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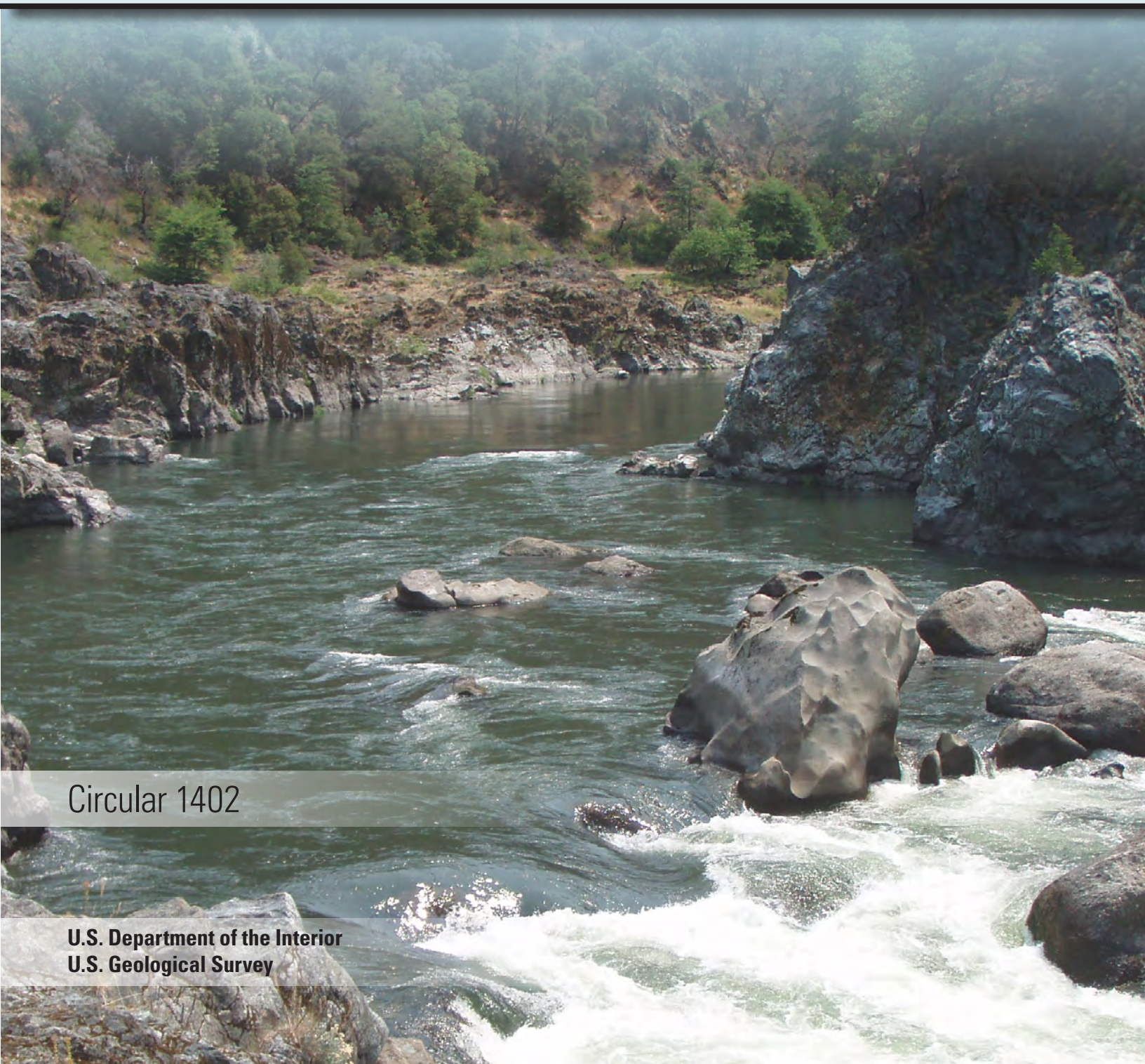
The National Climate Change and Wildlife Science Center Annual Report for 2013



