effective research and education activities needed to address climate change and sea level rise information needs in Florida. This workshop was organized by a three-university planning committee (Leonard Berry, James Jones, Eric Chassignet, Patricia Springer, Jo Ann Jolley, and Carolyn Cox). The workshop served as a brainstorming meeting to confirm priorities for a state-wide initiative in this area, and through breakout sessions, helped to outline content of the White Papers and identify contributing authors. This workshop provided the starting point for additional collaboration among faculty from most of the SUS universities to contribute to the development of the White Papers. The program and report from this workshop are available at: http://floridaclimate.org/march18_2011_home.php. The White Paper development evolved throughout the year to include additional university climate expertise and partner agencies who contributed to the papers.

The goals of the second workshop, held November 14-15, 2011, were to foster communication and cooperation among university scientists and the public and private sectors in Florida regarding climate change and sea level rise science and societal responses. The workshop also served as an effective platform to present and discuss the white papers to a broad audience of public and private agencies, and to determine important research and education needs that would contribute to understanding and the ability to respond to the associated economic and environmental risks and opportunities. The SUS university community worked with external groups to learn from stakeholders across various governmental agencies (from city to state levels in Florida) and from the private sector about their concerns about climate change issues and their needs for research and education to help them make more informed decisions and policies relative to economic and environmental goals.

A program committee that included university and external partners developed the program and helped attract speakers from public and private entities (Program Committee members were Jim Jones and Carolyn Cox of UF, Len Berry and Patty Springer of FAU, Eric Chassignet of FSU, Alison Adams from Tampa Bay Water, Jayantha Obeysekera from the South Florida Water Management District, Doug Parsons of the Florida Fish and Wildlife Commission, Jay Levenstein of Florida Department of Agriculture and Consumer Services, Leticia Adams of the Florida Chamber of Commerce, and Karl Havens of Florida Sea Grant. The organizing committee for this workshop was comprised of project leaders from the three lead universities. This workshop included presentations of the four White Papers developed in this project, three keynote speakers, and two panel discussions on needs related to climate change research and education, one focusing on Environment and Natural Resources and the other on Economics and Policy. The program and summary report can be found on the web site at: http://floridaclimate.org/nov15_2011_home.php.

c. Web site development

A web site, <http://floridaclimate.org>, was developed and put in place, not only to facilitate interactions among the three university partners in this project, but also to develop a climate change information system and portal that will connect Florida universities with state agencies, private industries, and other interested parties.

d. White papers

i. Biodiversity and Land Use

Experts in ecology and natural resource management from across Florida contributed to this document and provided informed assessments of the future of Florida's biodiversity under a changing climate. This process began at the State University System Climate Change Task Force Workshop held in Boca Raton, FL on March 18, 2011. During that event, participants in the Biodiversity Impacts break-out session completed a questionnaire regarding the state of current scientific understanding and concerns regarding the climate change impacts on Florida's natural resources. From this initial meeting, the primary authors enhanced the depth of the topics raised in the break out session through searching the scientific and management literature. We also researched the best available management strategies and challenges available in the published literature and through solicitation of our co-authors. All information presented in the final manuscript was discussed and approved by all white paper authors through the manuscript revision process. In addition, we had input and comments from two outside reviewers.

ii. Education, Training, and Outreach on Climate Change

A systematic statewide effort was implemented to compile and classify a comprehensive list of climate change educational opportunities that are available through the SUS. This process began at the State University System Climate Change Task Force Workshop. Participants in the *Initiating Education and Training* break-out session completed a questionnaire asking what climate change-related courses were offered at their universities. Three steps were followed to standardize the process of collecting information regarding the climate change courses available within the SUS; 1) Identify the courses available at each institution that contain climate change content, 2) Review and classify the identified courses, and 3) Organize and integrate the information. Courses were further organized into groups, depending on the branch of science in which their general disciplines were rooted and classified as Interdisciplinary.

