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Landscape and Climate Science and Scenarios for Florida

A workshop sponsored by the Peninsular Florida Landscape Conservation Cooperative and North Carolina State University

NORTH CAROLINA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

U.S. Fish & Wildlife Service

Open-File Report 2014–1150

U.S. Department of the Interior
U.S. Geological Survey

Cover. Mangrove islands, upper Lostman's River, Everglades National Park, by Paul Nelson, U.S. Geological Survey

U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2014

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Landscape and Climate Science and Scenarios for Florida

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By Adam Terando, Steve Traxler, and Jaime Collazo

Introduction

The Peninsular Florida Landscape Conservation Cooperative (PFLCC) is part of a network of 22 Landscape Conservation Cooperatives (LCCs) that extend from Alaska to the Caribbean. LCCs are regional-applied conservation-science partnerships among Federal agencies, regional organizations, States, tribes, nongovernmental organizations (NGOs), private stakeholders, universities, and other entities within a geographic area. The goal of these conservation-science partnerships is to help inform managers and decision makers at a landscape scale to further the principles of adaptive management and strategic habitat conservation. A major focus for LCCs is to help conservation managers and decision makers respond to large-scale ecosystem and habitat stressors, such as climate change, habitat fragmentation, invasive species, and water scarcity.

The purpose of the PFLCC is to facilitate planning, design, and implementation of conservation strategies for fish and wildlife species at the landscape level using the adaptive management framework of strategic habitat conservation— integrating planning, design, delivery, and evaluation. Florida faces a set of unique challenges when responding to regional and global stressors because of its unique ecosystems and assemblages of species, its geographic location at the crossroads of temperate and tropical climates, and its exposure to both rapid urbanization and rising sea levels as the climate warms.

In response to these challenges, several landscape-scale science projects were initiated with the goal of informing decision makers about how potential changes in climate and the built environment could impact habitats and ecosystems of concern in Florida and the Southeast United States. In June 2012, the PFLCC, in partnership with North Carolina State University, convened a workshop at the U.S. Geological Survey (USGS) Coastal and Marine Science Center in St. Petersburg to assess the results of these integrated assessments and to foster an open dialogue about science gaps and future research needs. This is one of two planned workshops that will be used to provide input for the PFLCC strategic plan. The second workshop will focus on management priorities and objectives, while this workshop focused on current scientific knowledge and research gaps. Five objectives were identified for this workshop:

- Examine results from current or recently completed integrated science projects that involve the PFLCC region.
- Examine approaches to decision analysis that have been applied in the Southeast or that could be applied in the PFLCC.
- Discuss current research efforts that will support PFLCC strategic planning goals and activities over the next 1 to 3 years.

- Identify science gaps or unfunded priorities that will be a focus of the PFLCC science implementation plan.
- Provide the above-mentioned input to a second management-focused workshop

In addition, the workshop focused on four science themes that have particular salience in the PFLCC geography and within the integrated assessments examined:

Science Theme 1: Climate and Sea Level Rise Projections
Science Theme 2: Coastal Impacts
Science Theme 3: Ecological Models
Science Theme 4: Decision Analysis

The choice of these four major themes is based on the recognition that there are multiple forcings and threats that affect systems and resources in the PFLCC. Within these themes, there are at least four major drivers of landscape change that are the focus of these integrated assessments:

- Policy choices for land and water use;
- Human population growth and impact;
- Economic capacity to affect changes on the landscape and to adapt; and
- Climate change and sea level rise.

This report provides a summary of the science presentations given at the workshop that reflect the current state of knowledge in the PFLCC with regard to how these drivers act in concert on ecosystems today, and the potential changes that could occur in the future. A summary is provided for several additional themes that emerged from participant discussions that speak to the workshop objectives. Finally, several recommendations are presented based on the information and discussions that occurred during the workshop.

Science Presentations

One of the principal objectives of the workshop was to provide an overview of the different landscape-level scientific assessment projects that cover the PFLCC geography. Following is a summary of each presentation, as well as short descriptions of the three integrated assessments that were associated with multiple workshop talks.

Southeast Regional Assessment Project

The Southeast Regional Assessment Project (SERAP) is a USGS-funded, integrated assessment that seeks to employ state-of-the-science climate and landscape projections to develop robust management strategies in response to global change in the Southeast United States (see fig. 1). Drs. Adam Terando, Ryan Sriver, Nathaniel Plant, Jennifer Costanza, and Barry Grand gave presentations on various projects and concepts in the SERAP that related to the Climate and Sea Level Rise, Coastal Impacts, Ecological Modeling, and Decision Analysis workshop science themes.

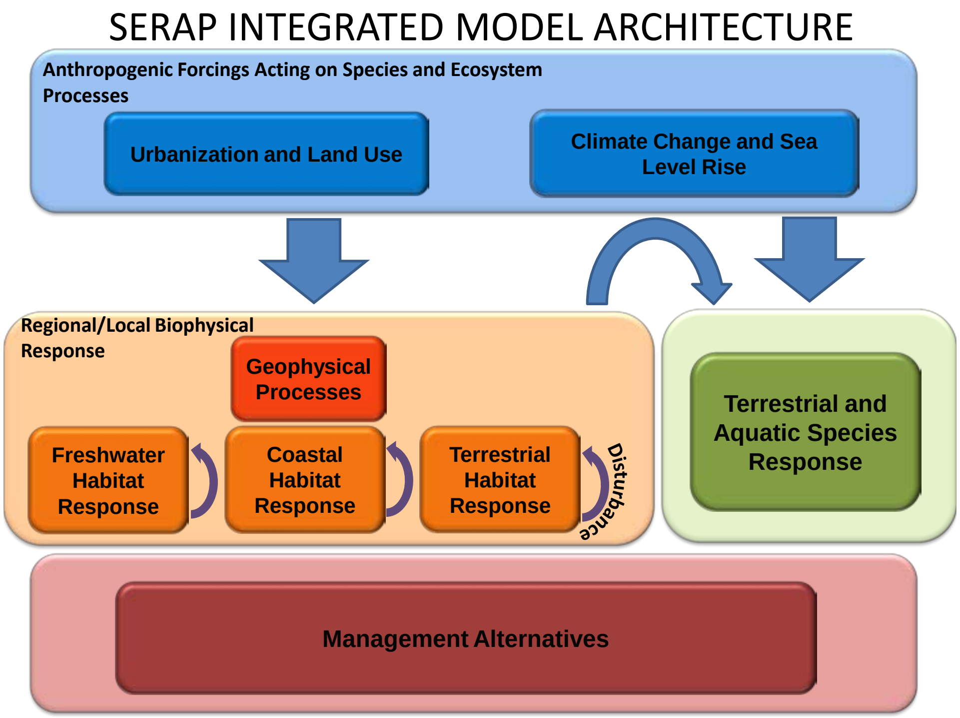

Figure 1. Southeast Regional Assessment Project (SERAP) modeling framework. Drs. Terando and Sriver discussed the results and approach to the climate change and sea level rise forcings. Drs. Plant and Costanza discussed the biophysical response for coastal and vegetative systems.

Presentation 1: Climate Modeling Results from the Southeast Regional Assessment Project – AdamTerando

Dr. Terando of North Carolina State University discussed the results from the downscaling work completed as part of the SERAP. These are statistically downscaled projections of daily temperature and precipitation available at a 12-km resolution for the entire Southeast United States for the years 1960–2099. There is a consensus among the downscaled models that there will be significant warming towards the latter part of the 21st century, including increases in extreme heat. The precipitation response is more uncertain, although there is some evidence of model projections showing increases in precipitation intensity and shifts in seasonality. The SERAP project used four greenhouse gases (GHG) emission scenarios and Dr. Terando noted that the most extreme of those scenarios (known as the "A1Fi" scenario) was not heavily used in the last Intergovernmental Panel on Climate Change (IPCC) assessment by the global climate modeling (GCM) groups, likely due to the perception that the prescribed GHG emissions were too extreme. However, our current emissions trajectory most closely tracks this scenario, highlighting the need for decision makers to consider these extreme scenarios when thinking of future adaptive actions.

Presentation 2: Regional and Global Sea Level Rise Projections Using an Earth System Model of Intermediate Complexity (EMIC) – Ryan Sriver

Dr. Sriver from the University of Illinois discussed problems with characterizing the decision-relevant uncertainties in the current generation of sea level rise (SLR) predictions. This problem was visualized in a graphic showing the predicted SLR by 2100, according to 15 different published studies from the early 1980s to the present. Disconcertingly, the range of predicted SLR was quite large in the earliest studies (reflecting a lack of knowledge about the system and our ability to simulate the response to a climatic perturbation), but then substantially contracted in the 1990s and early 2000s before increasing again in the latter part of the decade. This suggests a prevalence of overconfidence in the model results and a lack of convergence in SLR predictions as we accumulate more and more knowledge about the system. Dr. Sriver introduced the concept of an Earth system Model of Intermediate Complexity (EMIC) as a means to better characterize the parametric uncertainty in SLR predictions. An EMIC is a compromise between more complex models that are mechanistically sound but computationally inefficient, and simpler models that are more tractable but lack realism. For the SERAP, he and colleagues used an EMIC (called the UVic) to construct a 250-member ensemble of hindcasts and projections of regional SLR. The EMIC samples plausible values from three parameters (climate sensitivity to GHG, ocean diffusivity, and radiative effects of aerosols) that are important in determining the actual realized thermosteric SLR. The results show an increased global uncertainty bounds of roughly 30 cm, in addition to the overall uncertainty in SLR due to ice melt. The goal is to incorporate these results into Dr. Nathaniel Plant's model of shoreline change (see summary below).