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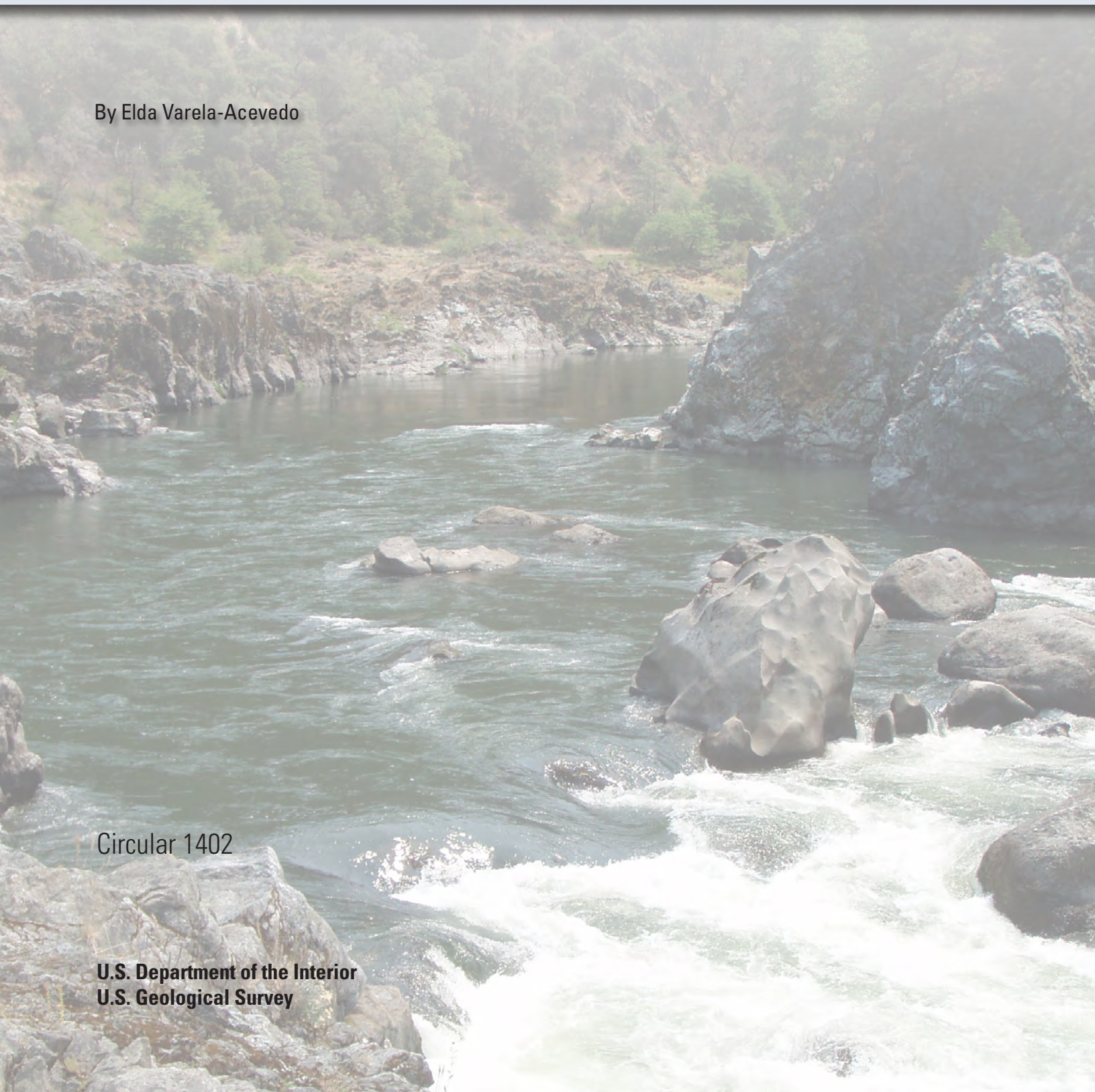
Cover. Rogue River in southern Oregon. Photograph by USGS.

The National Climate Change and Wildlife Science Center Annual Report for 2013

By Elda Varela-Acevedo



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U.S. Department of the Interior
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U.S. Department of the Interior
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U.S. Geological Survey
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U.S. Geological Survey, Reston, Virginia: 2014

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Suggested citation:
Varela-Acevedo, Elda, 2014, The National Climate Change and Wildlife Science Center annual report for 2013: U.S. Geological Survey Circular 1402, 32 p., *http://dx.doi.org/10.3133/cir1402*.