Course information was entered into a database to prepare it for analysis. The analysis consisted in describing the courses grouped by institution, level of relationship of their content with climate change (i.e. Level 1 – 4), and branch of science where they belonged. The authors organized bi-weekly conference calls to discuss the advances made in data collection and analysis. Analytical decisions were discussed and approved by the group of authors, either during conference calls or through the revision of different drafts of the document. A list of SUS courses gathered and the forms for taking courses across institutions can be found at <http://floridaclimate.org/climatecourses/>

iii. Climate Scenarios: A Florida Centric View

This white paper on climate scenarios is an outcome of the State University Climate Change Task Force Workshop held at FAU in Boca Raton, FL. It fulfills the need to assess our current knowledge on how global climate change affects Florida. Furthermore, it also addresses issues and specific questions of interest to the stakeholders such as climate projection uncertainty, extreme events, and natural vs. anthropogenic influences on climate. Based on the workshop discussions, an initial outline of the white paper was prepared and experts from several Florida institutions were then identified and approached to contribute within a specific time period. The contributors were from five Florida institutions (FSU, USF, UM, NOAA-AOML, NOAA-HRD, SFWMD) and their expertise spanned six disciplines (Meteorology, Oceanography, Hydrology, Social Science, Economics, and Law). The contributors to the white paper were all eager and forthcoming. The contributors were urged to refer to peer-reviewed literature as far as possible, to which they complied. FAQ's were also added in each section of the white paper to specifically address specific stakeholder questions on climate change. All the contributions were edited in a few iterations before it was sent out for peer review. The comments from peer review were addressed before the final version of the white paper was released.

iv. Florida Water Management and Adaptation in the Face of Climate Change: Climate Change and Florida's Water Resources

The concept for the White Paper grew out of discussions at the March 2011 workshop when it was agreed that Water Management and Coastal Adaptation should be merged as a White Paper because the two topics are so closely interwoven. A diverse working group of some eight faculty and five graduate students included Geosciences, Biology, Urban Design, and Regional Planning led by Dr. Marguerite Koch refined the concept and met on a biweekly basis. Much more material than was finally incorporated in the paper was generated, but the group finally focused on a coherent series of Water Management and Adaptation issues directly related to

climate change. External comment and cartographic help was provided by Florida International University and South Florida Water Management District.

IV. Key Outcomes

a. Initiating Workshop

During this one-day workshop, the lead representatives from Florida Atlantic University (FAU), Florida State University (FSU), and University of Florida (UF) set the stage with a discussion about the project and its goals. This was followed by concurrent breakout sessions covering five climate change topic areas: 1) assessment of climate change scenarios; 2) biodiversity and land use / land cover change; 3) coastal county adaptation; 4) education and training; and 5) water resources management. The workshop outcomes described in this summary report (http://floridaclimate.org/docs/summary_report_march.pdf) were intended to guide the development of white papers on each topic area as part of the final project deliverables. Among the ongoing tasks identified were:

- Creation of a web portal to share climate change information within the SUS and with cooperating agencies;
- Downscale global climate projections to be more relevant to Florida;
- Identify the effects of land use changes due to climate-generated population resettlement and biodiversity, and assess the impact of climate change on Florida's vital agriculture;
- Examine the current and potential impact of climate change on Florida's coastal resources, economy and job creation;
- Create a source of centralized, integrated data to help the entire system of water management;
- Develop a cross-university certificate program in climate issues to provide opportunities for any student without having to duplicate courses across SUS campuses.
- Work with state and federal agencies to target their priority needs as work progresses.