Presentation 3: A Bayesian Approach for Predicting Shoreline Change – Nathaniel Plant

Dr. Plant, from the USGS Coastal and Marine Science Center, discussed a general framework for quantitatively addressing uncertainty in coastal dynamics, climate, and potential management actions. Dr. Plant and Dr. Thieler have developed a Bayesian approach that maps relationships between key drivers of coastal inundation due to SLR and the uncertainty in those processes. As more information becomes available, either through better models, better data, or as time progresses, the variables' probability density functions (pdfs) are updated to reflect the updated state of knowledge (fig. 2). This framework allows us to connect diverse management problems that nevertheless have common variables, and to keep track of this uncertainty. These results are being used for the SERAP and the La Florida integrated assessments.

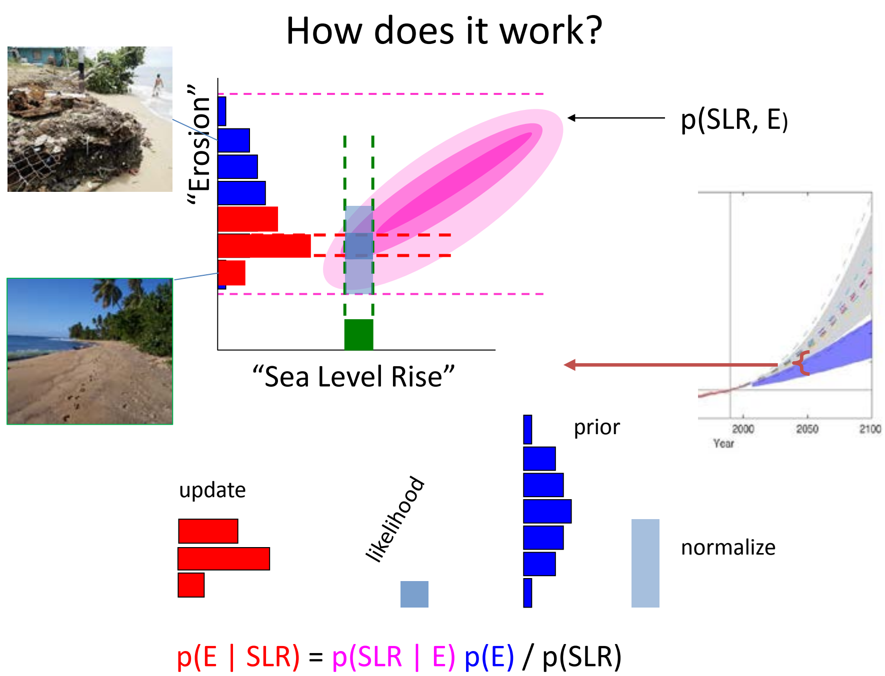

Figure 2. Bayesian approach to deriving probabilistic projections of coastline erosion due to sea level rise (SLR). “Prior” probabilities of erosion (E) (blue histogram) are derived from historic data and expert opinion. These probabilities are updated based on the SLR projections and its relationship to the erosion rates (the likelihood). The result is a probability density function of “posterior” probabilities (red histogram) that reflects our updated state of knowledge due to the inclusion of future potential SLR.

Presentation 4: SERAP Vegetation Dynamics and Urban Growth Modeling – Jennifer Costanza

Dr. Costanza from North Carolina State University presented the results from the vegetation dynamics and urban growth modeling undertaken as part of the SERAP project. The urban growth model, SLEUTH, is a cellular automata model where urbanization is simulated according to a set of “growth rules.” Each location in the study area has a probability of becoming urbanized, depending on the parameterizations of these growth rules. Monte Carlo simulations were used to characterize uncertainty in the projections, which are now complete for the entire SERAP study area. Vegetation dynamics are simulated by coupling an aspatial state-and-transition model (VDDT) with a spatial contagion model (TELSA). The model includes the urbanization projections, sea level rise projections from the Sea Level Affecting Marshes Model, and projected fire regime changes based on the downscaled climate projections. The outputs include transition maps that show the proportion of the landscape that shifts to different states within a defined habitat class or to another land use type due to urbanization or sea level rise. The model has not yet been applied in the PFLCC but the framework would allow it to be ported there.

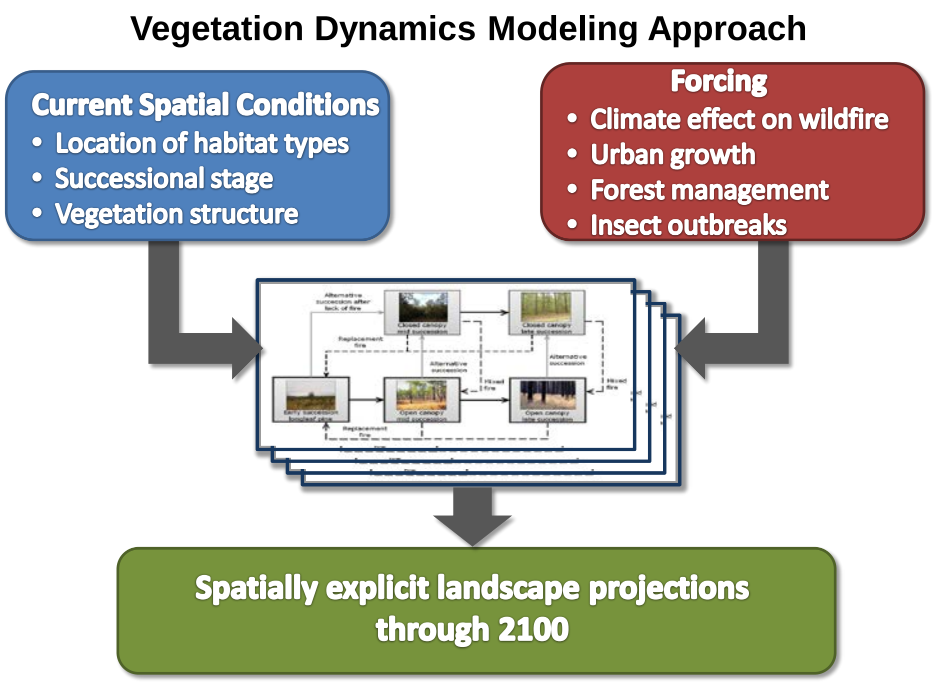

Figure 3. Framework for modeling vegetaiton dynamics as part of the Southeast Regional Assessment Project using an aspatial state-and-transition model (VDDT) and using a spatial contagion model (TELSA).

Presentation 5: Prototyping Optimal Conservation Strategies – Barry Grand

Dr. Grand from Auburn University discussed the process involved in helping conservation partners choose conservation strategies that maximize a set of objectives. To date, this work as it relates to the Southeast Regional Assessment Program is being conducted in the South Atlantic LCC. The alternative scenarios involve a status quo or “business-as-usual” scenario and an alternative strategy that seeks to select the ”best” conservation sites each year that over time will help restore two priority systems—open pine ecosystems and flood-plain forests. Using the urban growth, sea level rise, and vegetation succession models from the SERAP, the model projects the state of ~115,500 National Hydrography Dataset catchments in response to the changing landscape and the considered management actions. The results are predictions of sites that provide the greatest value (or return on investment) in order to maximize the set of objectives as defined by the LCC.

South Florida Scenarios for Conservation Planning

Presentation: Developing Scenarios for Peninsular Florida Landscape Conservation Cooperative Strategic Conservation (PFLCC) Planning – Mike Flaxman

Dr. Flaxman of GeoAdaptive and MIT discussed efforts to design scenarios of urbanization and sea level rise (SLR) that identify key actions, areas, and partners necessary to accomplish large landscape scale conservation. The scenarios use the statewide land parcel data available in Florida combined with Florida Natural Areas Inventory (FNAI) land cover and habitat data, lidar-based terrain data, and census data. These datasets are used in two scenarios—“Business as Usual” (BAU) and “Proactive” (PRO)—where the BAU simulates future landscape patterns assuming urbanization occurs to the limit of economic feasibility, coastlines are armored in response to SLR, and retreat from the coastline only occurs when physically or economically necessary. The PRO scenario differs in the development and is excluded from occurring in areas predicted to be inundated due to SLR. In both scenarios, conservation-directed resources are allocated to the remaining priorities (after urbanization) while accounting for protected areas that are predicted to be inundated. The resulting “conflict-maps” (fig. 4) that compare competing priorities and needs are being used by the PFLCC in their strategic conservation planning.

