FY 2012 Climate Science Center Funded Projects

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FY 2012 CLIMATE SCIENCE CENTER FUNDED PROJECTS

ALASKA

Implications of Glacier Change in Alaska

Principal Investigator: **Eran Hood**, University of Alaska Southeast
Cooperators & Partner: **Shad O'Neel**, U.S. Geological Survey Alaska Science Center; **Anthony Arendt**, University of Alaska, Fairbanks Geophysical Institute; and **Sanjay Pyare**, University of Alaska Southeast

As climate changes, watersheds along the Gulf of Alaska (GOA) are experiencing some of the highest rates of glacier melting on Earth, causing significant societal and ecological impacts on the structure and productivity of marine ecosystems, safety hazards related to glaciers, hydropower generation, and sea-level rise. This project will bring together scientists and land and resource managers at a workshop to establish a cross-disciplinary framework for developing new tools to monitor and anticipate future changes in glacier runoff along the GOA. This workshop will result in a more coordinated strategy for studying glacier change in Alaska and addressing key outstanding questions related to glacier change.

Validation of Yukon-Kuskokwim Delta Storm Surge Model

Principal Investigator: **Tom Ravens**, University of Alaska Anchorage
Cooperators & Partners: **Sarah Saalfeld**, U.S. Fish and Wildlife Service; **Torre Jorgenson**, Alaska Ecoscience; and **Joel Schmutz**, Alaska Science Center

Despite being a critical nesting habitat for many of Alaska's seabirds and other wildlife, relatively little is known about the western coast of Alaska in relation to the character and impact of Bering Sea storms, the extent and frequency of flooding and its impact on vegetation, wildlife, and water quality, or about the effects of climate change and sea-level rise on this area, its communities, and their infrastructure. This project aims to expand current understanding of coastal storms and the effect of climate change on the Yukon-Kuskokwim Delta by modeling 1) historical and projected future storms under assumed sea-level rise scenarios, 2) flood extent, depth, and frequency for different storms, and 3) impacts of storms on wildlife abundance and nesting sites, pond salinity, and sediment movement.

Linking Climate, Vegetation, and Ungulate Dynamics Across the Alaska Region

Principal Investigator **Jeffrey Welker**, Environment and Natural Resources Institute and Department of Biological Sciences, University of Alaska – Anchorage

Several possible mechanisms may be responsible for recent declines in many caribou herds, including the effects of climate change. This project aims to form a research consortium that will integrate two Alaskan Landscape Conservation Cooperative projects and facilitate coordination between leaders and colleagues in the scientific community to address caribou dynamics. The research conducted under this project will use the relationship between climate and caribou as a focal point to identify and explore the connections between climate, movement of soil nutrients, plant quality for animal foraging, caribou dietary behavior, and herd dynamics for caribou in Alaska, Western Canada, and Svalbard.

Alaska Integrated Ecosystem Model

Principal Investigator: **David McGuire,** University of Alaska, Fairbanks
Co-Investigators: **Scott Rupp, Vladimir Romanovsky, Eugenie Euskirchen,** and **Sergey Marchenko**

Ongoing climate change has the potential to affect terrestrial ecosystems and the services and resources they provide to the people of Alaska and to the nation. Assessments of the effects of climate change on ecosystem services have in part been hindered by the lack of sufficient forecasting tools. In Alaska, such tools need to consider how ecological processes play out in both space and time. This study aims to develop and apply an ecosystem model for Alaska that is capable of forecasting how landscape structure and function might change in response climate variations. This tool could be used by resource-specific impact models to assess the effects of climate change on specific natural resources in Alaska.

Thermokarst Monitoring at the Landscape Level: a Feasibility Study using Snow Datasets for Arctic Terrestrial Applications

Principal Investigators: **Glen E. Liston**, Cooperative Institute for Research in the Atmosphere, Colorado State University; **Benjamin Jones**, **Joshua Koch**, and **Courtney Amundson**, U.S. Geological Survey Alaska Science Center

Snow conditions and surface disturbances in Arctic areas related to thermokarst (a landscape of irregular depressions caused by the melting of ground ice), such as lake expansion, increased water drainage from thawing ice wedges, and riverbank thawing alters hydrology, carbon and nutrient flow, vegetation, and stream sediment. These disturbances may be increasing with climate change and could substantially affect fish and wildlife populations. However, the rate and extent of snow conditions and impacts and land surface change in the region, particularly in northern Alaska, are poorly quantified. The goals of this project will include reviewing and comparing current and past efforts to monitor thermokarst surface processes, analyzing landforms and processes associated with the melting of permafrost (frozen sediment or soil) in northern Alaska, and identifying the ways in which fish, wildlife, and habitat resources may be impacted by thermokarst-affected landscapes. Moreover, this project aims to produce snow datasets and create models to show snow distribution across space and time for the Arctic region of the United States that can be used in a wide range of climate, hydrologic, and ecosystem applications.

Western Alaska Coastal Hazards and Stream and Lake Monitoring

Principal Investigator: **Robert Grumbine**, National Center for Environmental Prediction (NCEP), National Oceanic and Atmospheric Administration (NOAA)
Co-Investigator: **Joannes J. Westerink**, University of Notre Dame
Cooperators & Partners: **Patrick C. Kerr**, University of Notre Dame; **Andre van der Westhuysen** and **Hendrik Tolman**, NCEP, NOAA; **Jesse C. Feyen** and **Yuji Funakoshi**, National Ocean Service, Office of Coast Survey, and Coast Survey Development Laboratory, NOAA
Joint Project: Alaska Climate Science Center, U.S. Fish and Wildlife Service, and the Western Alaska Landscape Conservation Cooperative

Coastal hazards, such as storm surges, erosion, and flooding, as well as coastal, stream, and lake processes, are very important factors that influence ecosystems in western Alaska. An analysis of coastal hazards and a monitoring program of streams and lakes are needed to provide a better understanding of how climate change will impact this region. This project will be implemented as a joint effort among the Alaska Climate Science Center (AK CSC), the U.S. Fish and Wildlife Service (USFWS), and the Western Alaska Landscape Conservation Cooperative (WALCC). Science activities include the development of conceptual models of coastal processes

and climate impacts in western Alaska and the production of a research-needs assessment that will guide WALCC and AK CSC efforts. The project also aims to model the relationship between stream and lake characteristics and ecosystem impacts and provide recommendations for the design and implementation of a stream and lake monitoring program for the Alaska region.

Assessing the Sensitivity of Alaska's Coastal Rainforest Ecosystems to Changes in Glacier Runoff

Principal Investigators: **Shad O'Neel**, U.S. Geological Survey Alaska Science Center; **Anthony Arendt**, Geophysical Institute, University of Alaska Fairbanks; and **Eran Hood** and **Sanjay Pyare**, University of Alaska Southeast

Coastal temperate rainforests along the Gulf of Alaska are experiencing high rates of glacier loss. Understanding the climate-induced vulnerability of land-to-ocean movement of freshwater due to glacier melting is critical since the variability in glacier runoff is much larger than that for other components of the water cycle. This project will develop methods to quantify runoff from watersheds along the Gulf of Alaska, allowing an assessment of impacts on coastal ecosystems. This study will also assess available data, develop an interdisciplinary conceptual model, and disseminate findings to both scientific peers and the public, paving the way forward to a better understanding of one of the least understood regional water cycles on Earth. New information from this study will provide a framework for assessing the future evolution of glacier discharge into the Gulf of Alaska, reducing uncertainty in determining the response of coastal ecosystems to a changing climate.

Integrating Studies of Glacier Dynamics and Estuarine Chemistry in the context of Landscape Change in the Arctic

Principal Investigators: **Matt Nolan**, University of Alaska Fairbanks, Cooperative Ecosystem Studies Unit
Co-Investigators: **Jim McClelland** and **Ken Dunton**, University of Texas at Austin

The Jago, Okpilak, and Hulahula rivers in the Arctic are heavily glaciated watersheds that are important for fish and wildlife, subsistence, recreation, and, potentially, resource extraction on the coastal plain. If current glacial loss trends continue, most of the ice in these rivers will disappear in the next 50-100 years. It is important to understand the response of these rivers to climate change and the role of shrinking glaciers in the future dynamics of these rivers and the estuarine environments they influence. The overarching goal of this project is to research 1) the amount of river water, sediment, nutrients, organic matter, and so forth in the Jago, Okpilak, and Hulahula rivers that come from glacier melt, 2) the effect that glacier inputs have on terrestrial, aquatic, and coastal ecosystems, and 3) the changes in river processes as glaciers disappear. This project will bring a better understanding about how inputs from glacier-dominated arctic rivers differ from un-glaciated rivers and will, in turn, improve the ability of resource managers to plan for potential changes in downstream ecosystem responses that may be different from region to region along the Arctic Ocean coast.

Yukon River Basin Project: Ecology, Soil Carbon and Permafrost Experiments

Principal Investigator: **Mark Waldrup**, U.S. Geological Survey

Various field studies are needed to address important data needs and to develop and improve prediction models related to ecosystems and climate change. The goal of this project is to support the Integrated Ecosystem Model (IEM), a modeling framework that integrates vegetation succession, disturbance, hydrology, and permafrost dynamics. Project activities include 1) carbon cycling studies, 2) vegetation studies, and 3)

climate and soil data collection. This research will build on existing infrastructure for studying ecosystems in the Yukon River Basin and the Alaska Peatland Experiment by the U.S. Geological Survey and its partners.