The workshop served as a good vehicle to expand the team working on the project. There was a high level of involvement by all the universities present.

b. Final Workshop

During this two-day workshop, the lead representatives from Florida Atlantic University (FAU), Florida State University (FSU), and University of Florida (UF), along with representatives from five other state universities, agencies, and private industry met to explore further collaboration on climate issues. As part of the ongoing collaborative process that began in early 2011, four white papers on climate science were presented on:

- Biodiversity and Land Use
- Climate Scenarios for Florida
- Water Management and Coastal County Adaptation
- Education, Training, and Outreach on Climate Change

The workshop served as an effective platform to unveil these research papers and to highlight the work being done in Florida on climate change. Current climate change projects were also showcased during an attended poster session that had over 65 participants. Our keynote speakers and panelists helped to further emphasize the importance of this work through their policy expertise, industry experience, national perspective, and in-depth analysis of the latest climate science. Video of the presentations are available at <http://floridaclimate.org/presentations>

The white papers and presentations are both a product and a beginning of our collaboration. While they represent the latest climate-related research in Florida, they have also helped us to identify gaps in information that can inform future research and education efforts for our state. Our goal is to continue the statewide collaboration amongst the universities, local and state agencies and the private sector to more effectively address the needs of Floridians.

c. Web Site

The web site, designed with input from all three campuses, was developed using the Florida Climate Change Task Force website address <http://floridaclimate.org>. This web site is operational and will be maintained by the three universities at least for the next year. As noted elsewhere in this report, a goal of the universities is to continue the collaboration that was initiated in this project and to expand and maintain the web site. One can find detailed information on:

- i. White Papers: This is one of the major outcomes of this project, and the full documents of each white paper can be downloaded from <http://floridaclimate.org/whitepapers/>
- ii. Presentations: The presentations given at the workshops can be viewed at <http://floridaclimate.org/presentations/>
- iii. Climate courses: As part of the process of developing the white paper “Florida Climate Change Education and Training: State University System Cooperative Plan”, the team prepared a list of climate-related courses from each of the 11 state universities and the University of Miami. See <http://floridaclimate.org/climatecourses/>
- iv. Workshop summaries http://floridaclimate.org/march18_2011_home.php and http://floridaclimate.org/nov15_2011_home.php
- v. Climate Expertise in Florida Universities: The Expert Finder allows the user to search among the climate experts from the 11 state universities and the University of Miami. See <http://floridaclimate.org/expertfinder.php>

d. White Paper Summaries

The final white papers are available at <http://www.floridaclimate.org/whitepapers>. Below are short summaries of each of these papers.

i. Biodiversity and Land Use

Principals/Leads: Susan Cameron Devitt, Jennifer Ruth Seavey

Contributors: Tom Hctor, Reed Noss, Corrie Rainyn, Martin Main, Odemari Mbuya

Florida’s abundant and unique biological resources are at particularly high risk for climate change impacts because of its low topography, extensive coastline, and frequency of large

storm events. Climate change is already making large sweeping changes to Florida's landscape, especially along the coasts. The drivers of this change are both physical and biological in nature. Changes in air and water temperature, freshwater availability, salt water intrusion, ocean acidification, natural disturbance regime shifts (e.g. fire, storms, flood), and loss of land area have already been observed in Florida.

Florida's biodiversity is already responding to climate change through changes in physiology, distribution, phenology, and extinction risk. Physiological stress is being observed among marine species and northward movement is becoming more common as a result of temperature shifts. Unfortunately, for Florida, species movement brings increased risk for invasions by non-native species. Sea turtle nesting and tree flowering dates are shifting earlier in time to keep pace with increasing temperatures. Climate change also brings elevated extinction risks for Florida's numerous endemic species and species of conservation concern. Numerous direct economic benefits are associated with conserving Florida's natural resources, such as tourism, recreation, and fisheries. In addition, Florida's biodiversity and natural systems provide significant ecosystem services that benefit all the citizens of Florida.

Maintaining species and ecosystem resiliency is critical to conserving Florida's biodiversity, and we recommend an active adaptive management framework to achieve this goal. The application of adaptive management demands that science take a leading role in management to promote the conservation of natural resources; reduce other anthropogenic threats to biodiversity; consider the use of assisted migration and other adaptation strategies; create migration corridors; and promote strategy development that is both creative and experimental. Fortunately, there are numerous agencies, institutions, and scientists in Florida who can facilitate both improved scientific research and management of climate change impacts on biodiversity at federal, state and local levels.