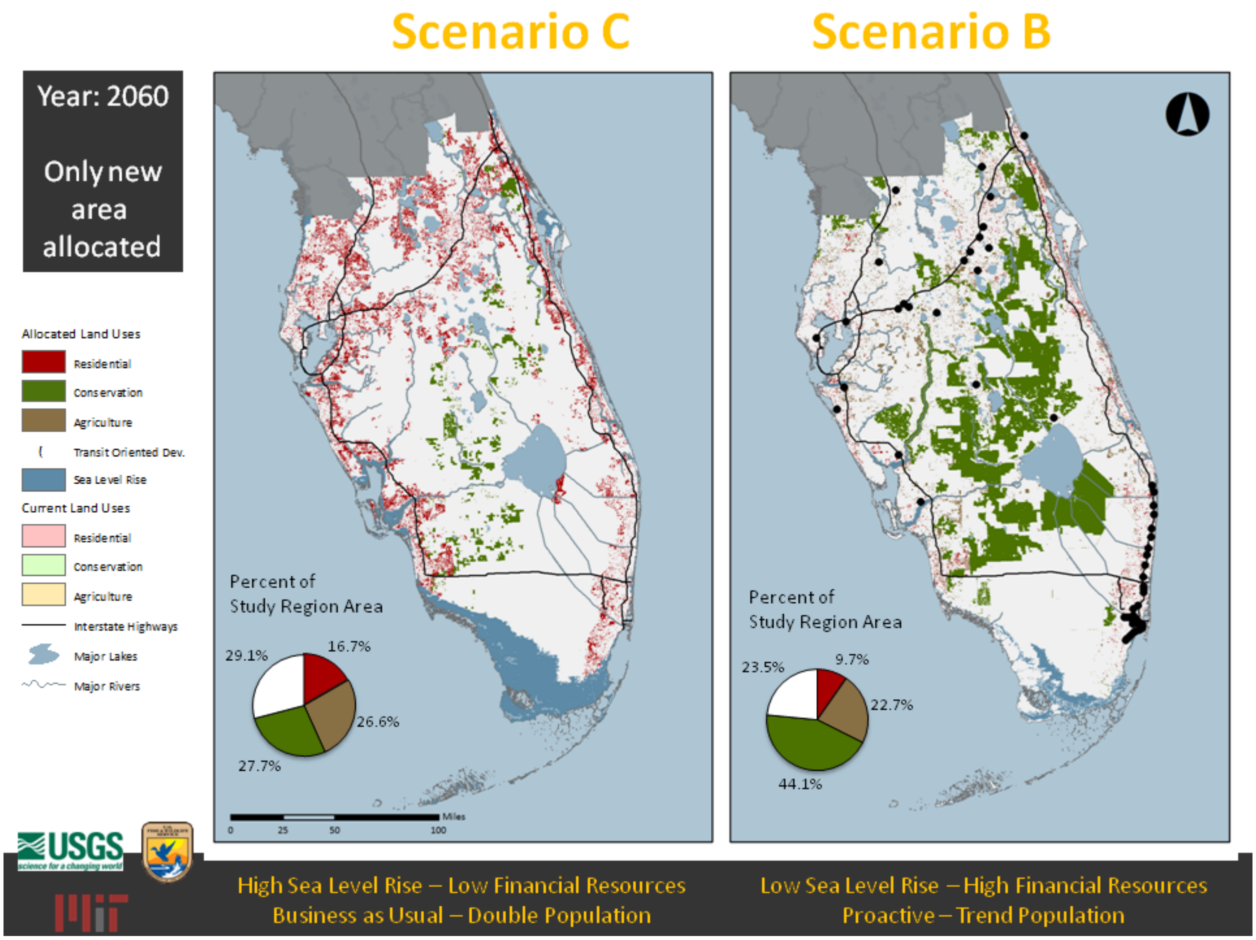

Figure 4. Example of landscape projection using land use and sea level rise scenarios developed by GeoAdaptive team.

USGS "La Florida" Project

The La Florida Project is a USGS-sponsored project composed of an interdisciplinary research team that is developing dynamically downscaled climate projections for Florida. The goal is to use these projections to drive a suite of previously developed ecological and hydrological models to assess the climate vulnerability of species, communities, and habitats in two focal regions (Suwannee River, and Big Bend and the Everglades).

Presentation 1: Climate Modeling Results from La Florida – Vasu Misra

Dr. Misra discussed the results from the dynamically downscaled climate projections produced as part of the La Florida project. He focused on differing projections of the Florida wet season from the two general circulation models (GCMs) used in the project. One advantage of using dynamically downscaled projections (that is, nested regional climate models (RCMs) within GCMs) is the ability to directly examine the climate dynamics as simulated by the GCMs and RCMs and identify the reason for structural uncertainty between models. Two GCMs (CCSM3 and HADCM3) and one RCM (Regional Spectral Model or RSM) are used in La Florida. The RSM resolution is 10 km compared to 1.4^{o}x1.4^{o} and 3.75^{o}x3.75^{o} for the GCMs (fig. 5). The results show different patterns of downscaled precipitation in the Southeast and Florida, with the HadCM3 showing more increases in precipitation (coupled with a much drier south Florida) and the CCSM3 showing less precipitation throughout the region. Dr. Misra attributes these differences to the different sea surface temperature (SST) projections, which then result in differing patterns of atmospheric stability and the location of the Bermuda High.

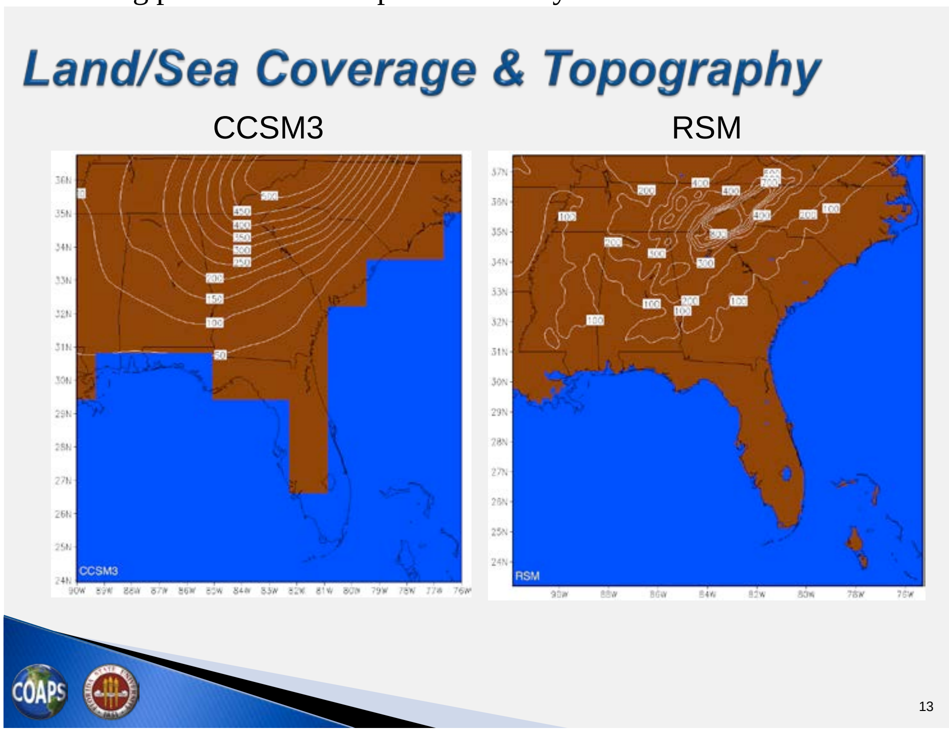

Figure 5. Horizontal resolution for one of the two general circulation models (CCSM3) used in the La Florida project compared to the regional spectral model (RSM).

Presentation 2: Ecological Modeling Results from La Florida – Tom Smith

Dr. Smith discussed the ecological and hydrological modeling results from the La Florida project. Two hydrodynamic models are used that simulate flow, salt transport, and tides. Using these models, Dr. Smith pointed out that in one scenario, the hydrodynamic models showed that sea level rise impacts could be mitigated with restoration activities. For ecological modeling, La Florida uses the Spatially Explicit Species Index and Across Trophic Level System Simulations, a suite of models for species and habitats in the Everglades that is also used by resource managers in south Florida. MaxEnt is also being used to develop climate envelope models to project potential northward range shifts for mangroves.

Intercomparison Presentation: Comparison of Statistical and Dynamical Downscaling Results – Adrienne Wootten

Adrienne Wootten from North Carolina State University presented the initial results from a comparison of the Southeast Regional Assessment Project (SERAP) and La Florida downscaled projections for the Peninsular Florida Landscape Conservation Cooperative geography. The comparison is part of a Climate Science Center-funded project examining differences between statistically downscaled projections (such as those from the SERAP) and dynamically downscaled projections (for example, the La Florida Project). The results show greater differences between projected daily maximum temperatures than daily minimum temperatures. Using the common reference period of 2041–2070 for the A2 (high) emissions scenario, the comparison shows daily maximum temperature increases of 2.5 to 4 °C and daily minimum temperature increases of 1.5 and 2.5 °C. The precipitation comparison shows large differences in projected changes and in the pattern of changes (fig. 6). The ensemble mean from SERAP projections shows a gradual decrease in projected precipitation from the Tampa Bay area to the Everglades and Miami region. Conversely, the La Florida projections show a steep gradient from increased precipitation near Miami to large declines in precipitation across most of the interior of the peninsula. These results suggest significant structural uncertainty between downscaling approaches that should be taken into consideration when using projections.

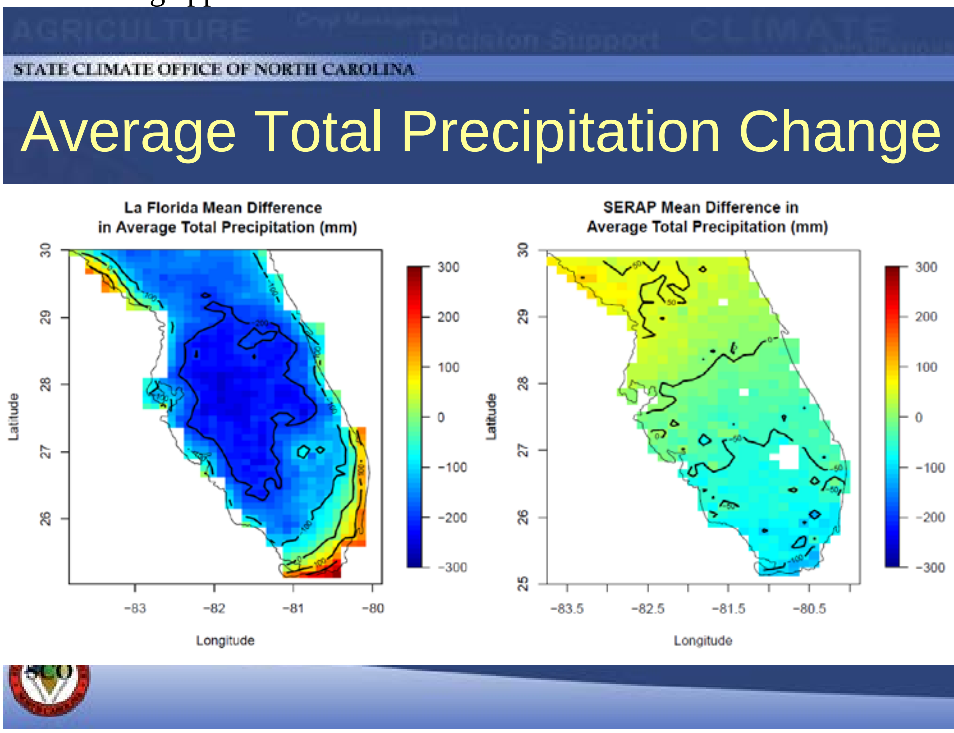

Figure 6. Comparison of precipitation projection for La Florida and the Southeast Regional Assessment Project (SERAP). Anomalies are shown in terms of differences in 2041–2070 precipitation compared to 1971–2000.