PACIFIC ISLANDS

Climate Change Research in Support of Hawaiian Ecosystem Management: An Integrated Approach

Principal Investigators: **Oliver Elison Timm**, International Pacific Research Center, University of Hawai`i at Mānoa; **Thomas W. Giambelluca**, Department of Geography, University of Hawai`i at Mānoa; and **Henry F. Diaz**, CIRES, University of Colorado, Boulder
Collaborators: **Carter Atkinson** and **Dennis LaPointe**, U.S. Geological Survey, Pacific Island Ecosystems Research Center; **Jonathan Price**, University of Hawai`i at Hilo and U.S. Geological Survey; **Michael D. Samuel**, U.S. Geological Survey, Wisconsin Cooperative Wildlife Research Unit

Climate change and its impact on natural environments are critical issues facing resource and ecosystem managers throughout the world and specifically in the Pacific U.S. region. The key goals of this study are 1) to understand how changes in the Earth's future climate system will affect the frequency and severity of extreme weather events in Hawai`i, 2) to support studies of the ecological impacts of climate change on native Hawaiian plants and animals and 3) to provide information needed by natural resource managers charged with preserving native biodiversity. To achieve these goals, this project will build on a previous Pacific Island Climate Change Cooperative (PICCC) project to update climate change projections (using a technique called *statistical downscaling*) for Hawai`i. With collaboration from partners at the U.S. Geological Survey (USGS) and the University of Hawai`i at Hilo, researchers will also assess species and ecosystem responses to potential climate variations, such as the recurrence and intensity of heat waves, droughts, and storms.

21st Century High-Resolution Climate Projections for Guam and American Samoa

Principal Investigators: **Yuqing Wang**, International Pacific Research Center, University of Hawai`i at Mānoa; **Kevin Hamilton, Axel Lauer**, and **H. Annamalai**, International Pacific Research Center, University of Hawai`i

The Pacific Islands are expected to be particularly vulnerable to the anticipated impacts of climate change due to their small, geographically isolated ecosystems and economies, and are extremely susceptible to rising sea-levels. Despite a high level of concern for the Pacific Islands, there is currently a lack of adequate small-scale projections of climate change in the American Samoa region. This study will use high-resolution (one kilometer) climate models to project anticipated 21st century changes in such things as rainfall, surface temperature and wind on Guam in the Mariana Islands and Tutuila in American Samoa. This work will build on and leverage ongoing modeling efforts of current and predicted climate change in Hawai`i. Results from this study, including estimates of the change in seasonal climatology and the frequency of extreme weather events, will be available for use by other researchers to inform hydrological and ecosystem models to predict future impacts of climate change.

Vulnerability of Hawaiian Forest Birds to Climate Change - Using Models to Link Landscape, Climate, Disease, and Potential Adaptation

Principal Investigators: **Michael D. Samuel**, U.S. Geological Survey, Wisconsin Cooperative Wildlife Research Unit; **Dennis A. LaPointe**, **Carter T. Atkinson, and Eben H. Paxton**, U.S. Geological Survey, Pacific Island Ecosystems Research Center

Cooperators & Partners: **Loyal Mehrhoff, Jeff Burgett,** and **Jim Kraus,** U.S. Fish and Wildlife Service; **Margaret Wild and Darcy Hu,** National Park Service; **Scott Fretz**, Hawai`i Department of Land and Natural Resources; and **Colleen Cole**, Three Mountain Alliance

The introduction of mosquitos and avian malaria are considered to be primary factors contributing to population declines and changes in the distribution of many native Hawaiian forest birds. Mosquito and malaria dynamics (abundance, location etc.) are strongly influenced by climate, particularly rainfall and temperature. Successful conservation of Hawaiian forest birds requires an analysis of climate change and its impact on the future disease risk of native bird populations. Key objectives of this research will be to 1) predict changes in avian malaria across space and time as a result of anticipated climate change, 2) evaluate the potential for bird species extinctions, 3) research and consider birds' genetic adaptation to malaria, and 4) assess the costs and effectiveness of conservation strategies to mitigate impacts on bird populations. This project will provide the first quantitative assessment of the long-term impact of climate change on bird malaria distribution and on Hawai`i's unique forest birds, and provide a crucial tool to adaptively manage recovery and promote disease resistance among avian populations.

Modeling Climate-Driven Changes to Dominant Vegetation in the Hawaiian Islands

Principal Investigators: **Jonathan Price**, University of Hawai`i at Hilo and U.S. Geological Survey and **James D. Jacobi**, U.S. Geological Survey, Pacific Island Ecosystems Research Center

Hawaiian vegetation is unusual in that most ecologically important plant species grow consistently across a wide range of physical environments, but vary greatly in local abundance, largely driven by climate. A number of studies have modeled and compared Hawaiian plant species across these broad environments; however, no comprehensive and quantitative study has been conducted to specifically assess the role of climate in determining the abundance of plant species in this region. This project will enable managers to examine vulnerabilities of vegetation species, plan restoration efforts, and mitigate threats to vegetation on the Hawaiian Islands as climate changes. The goal of this study is to consolidate and utilize several available datasets to generate species-specific models of dominant vegetation composition across the Hawaiian Islands in relation to several variables (rainfall, elevation, substrate age, slope, etc.). Additional data on the growth, reproduction, and dispersion of key plant species will inform the movement and transition patterns of different species, permitting researchers to predict changes to individual species as the climate changes.

Understanding How Climate Change is Affecting Hawai`i's High-Elevation Ecosystems: an Assessment of the Long-Term Viability of Haleakala Silverswords and Associated Biological Communities

Principal Investigators: **Paul D. Krushelnycky**, Department of Plant and Environmental Protection Sciences, University of Hawai`i at Honolulu; **Lloyd L. Loope**, U.S. Geological Survey, Pacific Islands Ecosystems Research Center

Cooperators & Partners: **Thomas Giambelluca**, Department of Geography, University of Hawai'i at Honolulu; **Donald Drake**, Department of Botany, University of Hawai'i at Honolulu; **Stephen Anderson,** Vegetation Management Program, Haleakala National Park; and **Matt Brown**, Resources Management Division, Haleakala National Park

The Haleakala silversword plant forms the foundation of a diverse alpine community, and its behavior likely reflects wider ecological responses to climate. This species is already exhibiting patterns of mortality related to climate-driven movement towards higher altitudes. This project aims to understand patterns and causes of recent declines in the Haleakala silversword population that are associated with decreasing precipitation,

increasing temperature, and related climate changes in Hawai`i's high-elevation ecosystems. Building on extensive research and datasets, this study will collect the demographic and climate data needed to construct a robust population model for the silversword and make future population projections under various climate scenarios. In addition, the project will conduct a range of seedling drought tolerance experiments to clarify causes of recent widespread mortality in the species, and determine methods most likely to lead to restoration success.

NORTHWEST

Integrated Scenarios of Climate, Hydrology, and Vegetation for the Northwest

Principal Investigator: **Phil Mote**, Oregon State University
Co-Investigators: **David Turner,** Oregon State University; **John Abatzoglou**, University of Idaho; **Dennis Lettenmaier**, University of Washington
Key Personnel: **David Rupp**, Oregon State University; **Dominique Bachelet** and **David Conklin**, Conservation Biology Institute
Cooperators & Partners: **Nicholas Coops**, University of British Columbia; **Marc Kramer** and **John Kim**, U.S. Forest Service; and **V. Sridhar**, Boise State University

Environmental changes, caused by climate change and landscape transformation, such as habitat degradation and the arrival of competitive invasive species, can strain the delivery of natural resources, push rare plants and animals towards extinction, and pose a direct challenge to resource managers. As scientists work to understand and predict the effects of climate change, foundational pieces of knowledge they require are how climate, vegetation, and the water cycle will change in the future. This project will integrate, for the first time, state-of-the-science predictive models of these environmental attributes of the Northwest U.S. The resulting datasets will be compatible with other hydrological and ecological modeling projects and will ultimately will lead to a next-generation climate change framework that allows land managers to identify potentially vulnerable areas, prioritize investment in projects to increase the resilience of forests and grasslands, and incorporate projected changes in fire danger into development of water and forest management plans, state forest assessments, and other strategic land management plans.

Climate Change and Peak Flows: Knowledge-to-Action to Help Managers Address Impacts on Streamflow Dynamics and Aquatic Habitat

Principal Investigator: **Anne Nolin,** Oregon State University
Cooperators & Partners: **Gordon Grant, Mark Kramer, and Brian Staab,** U.S. Forest Service Pacific Northwest Research Station; **Mohammad Safeeq** and **Sarah Lewis**, Oregon State University; **Jason Dunham,** U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center; **Marshall Gannett**, U.S. Geological Survey, Oregon Water Science Center; **Christina Tague**, University of California, Santa Barbara; and **Karl Morgenstern**, Eugene Water and Electric Board

Previous studies have shown that snow layers throughout the Cascade Mountains in the Northwest U.S. are highly vulnerable to warming temperatures, melting earlier and changing more readily from snow to rain. Less certain is how these changes are likely to affect streamflows, particularly in streams that derive much of their flow from deep groundwater and springs. These groundwater streams, which are currently characterized by very stable stream beds, banks, and vegetation, are paradoxically particularly sensitive to increasing peak flows in the winter, which may potentially change their suitability as habitats for threatened species, such as bull

trout and spring Chinook salmon. Through a study of watershed models, this project aims to discover how the warming climate, changing snow accumulations, and increasing peak flows are likely to affect these stream channels. Results will include field and modeling components and will guide management decisions affecting these streams, including how to operate dams, if water suppliers should plan for increased turbidity, and how to manage vegetation along rivers.