To develop effective active adaptive management in Florida, several administrative challenges need to be addressed such as current interpretation of legislation, lack of funds, stakeholder conflict, self-serving behavior, and the pace of change. Adaptive management can unlock these options for science and management to effectively address Florida's biodiversity conservation in the face of climate change. The preservation of Florida's rich biodiversity in the face of climate change is imperative to maintaining the unique and unparalleled natural beauty of the state and the critical ecosystem services provided by these natural systems to the citizens of Florida.

ii. Education, Training, and Outreach on Climate Change

Principal/Lead: Sebastian Galindo

Contributors: James W. Jones, Alana Edwards, Christine Lockhart, Carolyn Cox, Robert Ellingson, Julie Lambert, Allan Feldman, Jeffrey Ryan

Global climate changes are complex and challenging to communicate to society. As a consequence of deficiencies in communication and education, society lacks the means to adapt and mitigate the impacts of climate change, remaining incapable of pushing for effective, efficient, and equitable policies and actions on the matter. This communication challenge is evident in the Southeastern U.S., where broad sectors of the public remain unconvinced that climate change is a serious problem and scientists and educators in general lack the capability to translate science to lay audiences, making it harder for people to become informed or educated about climate science. Therefore, it is necessary to identify what educational opportunities are already available, and which ones are still needed to more broadly educate and inform relevant audiences.

The overall goal of this paper was to provide information on university climate change programs (research and education), university climate change institutes and centers, and initiatives statewide in Florida. The specific objectives were: a) describe the current status of climate change education within Florida, b) assess the extent at which educational needs related to climate change are being addressed, and c) identify action items required to enhance climate literacy of the State's population.

Through a systematic statewide effort, 406 courses with varying degrees of climate change content were identified within 12 surveyed institutions of higher education. Almost half of these courses are taught in disciplines within the physical sciences, and nearly a fourth are taught in the social sciences. The rest of the courses were in the curricula of life sciences (75), interdisciplinary programs (31), and humanities (6). The courses were further classified based on the amount of climate change content that they included. This course list can be found at <http://floridaclimate.org/climatecourses/>.

A set of educational needs were identified. The most important ones were to: a) promote stronger integration of climate change education with other sciences and disciplines; b) enhance students' access to current and future courses; c) develop the skills of scientists for translating scientific concepts to lay audiences; d) strengthen the preparation of K-12 science teachers to incorporate climate change concepts in their courses; and e) expand the integration of climate change education into Extension/outreach programs beyond agriculture and natural resources.

Two strategies are proposed to address the identified needs. The first one suggests the establishment of a state-wide, inter-institutional, and multidisciplinary minor/certificate on climate change. This program would enhance the access of students to a range of courses on climate change, improve the capacity of future scientists for translating sciences for the public, and promote the integration of climate change education into various disciplines. The second strategy focuses on the development and delivery of training curricula to enhance the knowledge and skills of university faculty (both teaching and extension) and K-12 science teachers in two main areas: 1) the integration of climate change education into their courses/programs, and 2) the translation of scientific concepts for multiple audiences.

iii. Climate Scenarios: A Florida Centric View

Principal/Lead: Vasubandhu Misra

Contributors: Elwood Carlson, Robin K. Craig, David Enfield, Benjamin Kirtman, William Landing, Sang-Ki Lee, David Letson, Frank Marks, Jayantha Obeysekera, Mark Powell, Sang-Ik Shin

It is shown that Florida represents a good example of a complex regional climate system, where relatively slow natural climate variations conflate or deflate the multiple sources of anthropogenic climate influences. Climate change in this document refers to all sources of anthropogenic influences, including greenhouse gas (GHG) emissions, aerosols, and land cover and land use change. However the basic fact irrespective of the source of these variations and change is that Florida, with its vast and growing coastal communities and changing and growing demography, will make itself more vulnerable to weather and climate events. With anticipation of further rapid increase in GHG emissions, it is prudent to act now in applying the necessary regional climate information that we have to educate the public and implement adaptation and mitigation plans. Some of the most apparent impacts of climate change and variability for Florida are as follows:

- i. Salt water intrusion from sea level rise is already becoming an issue for the freshwater demands of highly populated areas along the southeast coast, from the Florida Keys to Palm Beach. This issue may further worsen and become more widespread over time with climate change.
- ii. The displacement of communities, destruction of infrastructure and terrestrial ecology, and increased prospects of damage from storm surge would be an additional consequence of sea level rise.
- iii. The likelihood of the change in the statistics of Atlantic tropical cyclone intensity has a huge implication for the sustenance of coastal and inland communities in terms of damage to infrastructure and property, human mortality, and the modulation of the accumulated fresh water source in the summer, especially in South Florida.
- iv. Remote impacts of any perceived climate change in the characteristics of El Niño and Southern Oscillation (ENSO; although none have been conclusively found so far) will have an implication on the seasonal climate variability over Florida, especially in winter and spring seasons.
- v. Likewise remote impact of climate change over North Africa can have implications on dust transport across the Atlantic Ocean, which can change the air quality and health of Florida's neighboring oceans.
- vi. The uncertainty in the anticipated changes in Florida red tide (a harmful algal bloom) due to changes in ocean temperatures and long term variations of local scale terrestrial runoff can make the fishing industry and the human population vulnerable.
- vii. Florida's coastal reefs, which serve as a habitat for a variety of biota, are threatened by ocean acidification from increased levels of dissolved carbon dioxide. There is anticipation of inevitable future increases in the wealth of Florida coastal communities, which would lead to further infrastructure development that will make the coastal regions far more susceptible to even moderate (and unanticipated) changes in climate.

It is recommended that, with existing climate information, effective climate scenarios could be developed in the near term that would be useful to plan and test sustainable strategies for adaptation and mitigation of climate-related vulnerabilities. Ongoing scientific research is bound to further improve our ability to understand and predict our climate system to meet the strident demands for accurate climate projection.

In addition, the growing and aging population of Florida would make this state more vulnerable to climate variations and change. The demand for energy and water will proportionately grow, while changes in land cover, air quality, coastal waters from urbanization, industrialization and agriculture will be inevitable.

Several cross-disciplinary application studies on impacts of climate variability and change relevant to Florida and possibly other regions are suggested as a way to move forward in developing a sustainable and less vulnerable future for Florida.

Although it is pointed out in this document that sea level rise is one of the main issues confronting Florida in terms of the immediate impact of climate change, we have not included a description of it in this document. This is because there are several reports that have recently been released on sea level rise. They are listed below for our interested readers:

- i. Sea Level Changes in the Southeastern United States: Past, Present and Future (Mitchum 2011; available from http://coaps.fsu.edu/~mhannion/201108mitchum_sealevel.pdf)

- ii. Past and projected trends in climate and sea level for South Florida (Obeysekera et al. 2011; available from http://my.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/ccireport_publicationversion_14jul11.pdf)
- iii. IPCC workshop on sea level rise and ice sheet instabilities (Stocker et al. 2010; available from http://www.ipcc.ch/pdf/supporting-material/SLW_WorkshopReport_kuala_lumpur.pdf) Thirsty for answers: Preparing for the water-related impacts of climate change in American cities (Dorfman et al. 2010; available from <http://www.nrdc.org/water/thirstyforanswers.asp>)

iv. Florida Water Management and Adaptation in the Face of Climate Change: Climate Change and Florida's Water Resources

Principal/Leads: Leonard Berry, Marguerite Koch-Rose, Diana Mitsova-Boneva, Tara Root
Contributors: Frederick Bloetscher, Jorge Restrepo, Ramesh Teegavarapu, Jaap Vos, Nicole Hammer

The impacts of climate change on water resources management will have consequences for the economic sustainability and growth of the state of Florida. The state will be faced in the coming years with significant challenges for managing water in a highly dynamic and changing climate. Florida is expected to experience warmer temperatures, more prolonged droughts, higher precipitation events and more intense storms. The most important effects of these climate change impacts on water resources are increased threats on the sustainability of water supplies, flooding, and salt water intrusion in coastal areas, as well as threats to water quality.