Other Science Theme Talks

Coastal Impacts Presentation: Sea Level Rise for Impacts Assessment in Florida – Joshua Reece

Dr. Reece gave an overview of a sea level rise (SLR) vulnerability assessment for Florida that focuses on identifying the intersection of vulnerable species, taxa, and habitats with their adaptive capacity, conservation value, and information availability. Four SLR scenarios were used representing increases of 0.5, 1, 2, and 3 meters, along with population scenarios developed with the MIT research group. Dr. Reece laid out a four-step approach to their vulnerability assessment:

1. Identify taxonomic and ecologically representative species of Florida (results in ~1,000 species).
2. Use climate and population change information to refine this list to retain species that are most vulnerable to SLR (~300 species).
3. Use the vulnerability to identify species that have the highest risk of extinction (~100 species).
4. For each species and habitat type, create environmental niche models, spatially explicit demographic models, and detailed conservation plans under projected population growth models

for 2050 and 2100; SLR scenarios for 0.5, 1.0, 2.0, and 3.0 meters; and an ensemble average for climate change scenarios.
5. Provide final conservation recommendations for statewide adaptation planning.

Vulnerability to SLR is assessed using the Standardized Index of Vulnerability and Value Assessments. One insight from this work is that species could be vulnerable to SLR, but there is not enough known about life history to be able to make recommendations. To date, the results show that for the scenarios and species considered, invertebrates and reptiles have the highest vulnerability; plants have highest adaptive capacity; and mammals, reptiles, and birds have the highest conservation value. This work also extends to corridor suitability where the goal is to identify paths that could serve to link sources of vulnerable species to existing refuges.

Ecological Modeling Presentation 1: Results from Critical Lands and Waters Identification Project –

Jon Oetting and Tom Hoctor

Dr. Oetting discussed the origins, purpose, and future of the Critical Lands and Waters Identification Project (CLIP), a statewide natural resource spatial database. The CLIP identifies and maps data layers that describe the State's "green infrastructure," including patterns of biodiversity, landscapes (for example, greenways), surface water, groundwater, and marine systems. The CLIP is an outgrowth of previous research and conservation efforts spanning the past 20 years. The goal is to build off of Florida's conservation and land acquisition programs to help identify areas that are the highest priority for conservation. While not a plan itself, the CLIP can be used for conservation planning and strategic habitat conservation (SHC). To date, there is a technical advisory group with plans to incorporate a stakeholder advisory group in the future. The current iteration of the CLIP (CLIP 2.0) also maps priority conservation areas that could be impacted by SLR and urban growth (fig.7). Dr. Oetting outlined several objectives for the CLIP 3.0 database:

- Update CLIP core data layers with new information, including but not limited to land use change and climate change (primarily SLR).
- Revisit the prioritization of CLIP core data layers and aggregate models with respect to climate change.
- Evaluate the importance of coastal-to-inland connectivity with respect to SLR, and identify potential corridors.
- Evaluate the landscape context of CLIP priority areas to identify potentially compatible and incompatible surrounding land uses.
- Address conservation needs for water-restoration purposes, including opportunities for dispersed water storage.
- Evaluate ecosystem services provided by coastal natural areas with respect to storm protection and SLR.
- Categorize CLIP priority areas based on potential conservation strategies that could be applied to each area.
- Assess the potential impacts of SLR on federally designated critical habitat.

Dr. Oetting discussed how the CLIP is being using for SHC in a project called the Cooperative Conservation Blueprint (or the Blueprint). There is a regional pilot study in southwest Florida and the northern Everglades. The goal is to create a regional science-based map of landscape-scale conservation priorities (a regional CLIP) with a strong stakeholder emphasis that also examines ways to use existing incentives and new incentives to protect areas.

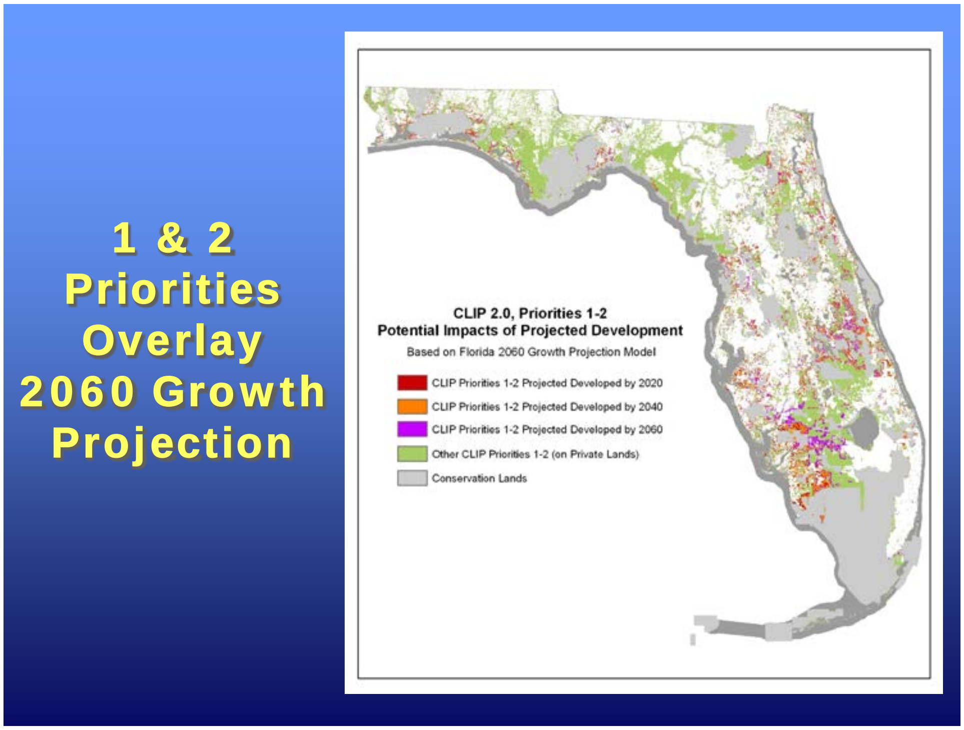

Figure 7. Intersection of high-priority Critical Lands and Waters Identification Project (CLIP) sites and projected time of development based on urbanization projections.

Ecological Modeling Presentation 2: Probabilistic Vegetation Succession Modeling Results With Sea Level Rise – Leonard Pearlstine

Dr. Pearlstine discussed his research in the Florida Everglades, which uses the vegetation succession model, Everglades Landscape Vegetation Succession (ELVeS). This is an empirical, probabilistic model that produces an overall joint probability distribution of vegetation community presence (fig. 8). In essence, the model predicts which vegetation community is most likely to occur at a site based on the probability distributions of six variables (for example, local hydrology, salinity, and topography). If a different community exists at a site, it may take several years of unfavorable conditions for the existing community before it switches to a new community. The model provides user flexibility with the ability to define communities, variables, and the relationships between them.

The model works well; for example, the accuracy rate for mangrove predictive mapping was 91 percent, although there were errors along transition boundaries with salt marsh and freshwater marsh. Some issues with the model are apparent in the erroneous prediction of fresh marsh and pine on some coastline locations. Future versions of ELVeS should correct this problem with the addition of “neighborhood awareness.” Other additions that could improve the model performance include better coastal-elevation profiles, inclusion of storm and fire events, accretion and subsidence rates, increased vertical resolution of the hydrologic models, and more long-term data on varying salinity levels along the coast under wet/dry-season and storm-event scenarios.

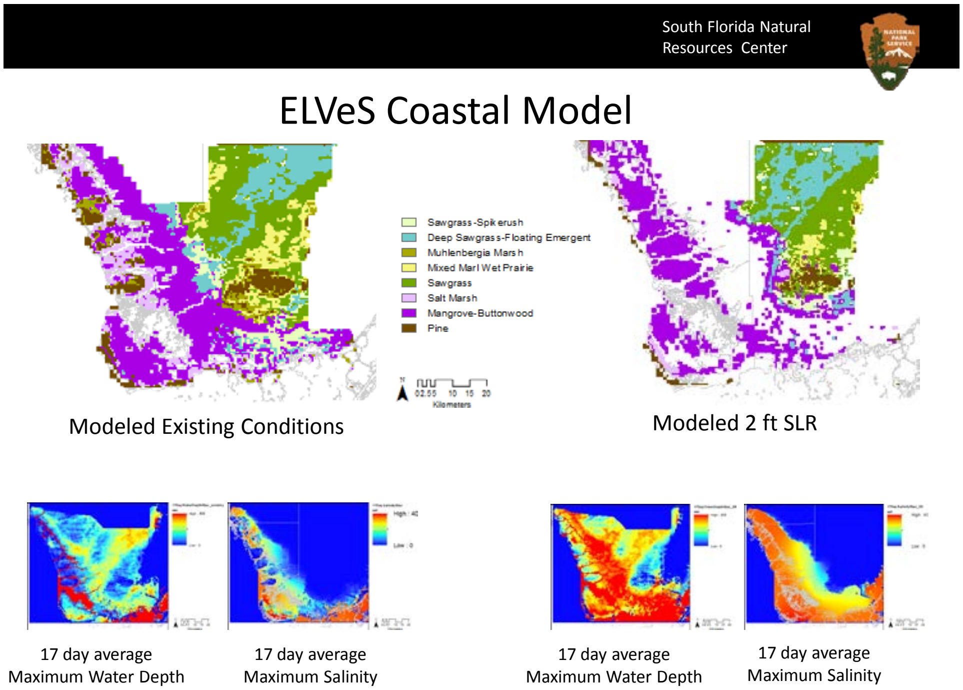

Figure 8. Sample results from the Everglades Landscape Vegetation Succession coastal model showing projected changes in vegetation communities in southwest Florida under a 2-foot sea level rise scenario.