Marshes to Mudflats: Climate Change Effects Along a Latitudinal Gradient in the Pacific Northwest

Principal Investigator: **John. Y. Takekawa**, U.S. Geological Survey, Western Ecological Research Center
Cooperators & Partners: **Susan De La Cruz** and **Karen Thorne,** U.S. Geological Survey, Western Ecological Research Center; **Bruce Dugger**, Oregon State University; **Bruce Jaffe**, U.S. Geological Survey, Pacific Coastal & Marine Science Center; **Susan Ustin**, University of California, Davis, Center for Spatial Technologies and Remote Sensing; **Heath Bollman**, Padilla Bay National Estuarine Research Reserve System; **Joseph Evenson,** Washington Department of Fish and Wildlife; **Jackie Ferrier**, Willapa National Wildlife Refuges; **Roger Fuller** and **Kit Crump**, The Nature Conservancy; **Alicia Helms,** South Slough National Estuarine Research Reserve; **Roy Lowe**, Oregon Coast Refuges; **Mary Mahaffy**, North Pacific Landscape Conservation Cooperative; **Doug Roster**, Nisqually and Grays Harbor National Wildlife Refuges; **Chris Ellings**, Nisqually Indian Tribe; and **Shannon Kirby**, Skokomish Indian Tribe

Coastal land managers are faced with many challenges in planning conservation strategies for nearshore habitats under future climate change scenarios. In the Pacific Northwest, these habitats are highly productive areas that support a wealth of wildlife species, from salmon to ducks. The salt marshes, mudflats, and shallow bays are connected habitats that are critical for these species and the local people and communities. Climate change effects, such as sea-level rise, are already altering these important areas, but scientists are unsure of the extent to which they are being affected or will be changed in the future. This study will examine the current bottom elevations, tidal range, and sediment of these connected nearshore habitats and determine how these elements affect plant and animal species at several sites along the Oregon and Washington coasts. This research will also be used to predict how climate change may alter these coastal systems in the future. The results from this project will provide scientific information to support future planning and conservation of natural resources in the coastal regions of the Pacific Northwest in response to a changing climate.

Extended Monitoring and Modeling of Climate Change Effects on Pacific Northwest Wetlands

Principal Investigator: **Alan Hamlet,** University of Washington
Cooperators & Partners: **Michael Adams**, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center; **Wendy Palen**, Simon Fraser University; **L. Monika Moskal**, **Maureen Ryan**, **Meghan Halabisky**, and **Se-Yeun Lee**, University of Washington; **Regina Rochefort**, North Cascades National Park; and **Lara Hansen**, EcoAdapt

Wetlands, which provide important natural services, such as movement of nutrients and carbon capture, are thought to be among the most sensitive ecosystems to changes in temperature and precipitation. Despite the importance and vulnerability of wetlands, resources to support their scientific evaluation and management in the Pacific Northwest and elsewhere have lagged substantially behind that of other ecosystem types. This interdisciplinary project combines complementary research efforts at multiple institutions and addresses wetlands across a range of locations and regions. Through the integration of remote sensing, hydrological and biological modeling, and traditional fieldwork, this research aims to explicitly characterize landscape-scale climate change impacts to wetland habitats and develop new approaches and technical tools needed to sustainably manage wetlands in a changing climate.

Predicting Climate Change Impacts on River Ecosystems and Salmonids Across the Pacific Northwest: Combining Vulnerability Modeling, Landscape Genomics, and Economic Evaluations for Conservation

Principal Investigators: **Clint Muhlfeld,** U.S. Geological Survey, Northern Rocky Mountain Science Center, and **Gordon Luikart**, The University of Montana
Cooperators & Partners: **Tim Beechie** and **Robin Waples**, National Oceanic and Atmospheric Administration (NOAA) Fisheries; **John Duffield**, **John Kimball**, **Erin Landguth**, and **Jack Stanford**, The University of Montana; **Leslie Jones** and **Gregory Pederson**, U.S. Geological Survey, Northern Rocky Mountain Science Center

Trout and salmon populations, which play a critical role in many ecosystems and economies, have dramatically declined in the Pacific Northwest (PNW) due to habitat degradation and fragmentation and introductions of invasive species, and are expected to be further impacted by future climate change. Understanding how climate change will influence the abundance, distribution, genetic diversity, and value of these native fish species is crucial for their management and recovery. This project will use modeling techniques to study how climate change might affect freshwater habitats of key trout and salmon species throughout the PNW. The goal of the study is to develop and provide novel tools that will help managers predict and respond to potential climate change induced impacts on habitats, populations, and economies.

Climate, Land Management and Future Wildlife Habitat in the Pacific Northwest

Principal Investigator: **Emilie Henderson**, Oregon State University
Cooperators & Partners: **James Kagan**, Institute for Natural Resources, Portland State University; **Megan Creutzburg** and **Anita Morzillo**, Oregon State University; **Jessica Halofsky**, University of Washington; **Miles Hemstrom**, U.S. Forest Service Pacific Northwest Research Station
Additional Support: Washington Department of Natural Resources

Balancing socio-economic and ecological demands on forests is an ongoing challenge and may be further complicated by future changes in climate. Land managers need information on the potential effects of climate change for future management planning that considers the diversity of valuable natural resources (forest products, clean water, wildfire control, etc.) that are linked to vegetation. The objectives of this project are to explore how climate and land management in southwestern Oregon and coastal Washington might interact to shape future vegetation and wildlife habitat, and determine what management actions will likely maximize habitats for key species. Through computer simulations that are run under a range of future management and climate scenarios, this project will build upon a body of knowledge that can help inform management planning for a changing future, raising the likelihood that ecosystems can be sustained for both humans and wildlife.

Improving Understanding of Threats to Whitebark Pine in the Western U.S.: Quantifying Climate Change Effects on Mountain Pine Beetle Outbreaks

Principal Investigator: **Jeffrey A. Hicke**, University of Idaho
Cooperators & Partners: **Polly Buotte**, University of Idaho and **Haiganoush K. Preisler**, U.S. Forest Service
Additional Support: U.S. Forest Service Western Wildland Environmental Threat Assessment Center and the U.S. Geological Survey Western Mountain Initiative

Whitebark pine is a high-elevation keystone tree species that grows throughout much of the western United States. It provides a critical habitat for wildlife, such as grizzly bears, influences soil and snow processes, and provides natural resources valued by the public. These trees are currently subjected to multiple threats, including attack by the mountain pine beetle, an aggressive bark beetle that has recently killed more than

hundreds of thousands of acres of whitebark pine. Studies show that climate warming is an important factor in the outbreak occurrence of this beetle. Future climate change is expected to increase the number, frequency, and/or severity of these beetle epidemics. This project will develop a model of mountain pine beetle outbreaks in whitebark pine using observations of beetle-killed trees, climate, and general tree conditions. The model will be used to map the probability of outbreaks in current climate conditions, as well as in future climate change scenarios. This study will increase understanding of climate/beetle relationships and produce estimates of the future vulnerability of whitebark pine to guide resource managers' decisions on conservation and treatment efforts.

Climate-Change Vulnerability in the Pacific Northwest: A Comparison of Three Approaches

Principal Investigator: **Joshua Lawler,** University of Washington
Cooperators & Partners: **Elizabeth Gray**, The Nature Conservancy; **J. Michael Scott**, U.S. Geological Survey Cooperative Research Unit, University of Idaho; **Rocky Beach**, Washington Department of Fish and Wildlife; **Leona Svancara**, Idaho Fish and Game; **Victoria Stevens**, British Columbia Parks

Understanding which plant and animal species will be most susceptible to future climate change is crucial for managing natural resources and public lands. The objective of this project is to compare the results of three of the different approaches that have been developed to assess the vulnerability of selected plants and animals using different future climate scenarios. This comparison will include approaches that 1) integrate expert-opinion-based assessments of climate sensitivities with projected changes in climate, 2) use numerical model projections to forecast potential climate-driven shifts in species distributions, and 3) combine measures of current climate and projected climatic changes.

Sagebrush Ecosystems in a Changing Climate

Principal Investigator: **Matt Germino,** U.S. Geological Survey Forest and Rangeland Ecosystem Science Center
Co-Principal Investigators: **Bryce Richardson** and **Nancy Shaw**, U.S. Forest Service Rocky Mountain Research Station; **David Pilliod**, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center; **Keith Reinhardt**, Idaho State University
Cooperators & Partners: **Kevin Feris** and **Marie-Anne deGraff**, Boise State University; **Kathleen Lohse**, Idaho State University; **Diane Debinski**, Iowa State University; **Kelly McCloskey**, Grand Teton National Park; **David Pyke**, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center; **Anne Halford**, Bureau of Land Management; **Charlie Baun**, State of Idaho and Department of Defense; and **Stuart Hardegree**, U.S. Department of Agriculture, Agricultural Research Service

Sagebrush plant communities drive natural processes and sustain the diversity of plants and animals in their ecosystems. Rapid and recent decreases in sagebrush, due to a lack of recolonization following wildfire, are a land-management concern in a large portion of the northwestern U.S. This project will assess the resistance and resilience of sagebrush to climate variability and examine how existing sagebrush habitat has responded to experimental manipulations of climate across the Snake River Plain, including warming scenarios and shifts in the amount and timing of precipitation. The study will relate these effects of climate change manipulation and the effects of natural climate variability on post-wildfire regeneration and seeding success to landscape scale models of sagebrush and climate. These climate science models will be used to guide restoration and preservation activities in the Northwest.

