MODELING CLIMATE CHANGE AND ECOSYSTEM RESPONSE— DEVELOPING TOOLS TO GUIDE RESOURCE MANAGEMENT IN THE SOUTHEASTERN UNITED STATES

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Abstract. Resource managers are at the forefront of a new era of environmental decision making. They must consider the potential effects of climate change on the Nation's resources and proactively develop strategies for dealing with those changes on terrestrial and aquatic ecosystems. This requires rigorous, scientific understanding of the interactions among the varying components of atmospheric, hydrologic, terrestrial, and biological systems and the ability to predict the resulting changes to ecological systems. The Southeast Regional Assessment Project is an interdisciplinary U.S. Geology Survey project that is designed to analyze climate change data and develop tools for assessing how climate change is likely to affect wildlife resources.

INTRODUCTION

The Southeast Regional Assessment Project (SERAP) is the first regional assessment funded by the U.S. Geological Survey (USGS) National Climate Change and Wildlife Science Center to integrate climate and landscape-change data and develop tools for assessing how changing conditions are likely to affect resources (Dalton and Jones, 2010). The project is designed to assess climate change, its effects, and the interactions with land cover, ecosystems, and priority aquatic and avian species in the Southeastern United States (Fig. 1).

The SERAP capitalizes on the integration of five existing projects: (1) "Designing Sustainable Landscapes," a project of the U.S. Fish and Wildlife Service Multistate Conservation Grant Program; (2) "Water Availability for Ecological Needs," a USGS multidisciplinary Science Thrust project; (3) "Climate Change in the Southeastern United States and its Impacts on Bird Distributions and Habitats," a USGS Southeast Pilot Project; (4) a sea-level rise study envisioned jointly by the USGS and the National Oceanic and Atmospheric Administration; and (5) two USGS sea-level rise impact-assessment projects that address inundation hazards and provide probabilistic forecasts of coastal geomorphic change. The SERAP expands on these projects and includes the following tasks, which were initiated in summer 2009.

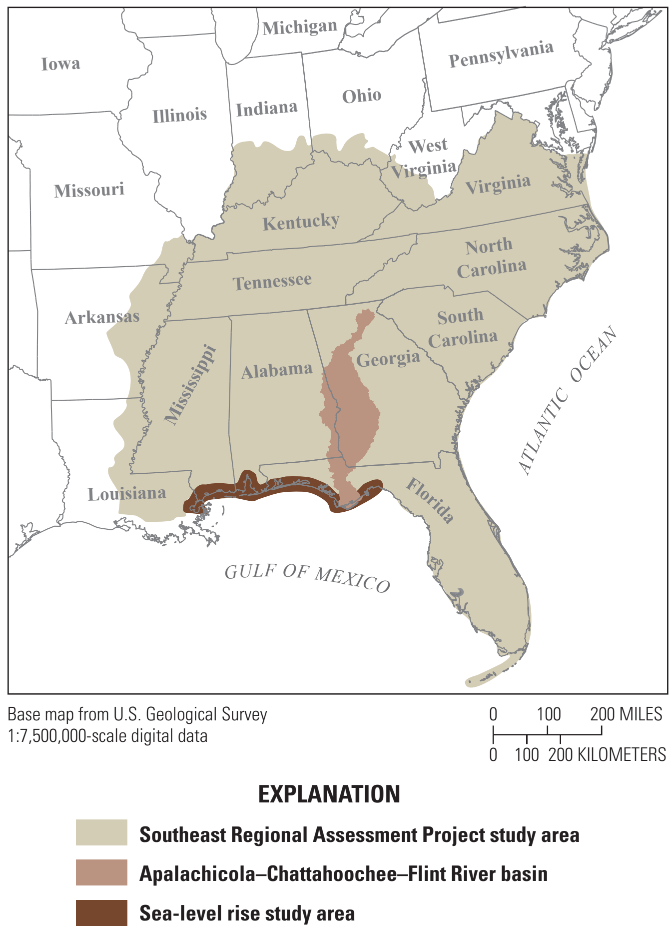

Figure 1. Study area for Southeast Regional Assessment Project (SERAP).

REGIONALLY DOWNSCALED PROBABILISTIC CLIMATE-CHANGE PROJECTIONS

Core climatic datasets are being developed for use in projecting regional ecosystem effects from 21st century climate change resulting from greenhouse gas emissions. The approach carefully assesses and propagates model uncertainty, downscales climate projections to the scale of ecosystem processes, and focuses on the most impact-relevant climatic variables. Central to the approach is quantifying the uncertainty associated with projections so that climate adaptation strategies can incorporate the full potential of climate change effects and likely ecosystem responses. For example, decision makers may insufficiently hedge against the risks associated with extreme climatic events that have a low probability of occurrence but have the potential to be high-impact events. Thus, a severe drought or a 500-year flood, while having a low probability of occurrence in any given year, still must be incorporated into decision making because of the high environmental, social, and economic costs. Projection uncertainty is quantified by using a Bayesian analysis of climate-model uncertainty given a set of global observations from the past 120 years.