Ecological Modeling Presentation 3: Spatial Prediction Maps from Climate Envelope Models: What Can They Tell Us? – Stephanie Romañach

Dr. Romañach, USGS research ecologist, discussed an approach to using climate envelope models (CEMs) to predict species presence and suitability under future climate scenarios. Currently, she is leading a project to develop models for 26 threatened and endangered (T&E) species in Florida. The goal is to build a flexible framework that can be applied to other species and regions. For the current model, they have developed projections showing the number of expected T&E species in refuges now compared to the future with climate change (based on IPCC emission scenarios A1b (mid) and A2 (high)). The climate variables used in the CEM include monthly mean temperature and precipitation calibrated on 50 years of observations (1950–1999) with projections for 2040–2059. An analysis of variance approach was used to characterize uncertainty in the CEMs. Results from the GeoAdaptive urbanization simulations are also being included in the simulation runs, and a guidebook detailing practical use and interpretation of CEM results is being developed. An example of the CEM for Florida refuges is shown in figure 9 below.

Spatial overlap of climate envelope models with U.S. Fish and Wildlife Service refuges

	10-12 T&E species	7-9 T&E species	4-6 T&E species	1-3 T&E species
Contemporary	10 refuges	22 refuges	28 refuges	100+ refuges
Mid-century: A1B		5 refuges	52 refuges	100+ refuges
Mid-century: A2		11 refuges	52 refuges	100+ refuges

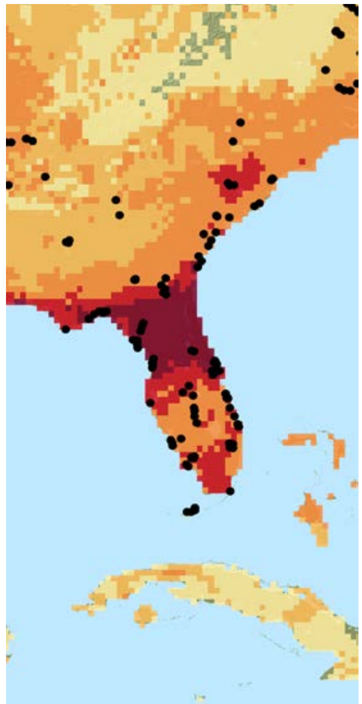

Figure 9. Projected changes in spatial overlap of Threatened and Endangered (T&E) species with U.S. Fish and Wildlife Service refuges under a "mid-"and "high- emissions" scenario.

Data Portal Demonstrations

Presentation 1: The Geo Data Portal – Jordan Walker

Jordan Walker from the USGS Center for Integrated Data Analytics (CIDA) gave a demonstration of the Geo Data Portal (GDP). The GDP is a Web-based portal application that provides access to global change datasets, particularly climate model output, in formats that are useful for ecological research. One feature of the GDP is the ability to upload shapefiles, or other user-defined areas of interest, and then retrieve model output for that area for the specific variables needed in the analysis. In addition to the GDP, there is a related project tentatively called the "Derivative Portal." This portal uses a dataset of statistically downscaled global climate models (12-km resolution) and calculates projections of one or more predefined temperature and precipitation thresholds (for example, projected annual days above 90 ^{o}F). More information about the GDP and derivative portals is available at *http://cida.usgs.gov/gdp/*, and in a recent webinar given by Nate Booth and Adam Terando for the National Conservation Training Center, available at *https://nccwsc.usgs.gov/webinar/114*.

Presentation 2: EverVIEW Data Viewer - Stephanie Romañach

Dr. Romañach gave a demonstration of the EverVIEW visualization program. This program helps ecologists working in the Everglades to quickly retrieve and visualize different environmental datasets for ecological modeling. In particular, the model is geared towards graphical display of NetCDF data, an increasingly common data format for use in global change research. A description of the model is available at *http://www.jem.gov/Modeling* and *http://pubs.usgs.gov/fs/2010/3046/*. Conzelman and Romañach (2010) summarize the purpose and utility of EverVIEW as follows:

"As modelers who study the Everglades increase their use of NetCDF for storing data, the need for powerful visualization software grows. Applications such as the EverVIEW Data Viewer meet that need by enabling users to inspect model output values in tabular form, understand the characteristics of the dataset with charts, and view modeling data spatially on a three-dimensional earth model. The USGS and JEM [Joint Ecosystem Modeling] are committed to working with natural resource managers and the modeling community to produce powerful visualization tools that help decision makers and scientists better manage and restore the complex systems placed in their care."

Emerging Themes from the Workshop

Several emerging themes became apparent during the respective science, panel, and group discussions. These themes formed the basis for the workshop recommendations put forward by the participants in the final workshop session.

Dr. Gerard McMahon, director of the USGS Southeast Climate Science Center, outlined the first emergent theme in terms of "Wicked Problems." The types of research problems being tackled by the scientists at the workshop are complex and multidimensional, involving multiple drivers and large uncertainties. The challenges associated with these problems point to the other emergent themes discussed during the workshop:

1. Defining endpoints and objectives as being critical to success;
2. The difficulty of defining and measuring "sustainable" landscapes;
3. Living with uncertainty while also working to characterize and reduce it;
4. Data overload for ecologists and biologists working on global change problems;
5. The need to improve linkages between scientific investigations; and
6. The need to prioritize the communication of science and to work for stakeholder buy-in.

In regard to the first theme, Dr. McMahon discussed the importance of defining endpoints in order to pass the "So what?" test. This typically entails providing results and metrics in a form that can be commonly understood and connected to human well-being or something that is valued by society. This theme was reiterated multiple times during the workshop. Dr. Grand discussed the importance of having well-defined objectives at the beginning of the structured decision making process. This will facilitate the scientific process in its role of defining, modeling, and predicting a set of alternative actions that can be taken by decision makers.

Another emergent theme centered on the question of how we promote and measure sustainability across landscapes. From a planning perspective, it was suggested that the Peninsular Florida Landscape Conservation Cooperative (PFLCC) can promote sustainability efforts by aligning its goals and objectives (to the extent practicable) with other LCCs and with regional and national strategies, such as the Southeast Conservation Adaptation Strategy. Several types of metrics were discussed that could be used to assess the sustainability (or vulnerability) of a system. It was mentioned that static assessments are still a useful tool to identify vulnerable systems (for example, due to sea level rise) and for use as a course planning filter. Specific metrics identified include ecological and biological measures of persistence, population viability, and functional ecosystem processes (for example, hydrology). Gaps in the ability to produce these metrics were identified, particularly in data on life history traits for species and biological and ecological thresholds. It was recommended that the PFLCC take a leading role to clarify which natural resource metrics are most appropriate for Florida.

The theme of uncertainty was pervasive throughout the workshop, as would be expected given the nature of these "wicked problems." Several speakers highlighted the importance of using a probabilistic framework to quantify and characterize what is known and not known about the system. Dr. Plant showed the value of Bayesian analyses for linking disparate variables and nodes that drive system change. Dr. Sriver also emphasized that we cannot ignore low probability events for two reasons: (1) while the event may have a low probability of occurrence, the consequences of the event could be very high (for example, storm surge overtopping a wall or a dune), and (2) our "best" estimate of the range of uncertainty may be overconfident, and indeed may become larger rather than smaller through time, learning that our knowledge of the system is more incomplete than previously thought. Dr. Flaxman suggested that one way to "live with" this daunting challenge is by constructing scenarios to test system responses that are robust to uncertainty and a variety of possible future actions.

Dr. Smith brought up the issue of "data overload," where biologists and ecologists attempt to conduct a scientific investigation in service of some decision or objective; however, the amount of variables and models to consider risks can be overwhelming. The concern is that this could lead to "paralysis by analysis," where time and resources are tied up in learning new methods and models to address a particular driver. The discussion pointed to the need for guidance on methods and models and a set of best practices that hopefully will mitigate some of the sunk costs that occur when scientists undertake complex, integrated assessments.

Along the lines of the "wicked problems," there also was discussion of the need for improved linkages both within and between landscape-level scientific investigations. Within investigations this must be done early in the process so that scientists from different disciplines have a similar language within which to operate, and a clearly defined plan for how the data, model, and tools are linked together. Integration between investigations could be improved through more use of data portals that already house large datasets (such as EverVIEW and the GDP) and data standards (such as the Open Geospatial Consortium, or OGC standards and NetCDF). All of these efforts help to leverage resources and build science capacity.

A final emergent theme was the importance of science communication and its relation to stakeholder buy-in. It was stressed that the tools developed by scientists for decision analysis must be user friendly. In addition, upfront science communication is important so that all parties have an understanding of the various (and often competing) values, goals, and objectives. The need for social scientists to bridge this gap was stressed. Other outlets for communication and stakeholder engagement were discussed, such as museums, "serious games" (a form of scenario exercises), and more user-friendly, decision-support tools and map products. Science communication was also voted as the top priority during the brainstorming session at the end of the workshop (see appendix B).

Recommendations from the Workshop Planning Team

Based on the vigorous discussion and the wealth of information presented at the workshop, the planning team proffers the following recommendations for consideration by the steering committee and the science team:

1. *To better inform the Peninsular Florida Landscape Conservation Cooperative (PFLCC) strategic plan and science plan, revisit the results and themes that emerged from this workshop, and compare with the results from the upcoming PFLCC management workshop.* If the outcomes and recommendations from both workshops exhibit significant areas of overlap, then the team charged with drafting the PFLCC strategic plan should be able to continue forward. If there is a significant mismatch between the science being performed and the tools being produced compared to the articulated needs of managers, then another workshop may be

necessary before the strategic plan is completed. Once the strategic plan is developed, then the PFLCC science plan can be completed.