Correlation and Climate Sensitivity of Human Health and Environmental Indicators in the Salish Sea

Principal Investigators: **Jamie Donatuto** and **Sarah Grossman,** Swinomish Indian Tribal Community, and **Eric Grossman**, U.S. Geological Survey, Western Fisheries Research Center

Joint project with the North Pacific Landscape Conservation Cooperative

The overarching goal of this project is to develop models of environmental and community health indicators in relation to climate change predictions. The sensitivity of species and habitats to climate variations will be cross-examined with recently developed Coast Salish (a cultural subgroup of people in Washington and Oregon) community health indicators, such as the practice of knowledge exchange and physiological well-being. This study will demonstrate how indigenous knowledge can be used in conjunction with established landscape-level conservation indicators (e.g., shellfish and water-quality) to identify resource management priorities. While results will be specific to participants in the study, no indigenous community in the coastal Pacific Northwest is immune to the impending threats of climate change and land-use policies. The methods developed through this proposal will be applicable to other First Nations and tribes across the region.

Utilizing Yurok Traditional Ecological Knowledge to inform Climate Change Priorities

Principal Investigators: **Kathleen Sloan**, Yurok Tribe
Joint project with the North Pacific Landscape Conservation Cooperative

The Yurok Tribe will conduct a two-part study on climate change impacts on Yurok Ancestral and Reservation Lands and resources, specifically on wildlife and habitats that support culturally significant species. The first phase will be the collection and documentation of traditional ecological knowledge through community observation and structured interviews that will be recorded, transcribed, and mapped. The second phase will consist of analyzing the data collected in order to identify scientific information needs, data gaps, and priority resources vulnerable to climate change impacts. This information will be summarized in a final report to inform future management and research efforts.

SOUTHWEST

Downscaled Climate and Hydrologic Response for California and the Great Basin

Principal Investigator: **Lorraine Flint**, U.S. Geological Survey California Water Science Center
Cooperators & Partners: **Alan Flint**, U.S. Geological Survey California Water Science Center; **Michael Moran**, U.S. Geological Survey Nevada Water Science Center**; John Dingman**, Bren School for the Environment, University of California; **James Thorne**, Information Center for the Environment, University of California; **Lisa Micheli**, Dwight Center for Conservation Science at Pepperwood; **Healy Hamilton**, University of California, Berkeley; **Stuart Weiss**, Bay Area Open Space Council; **Bridget Thrasher** and **Claudia Tebaldi**, Climate Analytics Group; **Deanne DiPietro**, Sonoma Ecology Center and California Climate Commons; and **Grant Ballard** and **Sam Veloz**, PRBO Conservation Science

As the predicted impacts of climate change are becoming more apparent, natural resource managers are faced with the task of developing climate adaptation plans. These managers need state-of-the-art, scientifically based information upon which to base these management plans and decisions consistently across California and the Great Basin. This project will apply historical, current, and projected climate data to a regional water model to examine water availability, biodiversity, and conservation. Analysis of this climate and hydrology data will help managers understand areas in the region and landscape where the effects of climate change are expected to be the most profound. The study will also address how the environment is likely to change and how certain the scientific community is about these changes. Collaboration among managers, scientists,

conservation organizations, and others will guide the utility, understandability, relevance, and accessibility of the findings from this project.

Effects of Sea-Level Rise and Extreme Events on California Coastal Habitats

Principal Investigators: **John. Y. Takekawa,** U.S. Geological Survey (USGS) Western Ecological Research Center and **Glen M. MacDonald**, University of California, Los Angeles (UCLA) Institute of the Environment
Cooperators & Partners: **Rich Ambrose**, UCLA Environmental Science and Engineering Program; **Patrick Barnard**, USGS Pacific Science Center; **Michael Casazza**, **Susan De La Cruz,** and **Steven Schwarzbach,** USGS Western Ecological Research Center; **Glenn Guntenspergen**, USGS Patuxent Wildlife Research Center; **Alex Hall**, UCLA Department of Atmospheric and Oceanic Sciences; **Bruce Jaffe**, USGS Pacific Coastal & Marine Science Center; **Cory Overton** and **Karen Thorne**, University of California (UC), Davis; **Susan Ustin**, UC Davis Center for Spatial Technologies and Remote Sensing; **Brian Collins,** U.S Fish and Wildlife Service (FWS) Tijuana River Estuary National Wildlife Refuge (NWR); **Kenneth Griggs** and **Eric Nelson**¸ FWS Humboldt Bay NWR; **Andy Yuen**, San Diego Refuge Complex

Climate change impacts, such as sea-level rise, are altering the productivity and diversity of ecosystems along the California coast, but little is known about the exact ways in which these ecosystems are being affected or how they will be changed in the future. The goal of this project is to provide scientific information to support future planning and conservation of coastal natural resources as the climate changes. The study will examine current weather patterns, elevations, tides, and sediment of connected coastal habitats to determine how they affect plants and animals, as well as to project how climate change may alter that balance. Understanding the physical processes and complex relationships within these nearshore habitats can be used to develop comprehensive vulnerability assessments for wildlife and ecosystems along the California coast.

Trans-Specific Drivers of Climate-Driven Variation in Forecasted Distributional Changes of Southwest Birds and Reptiles

Principal Investigator: **David J. Mattson**, U.S. Geological Survey (USGS) Southwest Biological Science Center
Cooperators & Partners: **Matthew J. Johnson, Erika Nowak, Jennifer Holmes, Michael Peters,** and **Paul Heinrich,** Northern Arizona University; **Charles van Riper III,** USGS Southwest Biological Science Center; **James R. Hatten**, USGS Columbia River Research Laboratory; and **J. Tomas Giermakowski**, University of New Mexico
Additional Support: USGS National Climate Change and Wildlife Science Center

Biodiversity is declining worldwide in ways that are consistent with previously predicted effects of climate change. Managers are faced with identifying where, when, and how to allocate their limited resources to ensure maximal effect when addressing emerging and evolving societal concerns about climate change. Forecasts of species biodiversity can provide managers with prospective identities and locations of species that are likely to be at future risk because of climate change. This research will address questions related to the use of species distribution models in predicting species' vulnerability to climate change. The project will also examine the connections between factors affecting species variation and species' characteristics, the relations between species-specific distribution forecasts and published vulnerability assessments, and the vulnerability of bird and reptile species to forecasted climate change in the southwestern U.S.

Comparative Analysis of Downscaled Climate Simulations: Providing Guidance to End Users

Principal Investigator: **Daniel Cayan,** Scripps Institution of Oceanography, University of California, San Diego (UCSD) and Water Resources Division, U.S. Geological Survey (USGS)

Cooperators & Partners: **Bridget Thrasher**, Climate Analytics Group; **Alex Hall**, Institute of the Environment and Sustainability, University of California, Los Angeles; **Alexander Gershunov,** Scripps Institution of Oceanography, UCSD; and **Mike Dettinger**, Water Resources;, USGS

To understand potential climate change impacts on ecosystems, water resources, and numerous other natural and managed resources, climate change data and projections must be downscaled from coarse global climate models to much finer resolutions and more applicable formats. This project will conduct comparative analyses to better understand the accuracy and properties of these downscaled climate simulations and climate-change projections. Interpretation, guidance and evaluation, including measures of uncertainties, strengths and weaknesses of the different methodologies for each simulation, will also be provided to enable potential users with the necessary information to select and apply the models.

Multi-Criteria Sensitivity Analysis of the Vulnerability of Hydrologic Systems to Climate Variability and Change in the Southwestern U.S.

Principal Investigator: **Ty Ferré**, University of Arizona (UA) Hydrology and Water Resources
Cooperators & Partners: **Jesse Dickinson**, U.S. Geological Survey (USGS) Arizona Water Science Center; **Christopher Castro**, UA Atmospheric Sciences; **Peter Troch, Rafael Rosolem** and **Hoshin Gupta**, UA Hydrology and Water Resources; **Stan Leake**, **Pamela Nagler** and **Randy Hanson**, USGS
Additional Support: UA Water, Environmental and Energy Solutions, the USGS National Institutes for Water Resources, USGS Office of Groundwater

The potential consequences of climate variability and climate change have been identified as major issues for the sustainability and availability of water resources in the United States. Long-term decreases in precipitation will result in lowered regional groundwater levels, loss of groundwater storage for communities, stream flow depletion, and loss of riparian (near-river) vegetation. This project will examine how hydrologic systems in the Southwestern U.S. respond to climate changes and how this response depends both on the frequency of the changes and the properties of the system. Existing hydrologic models of the Upper San Pedro Basin and the Upper and Middle Verde watersheds will be used with global climate models to simulate and project causes and impacts of climate change. An improved understanding of the vulnerability of hydrologic and riparian areas to future climate will inform managers about which systems may be most sensitive to trends and periodic variations in climate.

Climate Change Vulnerabilities and Adaptation Strategies to Wildfire in the Southwestern U.S.

Principal Investigator: **Mark W. Schwartz**, John Muir Institute of the Environment, University of California (UC), Davis
Cooperators & Partners: **Mark Lubell** and **Jim Thorne**, UC Davis; **Patrick Gonzales**, National Park Service; **Nate Stephenson**, U.S. Geological Survey; **Max Moritz**, UC Santa Barbara; **Tim Brown**, Desert Research Institute; and **Gregg Garfin**, University of Arizona
Additional Support: U.S. Geological Survey, and the National Park Service

Differing, often negative, responses to wildfire occur in plant communities in the southwestern U.S. under stress caused by climate change. This project aims to create a climate, fire, and vegetation vulnerability assessment for forests and woodlands in the Southwest to assist in strategic land management decision-making. This study will analyze the impact of climate change on wildfires, and assess where and when plant communities are predicted to exhibit stress as a consequence of unusual climatic conditions. Understanding fire behavior probabilities and forest vulnerabilities will provide decision support for the deployment of fuels management (prescribed fire and mechanical fuels reduction), as well as for appropriate management

responses to wildfire events. Moreover, an understanding of how vegetation is likely to change with climate will allow proactive land management decisions to guide forested ecosystems toward stable, functioning future states.