INTEGRATED COASTAL ASSESSMENT

The results from several projects are being used to assess the likelihood of coastal inundation, land loss, and habitat change due to sea-level rise. The scope of the effort is focused on northern Gulf coastal areas from Mississippi to Florida (Fig. 1) where the effects of sea-level rise are likely to be substantial and all three processes are occurring. These three processes are defined as follows: (1) inundation, the flooding of a static landscape; (2) land loss, change in the landscape as a result of erosion or subsidence; and (3) habitat change, the biologic response to the other two processes and other climatic drivers. The integration of these processes is achieved through consideration of the natural spatial overlap of the processes and is captured by observations, explicit numerical modeling, statistical coupling, and estimation of parametric uncertainty in key climate variables that constrain estimates of sea-level-rise projections. The intended outcome will be a succinct description of the interactions between sea-level rise and the landscape and habitat evolution, and tools to estimate the likely response of the environment to predicted sea-level rise. Quantification of uncertainties is an explicit part of this effort to enable probabilistic risk assessments that are required to address coastal-management problems.

INTEGRATED TERRESTRIAL ASSESSMENT

The potential effects of climate change on terrestrial species in the Southeastern United States will be assessed by developing a framework using adaptive management and the principles of strategic habitat conservation. Adaptive management is useful for addressing decisions related to climate change because it reduces structural uncertainty (lack of system understanding) and parametric uncertainty (limited understanding of system response). A stochastic vegetation-dynamics model is being used to develop spatially explicit projections of the potential effects of climate and landscape changes, including urbanization projections, on habitats of priority species. These results then inform response models of patch occupancy and range dynamics of North American avian and terrestrial species.

INTEGRATED AQUATIC ASSESSMENT

Climate-change effects on aquatic biota are projected by using a multiresolution approach in the Apalachicola–Chattahoochee–Flint (ACF) River Basin. The ACF was chosen because the basin supports multiple fish and wildlife species of conservation concern to federal and State managers, is regionally important for water supply, and is the subject of recent research providing the empirical basis for tool development. Ecological models demonstrating the effects of climate change on aquatic biota at resolutions ranging from coarse (the entire ACF River Basin) to fine (stream networks within the ACF River Basin) are being developed. These models provide estimates of biological responses for alternative climate scenarios and, at finer resolutions, provide potential management actions. In addition, these models are used to identify species and ecoregions that are especially vulnerable to projected climate-change effects; this information is the basis for developing models at appropriate resolutions for vulnerable terrestrial and aquatic species and to design data-collection strategies that will address the largest sources of uncertainty identified in model development.

OPTIMAL CONSERVATION STRATEGIES

The goal of the SERAP is to use information from all participating research teams in an adaptive management framework for strategic habitat conservation. The SERAP team is developing both optimal and robust conservation strategies that incorporate the potential effects of climate change on fish and wildlife populations at an ecoregion scale. For each eco–region, implementation of the following eight tasks will be based on input from stakeholders in the fish and wildlife conservation community.

- Identify focal species for planning conservation actions within each ecoregion.
- Assess the state of populations of focal species based on the best available information.
- Determine population and habitat objectives for focal species that will ensure their persistence.
- Identify and quantify the effects of management and policy alternatives for the conservation of focal species.
- Use habitat relations models developed for coastal, terrestrial, and aquatic assessment components of the study to predict population responses to climate change and conservation actions.
- Develop optimal conservation strategies based on management and policy alternatives that are most likely to sustain populations of focal species.
- Develop robust conservation strategies that are least sensitive to a wide variety of potential climate and landscape changes.
- Identify key elements for monitoring that will reduce uncertainty regarding the effect of climate change on terrestrial and aquatic populations and their habitats and measure progress toward population and habitat objectives.

LINKING DATA AND MODELS

A goal of this work is to enable climate-change assessments to be based on the same core datasets in order for consistent results to be compared across regions and ecosystems. By standardizing approaches to data processing and provision, we hope to minimize redundancy of data gathering by modelers, systematize and improve data quality-assurance procedures specific to the simulation models, and reduce the likelihood of misinterpretation or misuse of data. To implement this goal, a database is being established containing up-to-date down-scaled climate projections for the entire United States for a range of plausible future greenhouse-gas emission scenarios. These data will be available online as a comprehensive, Web-based resource for users to freely access through an interactive, easily manageable interface in formats that are familiar to ecosystem and impact modelers.

Previous conservation-planning efforts identified and prioritized lands for conservation based on the assumption that environmental conditions would remain static. Climate change likely will alter important system drivers, such as temperature, precipitation, and sea level beyond normal ranges, and information on the direction, degree, and uncertainty of these changes is needed to model ecosystem responses and to make informed management decisions. As research brings to light the importance of climate change on the Nation's resources, the need exists to develop effective conservation strategies based on sound science that recognizes and accounts for the effects of climate and landscape change on terrestrial and aquatic ecosystems.

REFERENCE

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.