The water resources white paper identifies specific water management and related energy and population issues that the state will have to address to increase its resilience and adapt to climate change. Florida currently has problems of limited groundwater supplies and recharge, and climate change will add to the uncertainty of future water supplies and demands of the state. Alternative water sources, such as desalination and reuse, will be significant components of Florida's future water supplies, along with conservation measures, to maintain sustainable water supplies under increased frequencies of droughts.

In addition to the challenge of developing alternative water supplies, high precipitation events and sea level rise poses several threats; most notably flooding of low-lying coastal areas, salt water intrusion into coastal aquifers, and migration of salt water inland through coastal canals and rivers that will be difficult to control. If tropical storm intensity increases, storm surges in coastal areas and added flooding on top of a higher groundwater table may overwhelm current flood control structures and impact infrastructure systems. The state will require unique regional solutions based on their vulnerability to different climate and sea level rise scenarios.

Regional and local assessments need further and more detailed analysis for specific adaptation planning. Further, implementation will take time, many decades in some cases, to develop new approaches and technologies for water supply, redesign and construct more robust flood control infrastructure, and high sea level protection systems. Although these are challenges, there are multiple academic, governmental, non-governmental, and private sector institutions that are

capable and prepared to work together to increase the resilience of the State of Florida's water management infrastructure to climate change.

V. Conclusions

There have already been real and tangible benefits to inter-university cooperation on climate issues in Florida. Florida State University's modeling and meteorological skills blended well with University of Florida's biodiversity and agricultural expertise and were complemented by Florida Atlantic University's focus on adaptation, water management and sea level rise impacts. This skill and experience set could be further enhanced by the addition of two or three other universities to this core, possibly University of South Florida (education network on climate change and new cities approach) and University of Miami (wide range of climate change science expertise).

1. With respect to the complex science of climate and the vital implications for Florida's future, it is clear that university-based science is well respected by agencies and the public.
2. The findings on current and potential future impacts are vital for Florida's economy. Understanding the impacts and responding to these climate impacts through careful short, medium, and long-term planning will allow key sectors such as Tourism, Construction, Agriculture, Natural Resources Management, and Services continue to be important for the state.
3. Numerous direct economic benefits are associated with conserving Florida's natural resources, including tourism, recreation, and fisheries. Maintaining species and ecosystem resiliency is critical to conserving Florida's biodiversity and the many economic and environmental services that it provides. This biodiversity is already responding to climate change in marine and terrestrial species as well as invasive species, and these changes elevate extinction risks for Florida's numerous endemic species. Fortunately, there are many agencies, institutions and scientists in Florida who can facilitate improved research and adaptive management of these resources.
4. Sea levels are rising around Florida's coast, threatening the built environment and natural systems. Some coastal areas are already being influenced by periodic street flooding and loss in effectiveness of some water management structures. Thus, sea level rise is an immediate threat that is already causing responsible coastal agencies to factor sea level rise into their decisions. Several recent studies by the Florida Climate Institute and by the South Florida Water Management District provide new scientific information on how much sea levels will rise over time, including a range that represents current scientific understanding. This new information can be used by decision and policy makers, taking into account the tradeoffs among costs and economic and environmental risks.
5. The most important effects of climate change on Florida's water resources are increased threats on the sustainability of water supplies, increased flooding and more salt water intrusion. When combined with projected increases in population, water managers and policy makers face new challenges that will require explicit consideration of projected climate change when planning for new or replacement infrastructure, ways of managing water during droughts and policies that help ensure adequate and equitable supply of fresh water to meet future demands.