Climate Change Vulnerability of Native Americans in the Southwest

Principal Investigator: **Karletta Chief,** University of Arizona, Department of Soil, Water, and Environmental Sciences

Native Americans in the Southwest United States are thought to be particularly vulnerable to climate change. Tribal resiliency to climate change can be affected by multiple climate-related threats and by tribal communities' close reliance on natural resources for sustenance, economic development, and maintenance of cultural traditions. A scientifically rigorous assessment of such threats to Native Americans is a pressing need across southwestern landscapes. This project will examine factors affecting Native American tribes, including water rights for fish and wildlife, protection of wetlands, and enhancement and recovery of the Pyramid Lake, Nevada fishery, and protection of important fish species. This project aims to help manage potential conflicts among stakeholders by providing a better understanding of system dynamics and climate projections in the region. This project will also identify and test best practices in collaborating with and delivering climate science to Native American tribes within the Southwest Climate Science Center's region.

NORTH CENTRAL

Projecting Future Effects of Land Management, Natural Disturbance, and CO_2 on Woody Encroachment in the Northern Great Plains in a Changing Climate

Principal Investigator: **Amy Symstad**, U.S. Geological Survey Northern Prairie Wildlife Research Center
Co-Investigators: **Dominique Bachelet**, Conservation Biology Institute and Oregon State University (OSU); **David King**, OSU; and **Ken Ferschweiler**, Conservation Biology Institute

Maintaining the native prairie lands of the Northern Great Plains (NGP), which provide an important habitat for declining grassland species, requires anticipating the effects of increasing atmospheric carbon dioxide (CO_2) concentrations and climate change on the region's vegetation. Specifically, climate change threatens NGP grasslands by increasing the potential encroachment of native woody species into areas where they were previously only present in minor numbers. This project will use a dynamic vegetation model to simulate vegetation type (grassland, shrubland, woodland, and forest) for the NGP for a range of projected future climates and relevant management scenarios. Comparing results of these simulations will illustrate the sensitivity of woody encroachment projections to climate change factors. Improved understanding of the effects of increasing CO_2, climate change, and land management practices on potential woody encroachment will be used to guide management practices to be most effective in protecting grassland habitat in the NGP into the future.

Projecting Climate Change Effects on Cottonwood and Willow Seed Dispersal Phenology, Flood Timing, and Seedling Recruitment in Western Riparian Forests

Principal Investigator: **Patrick Shafroth**, U.S. Geological Survey (USGS) Fort Collins Science Center
Co-Investigators: **Laura Perry**, Colorado State University (CSU) Biology Department; **Lauren Hay**, **Roland Viger,** and **Steven Markstrom**, USGS Modeling of Watershed Systems, National Resource Program; **Glen Liston**, CSU Cooperative Institute for Research in the Atmosphere; and **David Blodgett** and **Nathaniel Booth**, USGS Center for Integrated Data Analytics

Throughout western North America, warming associated with climate change is leading to both earlier spring peak streamflows and earlier seed dispersal, potentially reducing seedling establishment and in turn reducing the quality of riparian (near-river) forests, which provide critical habitat for diverse birds, mammals, reptiles, amphibians, and insects, and food and shade for fish and other aquatic animals. This project aims to predict these effects of climate change on cottonwood and willow tree regeneration in western forests by linking models of seed dispersal timing, streamflow hydrology, and seedling establishment, focusing on the upper South Platte River Basin as a study area. Results will help land managers anticipate future changes in riparian wildlife habitat quality, and potentially to respond to these changes by actively re-vegetating high-priority areas, or by working with water management agencies to schedule dam releases that favor cottonwood and willow establishment.

Integrating Climate and Biological Data into Land Management Decision Models to Assess Species and Habitat Vulnerability: A Collaboration for Greater Sage-Grouse and their Habitats

Principal Investigators: **Richard S. Sojda**, **Erik A. Beever**, **Kathryn M. Irvin**, and **Gregory T. Pederson,** U.S. Geological Survey (USGS) Northern Rocky Mountain Science Center (NOROCK)
Cooperators & Partners: **Cathy Whitlock**, Montana State University (MSU) Institute of Ecosystems (IoE); **Yvette Converse, Tom Olliff,** and **Sean Finn**, Great Northern Landscape Conservation Cooperative (LCC); **Rick Nelson**

and **Mike Olson**, Plains and Prairie Potholes LCC; **Jeff Warren**, U.S. Fish & Wildlife Service; **Rock Potts**, Charles M. Russell National Wildlife Refuge; **Sten Benes** and **Kate Kitchell**, Bureau of Land Management; **Andrea Ray**, National Oceanic and Atmospheric Administration; **John Sheppard, Michael Reilly, Donald Greer,** and **Elizabeth Shanahan,** MSU; and **Linda Vance**, University of Montana

Climate affects both the demographics of the Greater sage-grouse bird and the condition and long-term viability of their habitats, including sage-steppe communities. This project builds on collaboration among federal land managers, state wildlife biologists, scientists, and other organizations to create a long-term framework for implementing adaptive management for the sage-grouse. The study will examine factors that might be limiting grouse numbers and will investigate components of weather patterns in relation to projected climate change models. Precipitation and temperature, as well as variables such as evaporation and soil moisture, will be considered. Overall, the project will be focused on (1) providing workshops to foster collaboration and interpretation of climate information, (2) developing a sage-steppe habitat map, and (3) suggesting recommendations for an adaptive management framework.

The Value of Climate Information for Supporting Management Decisions within the Plains and Prairie Potholes LCC

Principal Investigators: **Max Post van der Burg**, U.S. Geological Survey (USGS) Northern Prairie Wildlife Research Center, **Cathy Cullinane Thomas** and **Tracy Holcombe**, USGS Fort Collins Science Center

Climate scientists need better and more information about the needs of decision-makers and managers, while decision-makers need better information about how a changing climate may affect their management and conservation objectives. The goal of this project is to build connections between the Plains and Prairie Potholes Landscape Conservation Cooperative (PPP-LCC), the North Central Climate Science Center (NC CSC), and the National Oceanic and Atmospheric Administration Climate Prediction and Projection Pilot Platform (NCPP) to facilitate a link between the users and producers of climate information, as well as to identify gaps between available and desired data. This project will develop a conceptual model of the interactions between climate change, land use change, and conservation and adaptation in the Plains and Prairie Potholes (PPR) region of the North-Central U.S. Relating climate variations to the prevailing land use and socioeconomic issues in the region will produce a framework that will enable climate scientists to guide managers towards currently available and useful climate information and design future research to address remaining key uncertainties affecting conservation decisions in the region.

Regional Short- and Long-term Climate Impacts on Northern Rocky Mountain's and Great Plain's Ecosystems: NASA DEVELOP program Central U.S. Node

Principal Investigator: **Jeff Morisette**, U.S. Geological Survey, North Central Climate Science Center

With joint funding from the North Central Climate Science Center (NC CSC) and NASA Applied Sciences Program, the NC CSC is supporting resource managers and their decision process through its Resource for Vulnerability Assessment, Adaptation and Mitigation Planning (ReVAMP), a collaborative research/planning effort supported by high performance computing and modeling resources. The NC CSC is focused primarily on climate data as input to the ReVAMP. However, the NASA DEVELOP program is being used to evaluate how remote sensing data sets can contribute to the ecological response models that will be implemented in the ReVAMP system. This work is demonstrating the utility of remote sensing in vulnerability assessment and then making sure the remote sensing data sets are fully embedded in the ReVAMP system. The use of remote sensing products are helping to scale ground-based measurement collected on managed lands to larger regions more suitable for analysis against climate modeling grids. The NASA DEVELOP program is covering the

cost of six graduate students and the NC CSC is covering 3 months of time dedicated to faculty advisors for the DEVELOP students.

Regional Extreme Climate Events: Gaining Understanding Through Past and Present Observations and Modeling

Principal Investigator: **Christopher Anderson**, Iowa State University

Climate in the North-Central U.S. is driven by a combination of factors, such as patterns in atmospheric circulation and geographic variations in hydrology, that determine the sustainability of ecosystems in the region as well as the goods and services they provide. This research activity will use a diverse set of region-specific approaches to evaluate efficacy of climate model simulations, provide interpretation of climate change mechanisms, and advance understanding of the relationship between climate, ecosystems, and species of interest. The project aims to 1) develop a model to examine past and present climate variations and assess the ability of climate models to effectively make future climate projections, 2) provide a region-wide evaluation of changes in water flow, and 3) provide climate information to ecosystems scientists, universities, and stakeholders for targeted ecosystem studies.

Vulnerability Assessment of Ecological Systems and Species to Climate and Land Use Change within the North Central Climate Change Center and Partner Land Conservation Cooperatives

Principal Investigator: **Andrew Hansen**, Montana State University

Determining which species, habitats, or ecosystems are most vulnerable to climate change enables resource managers to better set priorities for conservation action. To address the need for information on vulnerability, this research project will leverage the expertise of university partners to inform the North Central Climate Science Center on how to best assess the vulnerability of elements of biodiversity to climate and land use change in order to inform the development and implementation of management options. Outcomes from this activity will include 1) a framework for modeling vegetation type and species response to climate and land use change, 2) an evaluation of existing alternative vegetation and species response models, and 3) a presentation of vulnerability assessments for managers for incorporation into climate adaptation strategies.