ISSN 2330-5703 (online)

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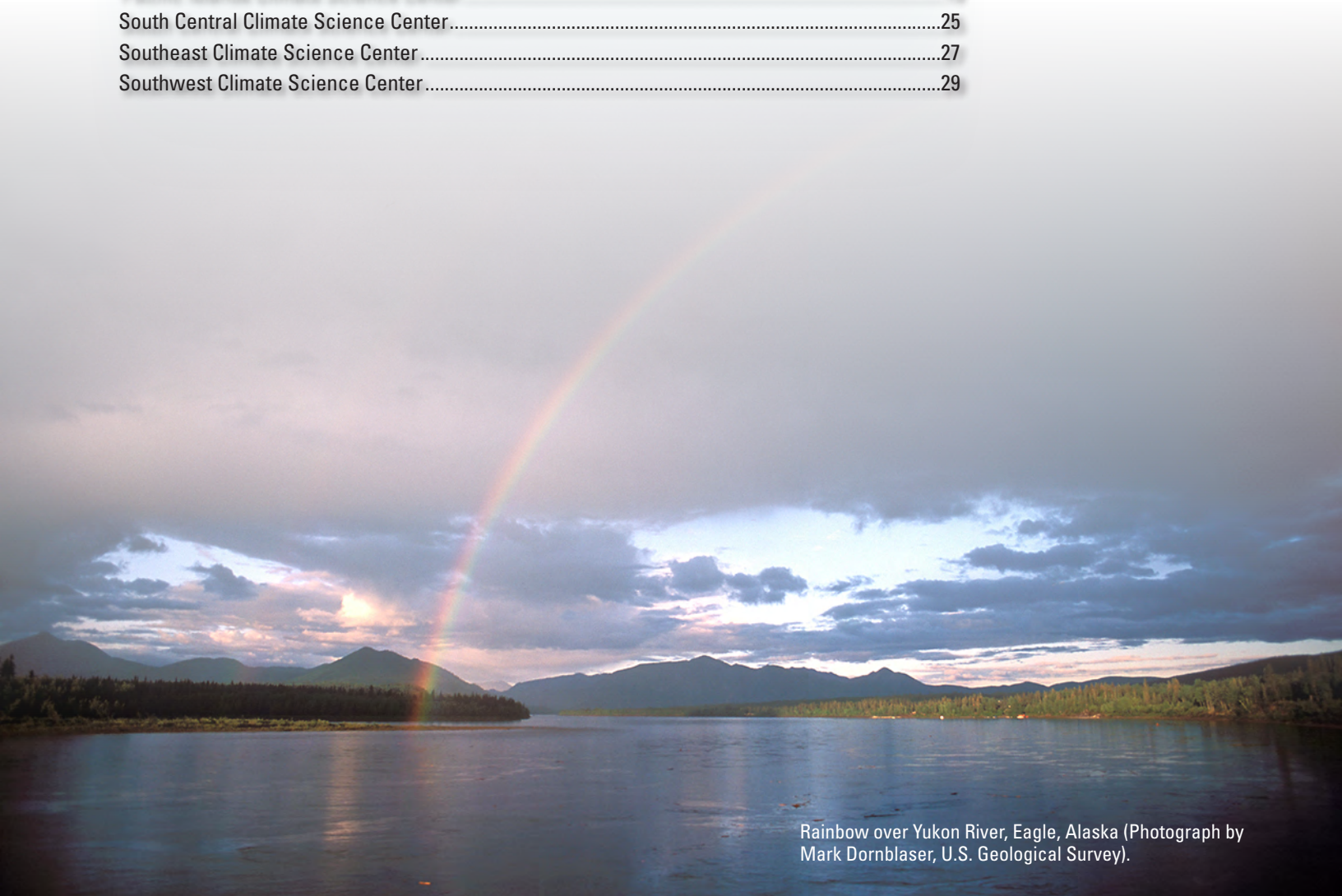

Rainbow over Yukon River, Eagle, Alaska (Photograph by Mark Dornblaser, U.S. Geological Survey).

Figures

The Colorado River passing through the Grand Canyon in Arizona (Photograph from U.S. Geological Survey).