2. *Work to ensure that the PFLCC science plan takes into account, and where possible, is harmonious with the science goals of the surrounding LCCs (Caribbean, Gulf Coastal Plains and Ozarks, Gulf Coastal Prairies, and South Atlantic) and the Southeast Climate Science Center.* This will help to leverage resources and promote the following coordinated conservation efforts:
    a. Expand vegetation dynamics work begun with the SERAP project into the PFLCC region.
    b. Compare urbanization model output from the SERAP and the MIT project to evaluate commonalities and major differences in projections.
    c. Ensure that science products that overlap at the boundary of the three LCCs in Florida are comparable and transparent, when possible.
    d. Develop a strategic science plan for the Southeast LCCs that at a minimum includes the PFLCC, South Atlantic LCC, and Gulf Coastal Plain and Ozarks LCC (ideally, would also include Gulf Coastal Prairies LCC and Caribbean LCC).
3. *Promote the use of climate and landscape scenarios that are relevant both for Florida and the surrounding region.* Given the computational resources required to develop these climate and landscape projections, the PFLCC should strive for consistent scenarios with other LCCs, if possible. For climate models, it is recommended that a minimum of two emission scenarios are selected, representing a high greenhouse gases (GHG) future and a low GHG future. Selecting a "middle-of-the-road" scenario may not be of much use as the likelihood of that future occurring is no higher than either of the two extreme options (and it is less useful from a planning and vulnerability assessment perspective).
4. *Explore options to create an online space through which researchers, managers, and other stakeholders could be directed to the appropriate portals to address their needs.* It is apparent from the workshop that there are a multitude of exciting and cutting-edge landscape-scale science initiatives. There are also several efforts to provide the accompanying infrastructure to serve scientists data and analysis needs in more effective ways. However, more outreach and communication is needed so that scientists are aware of these initiatives and tools. One possibility is to use the Griffin Group site as described by Dr. Ed Laurent (*http://griffingroups.com/*). This is currently being used to help build the Southeast Conservation Adaptation Strategy.
5. *Emphasize both "in reach" to agencies within the Department of the Interior and outreach to other agencies (for example, the National Oceanic and Atmospheric Administration and the U.S. Department of Agriculture), nongovernmental agencies, and other stakeholders such as private landowners.* This will be necessary to ensure the decision-support tools being developed are useful to managers and decision makers.
6. *Assess who the ultimate science end users are in the PFLCC and what are the most useful products for them.* Are the stakeholders of the PFLCC looking for large, integrated assessments that develop multiple alternative management scenarios, or species and habitat-centric research studies? Or are geographic information system products in more demand? A survey of end users may be helpful (perhaps partially conducted during the managers workshop) to match decision maker and researcher needs.
7. *Address which party or parties are responsible for hosting and serving data and products for the PFLCC.* Will this be a responsibility handled in-house by the Cooperative? Or will an

established entity, such as the USGS Center for Integrated Data Analytics, serve the data? Or will it be a completely distributed process with a link through some common portal such as the USGS Geo Data Portal?

Appendix A. List of Abbreviations

A1b	IPCC emissions scenario used in the third and fourth assessment reports representing a "mid-range" emissions scenario
A2	IPCC emissions scenario used in the third and fourth assessment reports representing a "higher end" emissions scenario
BAU	Refers to any "business-as-usual" scenario that reflects current policy or actions.
CCSM3	Third Generation National Center for Atmospheric Research Community Climate System Model
CEM	climate envelope model
CIDA	USGS Center for Integrated Data Analytics
CLIP	Critical Lands and Waters Identification Project
ELVeS	Everglades Landscape Vegetation Succession model
EMIC	Earth system Model of Intermediate Complexity
FNAI	Florida Natural Areas Inventory
GCM	global climate model or general circulation model
GDP	USGS Geo Data Portal
GHG	greenhouse gases
GIS	geographic information system
HADCM3	Hadley Center Coupled Model, version 3
IPCC	Intergovernmental Panel on Climate Change
LCC	Landscape Conservation Cooperative
lidar	light detection and ranging
NCSU	North Carolina State University
NetCDF	Network Common Data Form
NHD	National Hydrologic Dataset
OGC	Open Geospatial Consortium
PFLCC	Peninsular Florida Landscape Conservation Cooperative
PRO	"Proactive" scenario as opposed to a business-as-usual scenario
RCM	regional climate model
RSM	Regional Spectral Model
SDM	structured decision making
SERAP	Southeast Regional Assessment Project
SESI	Spatially Explicit Species Index
SHC	strategic habitat conservation
SLR	sea level rise
SLEUTH	Urbanization model: Slope Land use Excluded Urban Transportation Hillshade
SST	Sea surface temperature
T&E	threatened & endangered (species)
TELSA	Tool for Exploratory Landscape Scenario Analyses
UVic	University of Victory Earth System Model of Intermediate Complexity
VDDT	Vegetation Dynamics Development Tool

Appendix B. Results from Brainstorming Session

For the final workshop session, Tim Breault led a brainstorming session where participants were asked the following question: *If there was $100,000 available during the fiscal year for science in the Peninsular Florida Landscape Conservation Cooperative (PFLCC), what would you use those dollars to fund?*

Participants were asked to vote for a single priority based on 14 choices. The choices were all suggested research priorities for the PFLCC provided by the participants at the workshop. The top choice was for a robust communications platform. The tabulated results are listed in the table below:

Activity	Votes
Robust communications platform	5
Restoration scenarios	4
Conservation endpoints	3
Species surveys	3
Conceptual model	1
Life history data	1
Meta analysis	1
Model linkages	1
Inventory of existing research	0
Monitoring	0
No regrets conservation priorities and strategies	0
Outreach	0
Qualitative measures	0
Statewide projects	0

Conceptual model: Define the process for how the PFLCC will conduct science and further adaptive management strategies (that is, a mental map of the science process).

Conservation endpoints: Define objectives and performance metrics for ecosystem form and function at points in time and space. They must be linked to manager decision points.

Inventory of existing research: Describe current research projects in the PFLCC as they relate to core PFLCC objectives. This includes smaller scale ecological studies as well as landscape-level science.

Life history data: Projects that conduct basic research or targeted meta-analyses to better understand species traits, behavior, and habitat. Information could then be used to predict responses to environmental change.

Meta-analysis: Conduct a meta-analysis of biological and ecological responses to large-scale forcings in Florida.

Model linkages: Invest in projects that tie together results and models from different projects and disciplines in order to better link to conservation objectives. This could also include projects such as the Geo Data Portal that allow research to access model output and core datasets from different sources.

Additional examples include Bayesian network analyses such as that used by Nathaniel Plant (U.S. Geological Survey).

Monitoring: Monitor populations and systems so as to establish baselines against which future changes can be evaluated.

No regrets conservation priorities and strategies: These are landscape tools that build off of existing projects, such as the CLIP database or scenarios developed for south Florida.

Outreach: Invest in outreach to the public and other academic disciplines, including social scientists, economists, regulatory agencies, urban planners, and policymakers.

Qualitative measures: Methods to assess risk or uncertainty for candidate strategies by way of expert judgment.

Restoration scenarios: Model the robustness of different conservation and restoration scenarios under constraints of funding and climate and landscape changes.

Robust communications platform: Involves passive and active communication through an online presence and personal interactions with stakeholders and scientists. Also includes visualization tools that help people "see" the potential effects of global change as well as strategies to improve resilience and adaptive capacity.

Species surveys: Critical surveys of focal and surrogate species that are important for State and Federal agency actions.

Statewide projects: Landscape-level science projects that cover the whole State rather than only a portion of Florida.

Appendix C. List of Workshop Participants

Name	Location/Organization	Email	Title
Ronnie Best	U.S. Geological Survey (USGS)	ronnie_best@usgs.gov	Coordinator, Greater Everglades Science Program
Judy Boshoven	Defenders of Wildlife	jboshoven@defenders.org	Living Lands Manager
Laura Brandt	U.S. Fish and Wildlife Service	Laura_brandt@fws.gov	Wildlife Biologist
Tim Breault	Peninsular Florida Landscape Conservation Cooperative (PFLCC)	timothy_breault@fws.gov	Coordinator, PFLCC
Susan Cameron-Devitt	University of Florida	cameronse@gmail.com	Professor in Department of Wildlife Ecology and Conservation
Shawn Carter	National Climate Change and Wildlife Science Center (NCCWSC)	scarter@usgs.gov	Senior Scientist, USGS NCCWSC
Jaime Collazo	North Carolina State University (NCSU)	jaime_collazo@ncsu.edu	Professor in Department of Biology; Assistant Leader, NC Cooperative Research Unit
Jennifer Costanza	NCSU	jennifer_costanza@ncsu.edu	Post-Doc, Department of Biology, NCSU
Mike Flaxman	Massachusetts Institute of Technology	mflaxman@mit.edu	Professor in Department of Urban Studies and Planning, Head of GeoAdaptive
Bob Glaser	Florida Fish and Wildlife Conservation Commission	bob.glazer@myfwc.com	Research Scientist
Barry Grand	Auburn University	grandjb@auburn.edu	Professor, USGS Cooperative Research Unit Leader
Nicole Hammer	Florida Atlantic University	nicole.hammer@fau.edu	Climate Change Initiative Program Manager, Florida Center for Environmental Studies
Tom Hoctor	University of Florida	tomh@geoplan.ufl.edu	Director, Center for Landscape Conservation Planning, Department of Landscape Architecture
Dawn Jennings	U.S. Fish and Wildlife Service	Dawn_Jennings@fws.gov	Deputy Field Supervisor
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Ed Laurent	American Bird Conservancy	elaurent@abcbirds.org	Science Coordinator
Tricia Martin	The Nature Conservancy	tricia_martin@tnc.org	Central Florida Conservation Director
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Vasubandhu Misra	Florida State University (FSU)	vmisra@fsu.edu	Professor in Department of Meteorology, FSU
Mary Oakley	University of Florida	moakley@ufl.edu	Center for Landscape Conservation Planning
Jon Oetting	Florida Natural Areas Inventory (FNAI)	JOetting@fnai.org	Conservation Planner, Florida Natural Areas Inventory
Leonard Pearlstine	National Park Service	Leonard_Pearlstine@nps.gov	Landscape Ecologist, Everglades National Park