Adaptive Capacity and Decision Making Framework

Principal Investigator: **Dennis Ojima**, Colorado State University

While managers are already required to face uncertainty when making natural resource decisions, climate change adds an additional level of complexity to their management considerations. Development of a decision-making approach that acknowledges sources of uncertainty and incorporates the vulnerability of social-ecological systems to climate change is needed for sound natural resource management decisions. This research activity will determine and assess key factors affecting the capacity of social-ecological systems to adapt to climate changes. Moreover, this study will analyze the decision making framework of related and ongoing research efforts and will examine current vulnerability and risk assessment methodologies in the region. Results from this project will help to address natural resource management decisions dealing with climate change dynamics.

Wyoming Rapid Ecoregional Assessment

The North Central Climate Science Center and the National Oceanic and Atmospheric Administration (NOAA) will provide support requested by the Bureau of Land Management (BLM) for the Wyoming Rapid Ecological

Assessment. The overall goal of the Bureau of Land Management's (BLM) Rapid Ecoregional Assessments (REA) is to provide information that facilitates the development of ecological region-based conservation strategies on public lands and to facilitate planning, environmental analysis, and decision-making for regional natural resources. This project will enable the North Central Climate Science Center (NC CSC) to provide climate scientist support to the Wyoming Basins REA. This will be done thru the NC CSC in conjunction with the National Oceanic and Atmospheric Administration (NOAA). The objective is to provide a climate scientist team member to work with the BLM REA core science team responsible for producing the REA documents.

SOUTH CENTRAL

Terrestrial Connectivity across the South Central United States: Implications for the Sustainability of Wildlife Populations and Communities

Principal Investigator: **Kristen Baum**, Oklahoma State University (OSU)
Cooperators & Partners: **Samuel D. Fuhlendorf**, Department of Natural Resource Ecology and Management, OSU; **Kristopher L. Giles**, Department of Entomology and Plant Pathology, OSU; **Daniel Saenz**, Southern Research Station, U.S. Forest Service; **Monica Papes**, Department of Zoology, OSU; **Norman C. Elliot**, U.S. Department of Agriculture Agricultural Research Service; **Bill Bartush**, Gulf Coast Prairie Landscape Conservation Cooperative, National Wetlands Research Center; **Allan Janus**, Oklahoma Department of Wildlife Conservation

Connectivity, or the extent to which a landscape facilitates or impedes the movement of organisms, is an important component of the sustainability of wildlife populations and communities. Habitat fragmentation, modification, and loss have been implicated in the decline of almost all threatened and endangered species, and both continued land-use change and climate change will have an effect on habitats. The goal of this project is to use a systematic and comprehensive approach to evaluate terrestrial connectivity across the South Central United States. Models will be used to predict patterns of connectivity for species which vary in habitat preferences, methods of habitat selection, and responses to the area between habitats. Researchers will evaluate the implications of predicted land-use change across the study area, including a focus on climate change and dominant land uses within the region. The results of this project will include spatially explicit connectivity maps that can be used for making informed management decisions about terrestrial connectivity within this region.

Delineation of Fresh, Intermediate, Brackish, and Saline Marsh Types of the North Central Gulf of Mexico Coast

Principal Investigator: **Steve Hartley**, U.S. Geological Survey (USGS), National Wetlands Research Center
Cooperators & Partners: **Brady Couvillion** and **Bill Jones**, USGS; **Nicholas Enwright**, Five Rivers Services; **Mike Brasher**, Gulf Coast Joint Venture (GCJV) and Ducks Unlimited; **Barry Wilson**, GCJV and U.S. Fish & Wildlife Service; **Jenneke Visser**, University of Louisiana at Lafayette; and **Bart Ballard**, Texas A&M, Kingsville

Spatial data depicting marsh types (e.g. fresh, intermediate, brackish, and saline) for the north-central Gulf of Mexico coast are inconsistent across the region, limiting the ability of conservation planners to model the current and future capacity of the coast to sustain priority species. The goal of this study is to (1) update the resolution of coastal Texas vegetation data to match that of Louisiana, Mississippi, and Alabama, and (2) update vegetation maps for the Texas through Alabama region using current Landsat Imagery. Creating consistent regional vegetation maps will enable scientists to model vegetation response to and potential

impacts of future climate change.

Occurrence and Variation in Submersed Aquatic Vegetation (SAV) along the Northern Gulf of Mexico: a Hierarchical Approach to Assess Impacts of Environmental Change on SAV Resources

Principal Investigators: **Megan La Peyre**, U.S. Geological Survey (USGS), Louisiana Fish and Wildlife Cooperative Research Unit
Cooperators & Partners: **Andy Nyman**, Louisiana State University Agricultural Center; **Mike Poirrier**, University of New Orleans; **Brady Couvillion**, USGS, National Wetlands Research Center; **Joy Merino**, National Marine Fisheries Service; **Mike Brasher**, Ducks Unlimited, Gulf Coast Joint Venture (GCJV); **Stephen DeMaso,** U.S. Fish and Wildlife Service and GCJV; and **Barry Wilson**, GCJV

Submersed aquatic vegetation (SAV) communities are highly productive ecosystems that provide significant ecological benefits to coastal areas. Despite their critical importance, and their global decline, the scientific community lacks consistent baseline data on SAV resources across the gradient from fresh to brackish (slightly salty) to salt water. This project will 1) provide data on the occurrence and abundance of SAV (e.g., coverage, composition, seed resources) within the northern Gulf of Mexico, 2) quantitatively assess environmental factors affecting its variation across space and time, and 3) develop a conceptual model of factors influencing SAV resources. These data are critical in identifying numerical relationships between SAV resources and environmental variables, and will enable predictive modeling of SAV resources under different scenarios of landscape and climate change. This work will contribute to the refinement of existing models of ecosystem change and directly benefit efforts to forecast the effects of climate change on distribution, abundance, and diversity of SAV resources and the priority fish and wildlife populations that depend upon them.

Expert Workshop to Build CSC Expertise in Understanding the Social and Communication Dimensions of Climate Change

Principal Investigator: **Dennis Patterson**, Texas Tech University (TTU)
Cooperators & Partners: **Katharine Hayhoe**, TTU, and **Riley Dunlap**, Oklahoma State University

A limited amount of valid scientific information about global climate change and its detrimental impacts has reached the public and exerted a positive impact on the public policy process or future planning for adaptation and mitigation. This project is designed to address this limitation by bringing together expertise in the social and communication sciences from targeted academic institutions affiliated with the Department of the Interior's Climate Science Centers (CSCs) by means of a workshop. Workshop attendees will address and examine barriers to climate communication and methods for communicating science for policy application and engaging media and outreach. Results from the workshop will be published and made available as a resource to CSCs, scientists, land managers, and policymakers. This effort will bring together the expertise needed to ensure that the nation's CSCs are able to effectively communicate the science of the important but often misunderstood issue of anthropogenic climate change and meaningfully support effective policy across the United States

Evaluating the Assumption of Stationarity in Statistical Downscaling Applications

Principal Investigators: **Katharine Hayhoe**, Texas Tech University, and **Keith Dixon** and **John Lanzante**, National Oceanic and Atmospheric Administration Geophysical Fluid Dynamics Laboratory

Regional assessments of the impacts of climate change on both human systems and the natural environment require high-resolution projections to see the effects of global-scale change on the local environment. This project will address a critical and generally overlooked assumption inherent to these projections of regional,

multi-decadal climate change: that the statistical relationship between global climate model simulation outputs and real, observed climate data remain constant over time. Utilizing a "perfect---model" experimental design and the output of two high-resolution global climate model simulations, this study will evaluate and report on the ability of three different methods to simulate current and future temperature and precipitation in the U.S., with a focus on the southern Great Plains region. Differences between the methods' abilities during the late 20th versus late 21st century time periods will provide valuable information regarding the level of confidence we should attribute to the climate projections commonly used in impacts analyses and as the basis for decision-support and planning purposes.

Inter-Tribal Workshops on Climate Variability and Change

Principal Investigator: **Laurel Smith**, University of Oklahoma
Cooperators & Partners: **Renee McPherson, Randy Peppler**, and **Rachel Riley**, University of Oklahoma; **Wayne Kellogg**, Chickasaw Nation, U.S. Department of Environment Health and Safety; **Dana McDaniel Bonham**, Choctaw Nation of Oklahoma; **Kim Winton**, U.S. Geological Survey; **Filoteo Gómez,** Private Consultant

New partnerships among tribal nations and members of the climate science and conservation communities call for multicultural conversations about climate change, risk, and variability. To contribute to the goal of mutual understanding, this project will develop and implement a series of workshops that will (1) educate tribal representatives across the region about climate science and climate adaptation practices, (2) document climate impacts on the tribal nations and their peoples, lands, resources, and economies, and (3) extend, enhance, and foster dialogue among tribal representatives, climate scientists, and conservation leadership. By blending educational outreach with preliminary research on how tribal members know and conceptualize weather and climate, as well as how they have historically struggled with adapting to new climate conditions, this project will facilitate the design of products that tribal decision makers can use, help monitor climate change in the field, and provide lessons about adaptation that are useful for both tribal and non-tribal communities and businesses.

Synthesizing Ecohydrology Models as a Management Tool for Landscape Conservation under Climate Change

Principal Investigator: **Shannon Brewer**, Oklahoma Cooperative Fish and Wildlife Research Unit
Cooperators & Partners: **Chris Zou**, Natural Resource Ecology and Management, Oklahoma State University; **Paul Kemp**, International Centre for Ecohydraulics Research, University of Southampton; **Thomas Worthington**, Natural Resources Ecology and Management, Oklahoma State University
Additional Support: Oklahoma Cooperative Research Unit

To date, hydrological and ecological models have been developed independently from each other, making their application particularly challenging for interdisciplinary studies. The objective of this project is to synthesize and evaluate prevailing hydrological and ecological models in the South-Central U.S., particularly the southern Great Plains region. This analysis will identify the data requirements and suitability of each model to simulate stream flow while addressing associated changes in the ecology of stream systems, and will portray climate variability and uncertainty. The anticipated results and deliverables of this project will include a comprehensive, updated, and systematic report on recent developments in ecosystem hydrology with a focus on freshwater resource management. This synthesis report will directly address existing needs of the Landscape Conservation Cooperatives (LCCs) by providing information that can be readily used to help understand the effect of climate change and land management on hydrology and associated fish communities.