6. A climate-smart workforce is critically needed in Florida in all public and private agencies and businesses. Although there are good examples where various universities are teaching the next generation of Floridians about climate change, its potential impacts and options for societal adaptation and mitigation responses, more efforts are needed in formal university courses, including those that are preparing future K-12 teachers and continuing education to help agencies meet their goals of understanding and preparing for climate change in Florida.
7. There are many good examples in Florida of climate change planning by urban, county, regional and state agencies. Several examples were highlighted in the November workshop, including those by the Florida Fish and Wildlife Commission, the Southeast Florida Climate Change Compact (4 County Compact), Tampa Bay Water, South Florida Water Management District, Florida Power & Light, Plum Creek Development, ICLEI, and the Florida Department of Transportation. These initiatives include input by faculty from one or more of the universities in Florida, highlighting the importance of collaboration between universities and public and private agencies in Florida.
8. Information on future climate change projections is needed at local scales where vulnerabilities can be evaluated and decisions made to avoid unwanted economic and environmental impacts or to take advantage of changes that may favor certain decisions.
9. Information on likely climate and sea levels at different future time periods is needed to enable decision and policy makers to know when to act to adapt to those anticipated changes. University research is addressing these needs through new initiatives to provide Florida-specific climate futures for use in planning responses that lead to the best economic and environmental outcomes.
10. Communication, through formal education systems, with professional groups, with the diverse public agencies, and with the private sector will be an important part of our state's response to climate change. The University system is a critical component of this effort.
11. The challenge will be to rethink ways in which we manage water, land, power, and other resources. Emerging initiatives such as the Southeast Florida Regional Climate Change Compact (http://www.southeastfloridaclimatecompact.org/documents/AppB_Policy.pdf) are beginning to chart a way to accomplish this.

VI. Recommendations

A number of recommendations were discussed in the workshops and included in each of the white papers. The most important recommendations based on all of our activities and interactions among universities and with external stakeholders are summarized here. One thread that was echoed in all the white papers deals with increased public awareness, outreach and education about climate change issues – both general public awareness and informed decision-making and action.

- Collaboration among universities in Florida needs to continue, building on what was initiated in this project, but expanded beyond the three universities that led the project to include other universities in Florida that have strong research and education programs on climate change. It is recommended that this be done by developing a state-wide

initiative that expands the Florida Climate Institute, which currently has only two participating universities. There was strong endorsement from local and state agencies for this collaboration. This recommendation came out of the biodiversity and water white papers as well as from discussions with university and external participants in workshops.

- As a part of this continued and broadened collaboration among universities, the web site developed in this project should be enhanced and maintained in the future. This would, provide a portal for expertise from the outside and information to enhance the opportunities for Floridians to compete for and attract federal support to address climate change research and education. Florida's universities already have individuals and some programs that are recognized nationally and internationally, but these have not achieved the same success as other strong climate change centers and institutes in the USA have had.
- Research is needed to increase knowledge about Florida's future climate and sea levels based on the most current scientific methods, taking into account the information needed by Florida's public and private sectors to make decisions and policies that will lead to economic and environmental benefits to the state and its citizens. Research is needed to find ways to make Florida less vulnerable in a future world exposed to climate anomalies to put it on a strong footing and on a path of progressive development.
- Although we found that there are various formal courses in our various state universities, more efforts need to be directed at creating climate-literate citizens in Florida. One recommendation is to promote a stronger integration of climate change education with other sciences and disciplines.
- Establish a state-wide, inter-institutional, and multidisciplinary minor or concentration on climate change to enhance the access of students to a variety of courses on climate change, and make information available to students throughout the state about courses and minors, encouraging them to take advantages of courses in other Florida universities when they are not available on the student's campus.
- It was also recommended that universities develop and deliver training curricula to enhance the knowledge and skills of university faculty (both teaching and extension) and K-12 science teachers on two main areas: 1) the integration of climate change education into their courses/programs, and 2) the translation of scientific concepts to multiple audiences.