Nathaniel Plant	USGS	nplant@usgs.gov	Oceanographer
Josh Reece	FNAI	Josh830@gmail.com	Post-Doc, Department of Biology, University of Central Florida
Stephanie Romañach	USGS	sromanach@usgs.gov	Research Ecologist
Laurie Rounds	National Oceanic and Atmospheric Administration (NOAA)	laurie.rounds@noaa.gov	Gulf Coast Landscape Conservation Liaison, NOAA
Jennifer Seavey	University of Florida	jseavey@ufl.edu	Post Doc, Department of Wildlife Ecology and Conservation
Thomas Smith	USGS	tom_j_smith@usgs.gov	Research Ecologist, Principal Investigator for USGS La Florida Project
Ryan Sriver	Pennsylvania State University	rsriver@psu.edu	Professor in Department of Atmospheric Sciences, University of Illinois
Lydia Stefanova	FSU	lstefanova@fsu.edu	Assistant Research Scientist, Center for Ocean-Atmospheric Prediction Studies
Beth Stys	Florida Fish and Wildlife Conservation Commission	beth.stys@myfwc.com	Research Administrator
Adam Terando	NCSU	adam_terando@ncsu.edu	Climate Change Research Coordinator, NCSU (now Research Ecologist, USGS)
Steve Traxler	PFLCC	Steve_Traxler@fws.gov	Interim Science Coordinator, PFLCC
Jordan Walker	USGS Center for Integrated Data Analytics	jiwalker@usgs.gov	Computer Scientist, USGS
Adrienne Wootten	NCSU	amwootte@ncsu.edu	NCSU Phd Student in Marine Earth and Atmospheric Sciences

Appendix D. Additional Information for Landscape-Level Science Assessments

Critical Lands and Waters Identification Project

Purpose: Statewide natural resources spatial database to help conservation planning. Identifies Florida's "green infrastructure," (for example, how ecosystem function and biodiversity link to the health of human communities).
Web site: http://www.fnai.org/clip.cfm
Lead Institution: Florida Natural Areas Inventory
Data Available Online: Yes. Online map viewer is available at *http://data.labins.org/imf2/FREAC/FWC2.jsp*. Geographic information systems data for analysis purposes are available by request at: *http://data.labins.org/FWC/contact.cfm*.
Reports and Publications: Executive summary and technical description of the Critical Lands and Waters Identification Project are available at the Web site listed above.
Contact: See online contact page, *http://www.fnai.org/contact.cfm*.

La Florida

Purpose: The *La Florida* Project is a USGS-sponsored project composed of an interdisciplinary research team that is developing dynamically downscaled climate projections for Florida. The goal is to use these projections to drive a suite of previously developed ecological and hydrological models to assess the climate vulnerability of species, communities, and habitats in two focal regions (Suwannee River, and Big Bend and the Everglades).
Web site: http://fl.biology.usgs.gov/climate/la_florida.html
Lead Institution: USGS Southeast Ecological Science Center
Data Available Online: Dynamically downscaled climate projections are available online through the project's THREDD server (*http://coaps.fsu.edu/CLARReS10/thredds.shtml*).

Reports and Publications:

Stefanova, L., Misra, V., Chan, S., Griffin, M., O'Brien, J.J., and Smith, T.J., III, 2012, A proxy for high-resolution regional reanalysis for the Southeast United States; Assessment of precipitation variability in dynamically downscaled reanalyses: Climate Dynamics, *DOI 10.1007/s00383-011-y*.

Misra, V., Moeller, M., Stefanova, L., Chan, S., O'Brien, J.J., Smith, T.J., III, and Plant, N., 2011, The influence of the Atlantic warm pool on the Florida Panhandle sea breeze: Journal of Geophysical Research—Atmospheres: 116 p., D00Q06, *doi:10.1029/2010JD015367*, 2011.

Fourqurean, J.W., Smith, T.J., III, Possley, J., Collins, T.M., Lee, D., and Namoff, S., 2010, Are mangroves in the tropical Atlantic ripe for invasion? Exotic mangrove trees in the forests of South Florida: Biological Invasions, v. 12, p. 2509–2522.

Swain, E., Stefanova, L. and Smith, T.J., III, 2014, Applying downscaled climate model data to a hydrodynamic surface-water: American Journal of Climate Change, v. 3, p. 33–49.

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Southeast Regional Assessment Project

Purpose: The goal of the Southeast Regional Assessment Project (SERAP) is to employ state-of-the-science climate and landscape projections to develop robust management strategies in response to global change in the Southeast United States.
Web site: *http://serap.er.usgs.gov/*
Lead Institution: USGS through the National Climate Change and Wildlife Science Center (NCCWSC) and the Southeast Climate Science Center
Data Available Online: Data are available through the USGS Center for Integrated Data Analytics' Geo Data Portal (GDP) at *http://cida.usgs.gov/gdp/*.

Reports and Publications:

Open-File Report Describing the Project: *http://serap.er.usgs.gov/docs/SerapOFR2010_1213.pdf*.

Costanza, Jennifer K., Hulcr, Jiri, Koch, Frank H., Earnhardt, Todd, McKerrow, Alexa J., Dunn, Rob R., and Collazo, Jaime A., 2012, Simulating the effects of the southern pine beetle on regional dynamics 60 years into the future: Ecological Modelling, v. 244, 10 October 2012, p. 93–103, ISSN 0304-3800, *10.1016/j.ecolmodel.2012.06.037*.

Veran, Sophie, Kleiner, Kevin J., Choquet, Remi, Collazo, Jaime A., and Nichols, James D., 2012, Modeling habitat dynamics accounting for possible misclassification: Landscape Ecology, v. 27, no. 7, p. 943–956.

Jones, S.A., and Dalton, M.S., comps., 2012, U.S. Department of the Interior Southeast Climate Science Center Science and Operational Plan: U.S. Geological Survey Open-File Report 2012–1034, 48 p.

Jones, S.A., 2011, U.S. Department of the Interior Climate Science Centers: U.S. Geological Survey Fact Sheet 2011–3025, 2 p.

Gutierrez, Benjamin T., Plant, Nathaniel G., and Thieler, E. Robert, 2011, A Bayesian network to predict coastal vulnerability to sea level rise: Journal of Geophysical Research, v. 116, F02009, 15 p.

Bhat, K.S., Haran, M.I., Terando, A., and Keller, K., 2011, Climate projections using Bayesian model averaging and space-time dependence: Journal of Agricultural, Biological, and Environmental Statistics, v.16, no. 4, 22 p.

Bhat, K.S., Haran, M., and Goes, M., 2010, Computer model calibration with multivariate spatial output, *in* Chen, M-H, and others, eds., Frontiers of Statistical Decision Making and Bayesian Analysis: New York, Springer-Verlag, 16 p.

Viger, R.J., Hay, L.E., Jones, J.W., and Buell, G.R., 2010, Effects of including surface depressions in the application of the Precipitation-Runoff Modeling System in the Upper Flint River Basin, Georgia: U.S. Geological Survey Scientific-Investigations Report 2010–5062, 36 p.

Dalton, M.S., and Jones, S.A., comps., 2010, Southeast Regional Assessment Project for the National Climate Change and Wildlife Science Center, U.S. Geological Survey: U.S. Geological Survey Open-File Report 2010–1213, 38 p.

Viger R.J., Hay, L.E., Markstrom, S.L., Jones, J.W., and Buell, G.R., 2010b, Hydrologic effects of urbanization and climate change on the Flint River basin, Georgia: Earth Interactions, e-view, October 27, 2010.

Contact:

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North Carolina State University
Email: *adam_terando@ncsu.edu*

South Florida Scenarios for Conservation Planning

Purpose: To design scenarios and simulations of urbanization and sea level rise that identify key actions, areas, and partners necessary to accomplish large landscape-scale conservation. The project is generating management-relevant scenarios using participatory methods and comparing private conservation strategies under scenarios based on limited resources.
Web site: http://geoadaptive.com/scenariosflorida/
Lead Institution: GeoAdaptive, MIT, and Florida Fish and Wildlife Conservation Commission
Data Available Online: Results for the different sea level rise and land use scenarios are available at the project Web site: *http://geoadaptive.com/scenariosflorida/?page_id=72*.
Reports and Publications: Technical reports, book chapters, videos, and forthcoming articles are available at *http://geoadaptive.com/scenariosflorida/?page_id=10*.
Contact:
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Appendix E. Workshop Description and Agenda

North Carolina State University
in Partnership With the
Peninsular Florida Landscape Conservation Cooperative

Landscape and Climate Science and Scenarios Workshop

June 13–14, 2012
USGS Coastal and Marine Science Center
600 Fourth Street South
St. Petersburg, FL

The Peninsular Florida Landscape Conservation Cooperative (PFLCC) is hosting a "Landscape and Climate Science and Scenarios Workshop" in St. Petersburg, Fla., at the USGS Coastal and Marine Science Center. The goal of this workshop is to examine the current state-of-the-science as it relates to potential global change impacts in the PFLCC and to develop recommendations that will guide PFLCC research priorities. The workshop will bring together a small group of researchers, managers, and decision makers to discuss potential climatic and landscape changes in the PFLCC region based on the results of several regional integrated assessments and other scientific investigations. The workshop structure will consist of a combination of science presentations and panel discussions focused on project results, combined with an open dialogue about future science needs. In addition, participants will discuss several decision-analysis approaches that use results from integrated assessments to inform conservation planning. Finally, the workshop will provide a hands-on tutorial of currently available data portals for accessing global change datasets relevant to science and conservation efforts in the PFLCC.