NORTHEAST

Critically Evaluating Existing Methods and Supporting a Standardization of Terrestrial and Wetland Habitat Classification and Mapping that Includes Characterization of Climate Sensitive Systems

Principal Investigators: **David Diamond**, University of Missouri and **Don Faber-Langendoen,** NatureServe

This project will facilitate coordination among the scientific community to provide a comparison of existing habitat classification and mapping products within the footprint of the Northeast Climate Science Center (NE CSC). This study will also provide an evaluation of habitat vulnerability to climate change within the region and recommendations for needed improvement in habitat mapping products for the future.

Characterization of Spatial and Temporal Variability in Fishes in Response to Climate Change

Principal Investigator: **Brian Irwin**, U.S. Geological Survey Georgia Cooperative Fish and Wildlife Research Unit
Cooperators & Partners: **Tyler Wagner**, Pennsylvania Cooperative Fish & Wildlife Research Unit and **James R. Bence**, Quantitative Fisheries Center, Michigan State University

Currently, there exists much uncertainty regarding how climate change will influence different populations or ecosystems. To improve current understanding and forecasting of population responses to climate variability, the role of variability must be considered when examining system dynamics and species interactions. This project will use an analytical framework to quantitatively estimate how variation in fish populations may respond to climate change and other important changes regionally. This study also aims to communicate scientific uncertainties in ways that are useful to decision makers and to provide decision makers and managers with the ability to detect and predict impacts of climate change on fish populations.

Developing Fish Trophic Interaction Indicators of Climate Change for the Great Lakes

Principal Investigators: **Richard T. Kraus**, **Patrick Kocovsky**, **Mark Rogers**, and **Brian Weidel**, U.S. Geological Survey, Great Lakes Science Center, Lake Erie Biological Station; **Carey Knight** and **Ann Marie Gorman**, Ohio Department of Natural Resources, Division of Wildlife

It is predicted that climate change, which can result in increased temperature, eutrophication (the occurrence of excessive nutrients in a body of water), and changes to freshwater inputs, will alter food web dynamics and consequently the sustainability of fish populations in the Great Lakes, which provide significant multi-national fishery resources. This project will evaluate aquatic food web structures as indicators of climate change to determine which fish species are most at risk. Analyses in the study will include 1) examination of the distribution of dominant prey and predator fishes, 2) variability in diet and food web position of fishes related to seasonal-driven habitat changes and 3) seasonal environmental variability as related to long-term climate change. Results will be used to serve management agency needs to adaptively maintain sustainable large lake fisheries.

Extending the Northeast Terrestrial Habitat Map to Atlantic Canada

Principal Investigator: **Kevin McGarigal**, Department of Conservation, University of Massachusetts and **Mark G. Anderson** and **Charles Ferree**, The Nature Conservancy

Consistent and accurate landscape datasets are important foundational products for ecological analyses and for understanding and anticipating the effects of climate change on forested, agricultural, and freshwater systems across the U.S. and Canada. The objective of this project is to extend an existing terrestrial habitat

map of the north Atlantic U.S. to Atlantic Canada and southern Quebec, using and modeling field-collected data combined with national and provincial datasets. This GIS map will 1) provide a foundation upon which further research, such as species vulnerability analyses, can advance, 2) allow each relevant state and province to identify terrestrial habitats consistently across borders, 3) allow for analysis of regional connectivity, and 4) facilitate an understanding of terrestrial animal and plant populations in relation to climate change.

Bringing People, Data, and Models Together – Addressing Impacts of Climate Change on Stream Temperature

Principal Investigators: **Austin Polebitski**, **Yi-Chen E. Yang**, **Richard N. Palmer**, and **Casey M. Brown**, University of Massachusetts; **Ben H. Letcher**, U.S. Geological Survey; and **Keith H. Nislow**, U.S. Forest Service

Few studies have focused specifically on the impact of climate change on freshwater ecosystems, resulting in a lack of useful, actionable, and climate-informed information for resource and watershed managers. This project will conduct two primary activities: 1) a campaign to gather existing stream temperature data within the Northeast U.S. with additional data collection as needed, and 2) an evaluation of the ability of state-of-the-art statistical and deterministic stream temperature models to replicate stream temperature measurements and to scale measurements to larger regional contexts.

A Stream Temperature Inventory Network and Decision Support Metadata Mapper - Evaluating the Resources to Understanding Climate Change Effects on Streams in New England and the Great Lakes States

Principal Investigator: **Jana Stewart**, U.S. Geological Survey (USGS) Wisconsin Water Science Center
Co-Investigators: **Marcus C. Waldron** and **David Armstrong**, USGS Massachusetts Water Science Center; **Jim McKenna**, USGS Great Lakes Science Center; **Dana Infante**, Michigan State University; and **Kevin Wehrly**, Institute for Fisheries Research, Michigan Department of Natural Resources

Stream data for the northeastern U.S. are needed to enable managers to understand baseline conditions, historic trends, and future projections of the impacts of climate change on stream temperature and flow, and in turn on aquatic species in freshwater ecosystems. This project seeks to move toward development of a coordinated, multi-agency regional stream temperature framework and database for New England (ME, VT, NH, CT, RI, MA) and the Great Lakes States (MN, WI, IL, MI, IN, OH, PA, NY) by building a community around the efforts of this study. These efforts include 1) compiling metadata about existing or historic stream temperature monitoring locations and networks, 2) developing a web-based decision-support mapping system to display, integrate, and share the collected information, and 3) developing data system capabilities that integrate stream temperature data from several data sources.

A Research and Decision Support Framework to Evaluate Sea-Level Rise Impacts in the Northeastern U.S.

Principal Investigator: **E. Robert Thieler**, U.S. Geological Survey, Woods Hole Coastal and Marine Science Center
Co-Investigators: **Nathaniel G. Plant** and **Dean B. Gesch,** USGS, and **Radley Horton**, Columbia University
Additional Support: North Atlantic Landscape Conservation Cooperative

Previous approaches to quantify coastal vulnerability to sea-level rise have had major shortcomings, including the possibility that their underlying assumptions are not uniformly valid. This project will conduct a study to distinguish the differing ways that coastal areas of the northeastern U.S. will respond to sea-level rise. This

information will be used to develop a scientific research and decision-support program that addresses the cross-cutting and unique problems in these areas related to climate change and sea-level rise.

SOUTHEAST

Connectivity for Climate Change in the Southeastern U.S.

Principal Investigator: Nick Haddad, Department of Biology, North Carolina State University (NCSU)
Cooperators & Partners: **Jen Constanza**, NCSU, and **Ron Sutherland**, Wildlands Network

Habitat fragmentation, caused by agriculture and urbanization, creates barriers to migration that prevent plants and animals from changing habitats to adapt to climate fluctuations, potentially causing severe problems with biodiversity. The most commonly recommended strategy to address this problem and protect wildlife as climate changes is to increase landscape connectivity; however, there are great challenges to implementing this strategy in the southeastern U.S. because most intervening lands between habitats are held in private ownership. This project will combine data on key wildlife species and their habitats throughout this region using computer modeling technologies to create a map of landscape connectivity that will identify key linkages for wildlife habitats and key targets for conservation to facilitate habitat movements as climate changes. This work will engage Landscape Conservation Cooperatives (LCCs) and other stakeholders in identifying the focal species and habitats, and in designing and implementing a connectivity plan in the southeastern U.S. to preserve biodiversity and permit wildlife to adapt to a changing climate.

Ecological Implications of Mangrove Forest Migration in the Southeastern U.S.

Principal Investigator: **Michael Osland**, U.S. Geological Survey (USGS) National Wetlands Research Center (NWRC)
Cooperators & Partners: **Ken W. Krauss** and **Richard H. Day**, USGS NWRC, and **Mark Hester**, University of Louisiana

Warmer winter temperatures and reductions in the intensity of freeze events, due to climate change, would likely lead to the expansion of mangrove forests and the displacement of salt marshes in parts of the U.S. Gulf of Mexico and Atlantic coast. The objective of this research project is to use prediction models to better evaluate the ecological implications of mangrove forest migration and salt marsh displacement on coastal wetland soil processes and the consequent implications for coastal wetland responses to sea-level rise and carbon storage.

Assessing Climate-Sensitive Ecosystems in the Southeastern U.S.

Principal Investigator: **Jaime Collazo**, U.S. Geological Survey and North Carolina Cooperative Fish and Wildlife, and **William J. Wolfe**, USGS Tennessee Water Science Center
Cooperators & Partners: **Jennifer Costanza**, North Carolina State University; **Milo Pyne**, **Carl Nordman,** and **Rickie White**, NatureServe; and **William Gould**, U.S. Forest Service

The southeastern U.S. contains a unique diversity of ecosystems that provide important benefits, including habitats for wildlife and plants, good water quality, and various recreation opportunities. While information on climate change implications exists for some of these ecosystems, a synthesis of this information for the entire Southeast is needed to enable regional decision-makers to prioritize current efforts and plan future research and monitoring programs to ensure protection of these ecosystems. This project will combine existing

information for climate-vulnerable parts of the Southeast U.S. and the Caribbean related to current threats, climate change impacts, and the capacity of ecosystems to adapt to climate change. Data from ecological and geographic databases, scientific literature, technical reports, and expert knowledge will be used to assess climate affects. The result of this research will be a list of key conservation strategies that will help ecosystems adapt to climate change.

Synthesis of Climate Model Downscaling Products for the Southeastern United States

Principal Investigator: **Ryan P. Boyles**, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University (NCSU)
Cooperators & Partners: **Adrienne Wootten, Kara Smith,** and **Fred Semazzi**, NCSU; **Vasu Misra** and **Lydia Stefanova**, Florida State University; **Tom Smith**, Southeast Ecological Science Center, U.S. Geological Survey (USGS); and **David Blodgett**, Center for Integrated Data Analytics, USGS

The large number of downscaling methodologies (used to translate large-scale climate information to a local scale) produced by governments and academic researchers involve different approaches, resolutions, time periods, and variables that limit the ability of users to form meaningful conclusions and evaluate the results of climate adaptation and conservation strategies. To address these issues, this project will 1) summarize the various methods available for downscaling models, 2) identify the metrics most appropriate for evaluation of climate model usability for the ecology and conservation community in the southeastern U.S., and 3) begin a longer-term effort to evaluate the range of climate modeling products over this geographic region. These objectives will be accomplished through a comprehensive literature review and engagement with the Landscape Conservation Cooperative (LCC) and U.S. Geological Survey (USGS) scientific and practitioner community.

Hydrological Modeling for Flow-Ecology Science in the Southeastern U.S.

Principal Investigator: **Jonathan Kennen**, U.S. Geological Survey New Jersey Water Science Center
Co-Investigators: **Peter Caldwell, Ge Sun,** and **Steven McNulty**, U.S. Forest Service, and **Stacy Nelson**, North Carolina State University

Integrated modeling approaches are needed to assess the impact of climate change, land use, and water use on stream flow to ensure healthy river ecosystems and an adequate supply of water for humans. The objectives of this project are to 1) inventory existing hydrologic modeling efforts in the Southeast U.S. region, 2) evaluate and compare the performance of these models in predicting stream flows, 3) demonstrate the feasibility of using regional and local scale models to identify unique areas of concern and understand water dynamics for climate change assessments and 4) synthesize work on developing and evaluating stream flow-ecology relationships in the region.

A Handbook for Resource Managers to Understand and Utilize Sea-Level Rise and Coastal Wetland Models for Ecosystem Management under Future Conditions

Principal Investigator: **Thomas W. Doyle,** U.S. Geological Survey National Wetlands Research Center
Cooperators & Partners: **Laurie Rounds,** National Oceanic and Atmospheric Administration, and **Martha Segura**, National Park Service

Various sea-level rise and coastal wetland models of different designs and scales have been developed for predicting habitat and environmental change, but have not yet been synthesized to inform natural resource managers of each model's utility and limitations. Some models are accessible as online tools while others require more expert capacity to run for any given park, refuge, reserve, or regional application. This project

aims to construct a handbook from training and feedback sessions with U.S. Fish and Wildlife Service (FWS) resource staff and other coastal managers (e.g. National Oceanic and Atmospheric Administration, U.S. National Park Service) across the pan-Gulf and South Atlantic states of the southeastern U.S. This handbook will contain published decision-support tools and simulation models for sea-level rise and climate change assessments to assist land and resource managers in making important decisions related to climate change.

Communicating and Using Uncertain Scientific Information in the Production of 'Actionable Science'

Principal Investigator: **Brian Irwin,** U.S. Geological Survey Georgia Cooperative Fish and Wildlife Research Unit (GCFWRU)
Cooperators & Partners: **Clint Moore**, GCFWRU, and **Meredith Gore**, Department of Fisheries & Wildlife and School of Criminal Justice, Michigan State University

One of the most pervasive problems facing natural resource managers and science communicators is the existence of numerous social and ecological uncertainties. Despite these uncertainties and the fact that forecasts of future climate conditions are typically imperfect, decision makers are expected to communicate and use the information available when making policy choices that affect multiple user groups. The objective of this project is to provide a synthesis of information that will have practical use as decision support for conservation practitioners and decision makers at various administrative levels. This tool will be developed through interdisciplinary interactions and a comprehensive literature review and will focus on climate change in the southeastern United States.

Developing Long-Term Urbanization Scenarios for the Caribbean LCC as Part of the Southeast Regional Assessment Project

Principal Investigator: **Jaime Collazo,** U.S. Geological Survey North Carolina Cooperative Fish and Wildlife Research Unit

This project extends the long-term urbanization modeling efforts already being undertaken for the South Atlantic, Gulf Coastal Plains and Ozarks, and Appalachian Landscape Conservation Cooperatives (LCCs) as part of the Southeast Regional Assessment Project (SERAP) into the Caribbean LCC.

Assessment of Terrestrial and Aquatic Monitoring Programs in the Southeastern United States

Principal Investigator: **Damian Shea,** North Carolina State University

A significant challenge faced by climate scientists in the public and private sector is the need for reliable and complete information about the historical status of ecological systems expected to be influenced by climate change. While many organizations monitor one or more aspects of aquatic and terrestrial ecosystems, these monitoring programs are seldom coordinated and the associated data are not readily available. This project aims to support the efforts of multiple federal, state, and other organizations in the development of a comprehensive and integrated assessment of monitoring programs associated with atmospheric, stream, and terrestrial ecosystems. Components of this study will include compiling and mapping current sources of existing ecosystem quality and quantity data, and assessing the available information from these sources. Results from this proposed work will provide the region's scientists and decision makers with accurate and comprehensive information about monitoring programs that can be used to assess the potential effects of climate change in the southeastern United States.

Southeast Regional Assessment Project (SERAP)

Principal Investigator: **Brian Hughes,** USGS Georgia Water Science Center and various investigators

Many of the ecosystems in the southeastern United States are increasingly under threat due to rapid human development and will potentially be affected by climate change. Moreover, climate change will likely alter important ecological factors (temperature, precipitation, and sea-level rise), making it difficult, if not impossible, to maintain and use historic and current environmental condition data in conservation planning efforts for the future. Therefore, there is a need to develop and adapt effective conservation strategies to cope with the effects of climate and landscape change on future environmental conditions. The Southeast Regional Assessment Project (SERAP) seeks to integrate multidisciplinary project components to aid conservation planning and design so that ecosystem management decisions can efficiently be made across a range of species and environments. SERAP will provide a suite of regional climate, watershed, and landscape-change analyses and develop the interdisciplinary framework required for the biological planning phases of adaptive management and strategic conservation.

Developing Long-Term Urbanization Scenarios for the Appalachian and Gulf Coastal Plain and Ozarks LCCs as Part of the Southeast Regional Assessment Project

Principal Investigator: **Jaime Collazo,** U.S. Geological Survey North Carolina Cooperative Fish and Wildlife Research Unit

Changing urbanization patterns in the southeastern U.S. region may present special challenges or opportunities for conservation over the coming decades that require collaborative modeling efforts. Using a modified version of the U.S. Geological Survey's SLEUTH (Slope, Land cover, Exclusion, Urbanization, Transportation, and Hillshade) urban growth model, this project will develop baseline and future scenarios of urbanization over the next 50-100 years for the regions covered by the Appalachian and Gulf Coastal Plain and Ozarks Landscape Conservation Cooperatives (LCCs). This project extends prediction models by building upon work already being done as part of the Southeast Regional Assessment Project (SERAP).

Predicting Vulnerability of Southeastern Sea Turtle Nesting Beaches to Climate Change

Principal Investigator: **Kristen M. Hart,** U.S. Geological Survey Southeast Ecological Science Center

Sea-level rise, increased storm frequency, and altered temperature and humidity associated with climate change may reduce the suitability of nesting and foraging habitats used by federally threatened and endangered species, such as the loggerhead sea turtle. The goal of this project is to produce a vulnerability assessment of coastal habitats representing important nesting grounds for loggerhead and other endangered sea turtles (e.g. Kemp's ridleys, green turtles, and leatherbacks). This project will build upon work already being done to develop vulnerability maps under a number of current and future climate scenarios. These maps will provide management guidance and will serve to identify knowledge and data gaps as primary sources of uncertainty.

Impact of Ocean Warming and Acidification on Growth of Reef-Building Corals

Principal Investigator: **Ilsa B. Kuffner***,* U.S. Geological Survey St. Petersburg Coastal and Marine Geology Science Center

Two significant contributing factors to the degradation of coral reef ecosystems are increasing ocean surface temperatures and decreasing ocean acidification. Both factors are related to anthropogenic disturbances of the global carbon cycle. However, there are too few datasets at this time to make educated predictions on the

precise impact of these factors. This study aims to identify differences in climate vulnerability among three important reef-building coral species, and subsequently to inform resource management decisions regarding reef restoration and species protection policies. Project goals include a study addressing long-term variability in ocean temperature and acidification and the corresponding response of coral reef development. This data will be used as important baseline information as ocean conditions continue to change.

Integrating the Effects of Global and Local Climate Change on Wildlife in North America

Principal Investigators: **Rob Dunn** and **Nick Haddad**, Department of Biology, North Carolina State University (NCSU); **Steve Frank**, Department of Entomology, NCSU; and **Nadia Singh**, Department of Genetics, NCSU

The southeastern U.S. has experienced large-scale changes in urbanization with consequent effects on local climate. To-date, the impacts of these changes on wild species appear to be overlooked, despite their importance to conservation and wildlife planning. The overarching goal of this project is to model and understand the influence of current urban warming and future global warming on species of conservation concern. This study aims to understand a combination of local mitigation techniques and regional conservation decisions that best facilitate future conservation in the southeastern U.S.