Workshop Objectives:

- Examine results from current or recently completed integrated science projects that involve the PFLCC region.
- Examine approaches to decision analysis that have been applied in the Southeast or that could be applied in the PFLCC.
- Discuss current research efforts that will support PFLCC strategic planning goals and activities over the next 1 to 3 years.
- Identify science gaps or unfunded priorities that will be a focus of the PFLCC science implementation plan.
- Provide the above-mentioned input to a second management-focused workshop.

Four science themes will be covered that focus on key areas of climate and landscape change in the region: climate and sea level rise projections, coastal impacts, ecological models, and decision analysis. The presentations for the first three science themes will be "results oriented," stressing insights gained about potential future climatic and landscape changes, rather than focusing on the specific process or methods involved in reaching a science team's conclusions. The decision-analysis theme will highlight project results but will also cover methodological considerations and the challenges of conservation planning, given the complexity and uncertainty associated with integrating multiple processes, models, and disciplines.

Key Questions for Discussion by Science Theme:

Climate Change and Sea Level Rise (SLR):

- Are the current downscaling models adequate?
- Are the results from statistical and dynamic, downscaled models similar?
- Is the spatio-temporal resolution and available variables sufficient for ecological and landscape modeling in the PFLCC?
- What is the current best estimate and robust estimate of potential regional SLR (due to both eustatic and steric changes) by mid-century and 2100?

Coastal Impacts:

- What potential SLR scenarios are being used statewide?
- What type of uncertainty surrounds these scenarios?
- What are the strengths and weaknesses of next-generation, “nonbathtub” coastal inundation models?

Ecological Modeling:

- Should species or habitats be used to gauge likely climate and landscape change impacts and the relevance to decision making?
- What abiotic and biotic processes are most important to consider in the context of climate change?
- Which preexisting layers are most useful for ecological and habitat modeling (for example, the Critical Lands and Waters Identification Project and the Florida Natural Areas Inventory)?

Decision Analysis:

- What is the process for facilitating decision making in each approach?
- What are the strengths and weaknesses of approaches to characterize future urbanization potential?
- Are these approaches scalable? Can they be applied across the PFLCC geography?
- What is the best way to portray the information? Web sites? Workshops?
- What decisions related to conservation adaptation do the managers need to make in 1 to 3 years?
- Is there a common set of PFLCC ecological/conservation/societal endpoints that is targeted across decision-analysis approaches?

Workshop Deliverable:
The workshop will generate a report that will summarize the major landscape-level science projects and key results, summarize user discussions, and provide guidance as to future science needs. The report will be provided to the steering committee for the development of the upcoming strategic plan and will be used to inform a subsequent management-focused workshop.

For more information, please contact:

- Adam Terando, Climate Change Research Coordinator, North Carolina State University, adam_terando@ncsu.edu or (919) 513–7337
- Steve Traxler, Interim Science Coordinator, Peninsular Florida Landscape Conservation Cooperative, Steve_Traxler@fws.gov or (772) 469–4265

Appendix F. Agenda

WEDNESDAY, JUNE 13

11:45–12:45	REGISTRATION AND LUNCH (provided at workshop)
12:45–1:00	**Welcome and Introductions** • Tim Breault, Coordinator and Steve Traxler, Interim Science Coordinator, Peninsular Florida Landscape Conservation Cooperative *Perran Ross, University of Florida, will serve as moderator and workshop facilitator for the duration of the meeting.*
1:00–1:30	**Setting the Stage – The Southeast Perspective** • Jerry McMahon, Director, Department of Interior Southeast Climate Science Center, USGS *Objective:* What are the regional conservation and adaptation goals, gaps, and needs and what is the role of the CSC and LCCs in addressing them?
1:30–1:45	**Setting the Stage – The PFLCC Perspective** • Tim Breault, PFLCC *Objective:* Describe the goals of the PFLCC, current conservation and adaptation challenges in the region, and how the workshop helps to advance the strategic planning process.

1:45–3:15	**Climate and Sea Level Rise Model Results in the PFLCC** • Adam Terando, Department of Biology, North Carolina State University, *Climate Modeling Results from Southeast Regional Assessment Project (SERAP)* • Vasu Misra, Department of Meteorology, Florida State University, *Climate Modeling Results from La Florida* • Adrienne Wootten, Department of Marine, Earth, and Atmospheric Sciences, NCSU, *Comparison of Statistical and Dynamical Downscaling Results* • Ryan Sriver, Department of Geosciences, Pennsylvania State University, *Regional and Global Sea Level Rise Projections using an Earth System Model of Intermediate Complexity (EMIC)*
Objective: Present and discuss results from downscaled climate model projections as well as global sea level rise projections.	
3:15–3:45	**Climate Model Results - Panel Discussion** • Shawn Carter, Chief Scientist, National Climate Change and Wildlife Science Center (NCCWSC) • Vasu Misra, FSU • Tom Smith, St. Petersburg Coastal and Marine Science Center, USGS • Ryan Sriver, PSU • Adrienne Wootten, NCSU
Objective: Discuss challenges associated with developing downscaled climate change data and quantifying projection uncertainty, while still providing useful information to scientists and decision makers.	
3:45 - 4:00	**BREAK**
4:00–4:45	**Coastal Impacts Modeling Results** • Nathaniel Plant, St. Petersburg Coastal and Marine Science Center, USGS, *Bayesian Predictions of Coastal Erosion* • Joshua Reece, Department of Biology, University of Central Florida and Jon Oetting, Florida Natural Areas Inventory, *Sea Level Rise Scenarios for Impacts Assessment in Florida*
Objective: Present results from two methods for predicting and visualizing coastal vulnerability to sea level rise.	

4:45–5:15	**Coastal Impacts Modeling Results - Panel Discussion** • Nathaniel Plant, USGS • Judith Boshoven, Defenders of Wildlife • Tom Hoctor, Department of Landscape Architecture, University of Florida • Laurie Rounds, Gulf Coast Landscape Conservation Liaison, NOAA Ocean & Coastal Resource Management *Objective:* Highlight issues in modeling coastal responses to sea level rise. Discuss the types of useful/actionable information that are generated by different modeling approaches and major science gaps.
5:15–5:45	**Wrap-up and Discussion of Day 1** *Objective:* Identify current gaps or near-future needs for climate and coastal impacts modeling. Discuss the potential for collaborative efforts, leveraging of resources and expertise, and primary critical needs for decision makers and scientists using these data.
5:45	**Defenders of Wildlife/FWC Review of Florida Adaptation Guide (Post-workshop activity)**

8:00–8:30	**BREAKFAST (provided at workshop)**
8:30–10:00	**Ecological Modeling Results** • Jennifer Costanza, Department of Biology, NCSU, *Vegetation Dynamics Results from SERAP* • Tom Hoctor, UF, *Results from Critical Lands & Waters Identification Project (CLIP)* • Leonard Pearlstine, Everglades and Dry Tortugas National Parks, National Park Service • Stephanie Romañach, Southeast Ecological Science Center, USGS, *Spatial prediction maps from climate envelope models: what can they tell us?* • Tom Smith, USGS, *Ecological Modeling Results from La Florida*
Objective: Review results from existing projects in or near PFLCC that link different aspects of climate and landscape change to ecological responses.	
10:00–10:30	**Ecological Modeling Results- Panel Discussion** • Jaime Collazo, NC Cooperative Fish and Wildlife Research Unit, NCSU/USGS • Catherine Langtimm, Southeast Ecological Science Center, USGS • Stephanie Romañach, USGS
Objective: Discuss challenges in developing robust ecological response models. Highlight success stories and the steps necessary to evaluate effects of climate and landscape change on species or habitats.	
10:30–10:45	**BREAK**

10:45–12:00	**Decision Analysis Approaches and Results** ● Mike Flaxman, Department of Urban Studies and Planning, Massachusetts Institute of Technology, *Alternative Futures for Southern Florida's Greater Everglades Landscape* ● Barry Grand, Alabama Cooperative Fish and Wildlife Research Unit, Auburn University/USGS, *Optimal Conservation Decision Framework for SERAP*
Objective: Discuss approaches to translating landscape/climate/ecological models into actionable information for decision makers. Convey strengths of different approaches as well as challenges in deploying aspects of the chosen decision-analysis framework.	
12:00–12:30	**Decision Analysis Approaches - Panel Discussion** ● Mike Flaxman, MIT ● Barry Grand, Auburn/USGS ● Tom Hoctor, UF ● Tricia Martin, Central Florida Conservation Director, The Nature Conservancy
Objective: Discuss the types of information that different decision analysis approaches generate that allow for more robust planning and adaptation efforts. Identify major gaps in the decision analysis frameworks that hinder the ability of managers/planners to take action.	
12:30–1:45	**LUNCH (provided at workshop)**
1:45–3:00	**Data Portal Demonstrations** ● Jordan Walker, Center for Integrated Data Analytics (CIDA), US Geological Survey, *The Geo Data Portal* ● Stephanie Romañach, USGS, *EverVIEW Data Viewer*
Objective: Hands-on demonstration of several data portals that are on-line or will be on-line in near future. Demonstration of types of data available and value-added features for scientists and decision makers wishing to understand potential impacts of future climate and landscape change.	

3:00–3:30	**Discussion – Current and Forthcoming Science** • Jerry McMahon, SE CSC • Damian Shea, Professor of Biology at NCSU and Principal Investigator, SE CSC *Objective:* Highlight currently funded CSC, LCC, and NCCWSC projects and expected products or knowledge gained.
3:30–3:45	**BREAK**
3:45–5:00	**Discussion – Priority Science Needs for the PFLCC** *Objective:* Develop recommendations for priority science needs over the next 1-5 years that address major gaps in the ability for scientists and decision makers to analyze, respond, and adapt to future climate and landscape changes.
5:00–5:30	**Summary & Closing Remarks** • Tim Breault and Steve Traxler, PFLCC

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