Abbreviations

ACCCNRS	Advisory Committee on Climate Change and Natural Resource Science
AK CSC	Alaska Climate Science Center
CLU	USGS Climate and Land Use Change Mission Area
CSC	Climate Science Center
CSU	Colorado State University
DOI	Department of the Interior
ECCF	Early Career Climate Forum
FY	Fiscal Year
GIS	geographic information system
GOA	Gulf of Alaska
IARC	International Arctic Research Center
KCS	key cultural significance
LCC	Landscape Conservation Cooperative
LSU	Louisiana State University
MSU	Montana State University
NC CSC	North Central Climate Science Center
NCCWSC	National Climate Change and Wildlife Science Center
NE CSC	Northeast Climate Science Center
NPS	National Park Service
NW CSC	Northwest Climate Science Center
OKState	Oklahoma State University
OSU	Oregon State University
OU	University of Oklahoma
PI	Principal Investigator
PI CSC	Pacific Islands Climate Science Center
ReVAMP	Resource for Vulnerability Assessment, Adaptation, and Mitigation Planning
SAC	Stakeholder Advisory Committee
SC CSC	South Central Climate Science Center
SDM	Structured Decision Making
SE CSC	Southeast Climate Science Center
SET	surface elevation table
SST	sea surface temperature
SW CSC	Southwest Climate Science Center
TTU	Texas Tech University
UCLA	University of California, Los Angeles
UMass	University of Massachusetts
UOG	University of Guam
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
USVI	U.S. Virgin Islands
UW	University of Washington
WERI	Water and Environmental Research Institute

The National Climate Change and Wildlife Science Center Annual Report for 2013

A Word From Our Director

T. Douglas Beard, Jr., Ph.D., National Climate Change and Wildlife Science Center Director.

Welcome to the second annual report of the U.S. Geological Survey (USGS) National Climate Change and Wildlife Science Center (NCCWSC) and the Department of the Interior (DOI) Climate Science Centers (CSCs). In fiscal year 2013 (FY13), the NCCWSC and CSCs completed an important infrastructure-building phase. We completed our team of eight USGS CSC directors by hiring David Helweg as the Pacific Islands CSC director, and all CSCs now have published science agendas to guide their work. We are now moving to a phase in which CSCs focus more tightly on a select number of high-priority themes that address common management questions, and we link these themes and questions with NCCWSC-managed, national-scale projects that complement our regional work. These projects will provide resource managers with actionable science—science that can be applied to real-world problems. In FY13, we funded more than 50 new research projects that focus on how climate change may affect natural resources as well as management actions that can be taken to help offset such effects. Additionally, the Federal Advisory Committee on Climate Change and Natural Resource Science (ACCCNRS) held its first meeting in September 2013 and identified five key areas in which they will provide key strategic input. Expanding our team and strengthening linkages to our partners will help the NCCWSC and CSC enterprise continue to provide world class actionable science to support the long-term sustainability of our natural systems.

Quick Year in Review

- The DOI CSCs awarded nearly $7 million in FY13 funding to universities and other partners for climate and land-use change research.
- FY13: A permanent director, David Helweg, Ph.D., was hired for the Pacific Islands CSC (PI CSC), completing the CSC leadership team. In addition, staff scientists were hired at the Alaska (AK), Northeast (NE), and Southeast (SE) CSCs, with recruitment underway at NCCWSC and the other CSCs:
  - AK – Jeremy Littell, Ph.D. (Applied Climate Scientist)
  - NE – Michelle Staudinger, Ph.D. (Science Coordinator)
  - SE – Mitchell Eaton, Ph.D. (Research Ecologist)
- Completed the formation of regional Stakeholder Advisory Committees (SACs) for each of the eight CSCs and a national advisory committee (ACCCNRS) to oversee the NCCWSC-CSC enterprise.
- NCCWSC staff is working to create a searchable public database on climate change vulnerability assessments.
- NCCWSC scientists Shawn Carter, Michelle Staudinger, and Laura Thompson authored articles for the November 2013 issue of the Ecological Society of America's journal *Frontiers in Ecology and the Environment*, which was devoted to an assessment of climate change effects on biodiversity and ecosystems, and the consequences for people.

NCCWSC Headquarters Staff

The NCCWSC staff is located at the USGS headquarters in Reston, Virginia. This team guides and supports the CSCs in accomplishing their science agenda goals.

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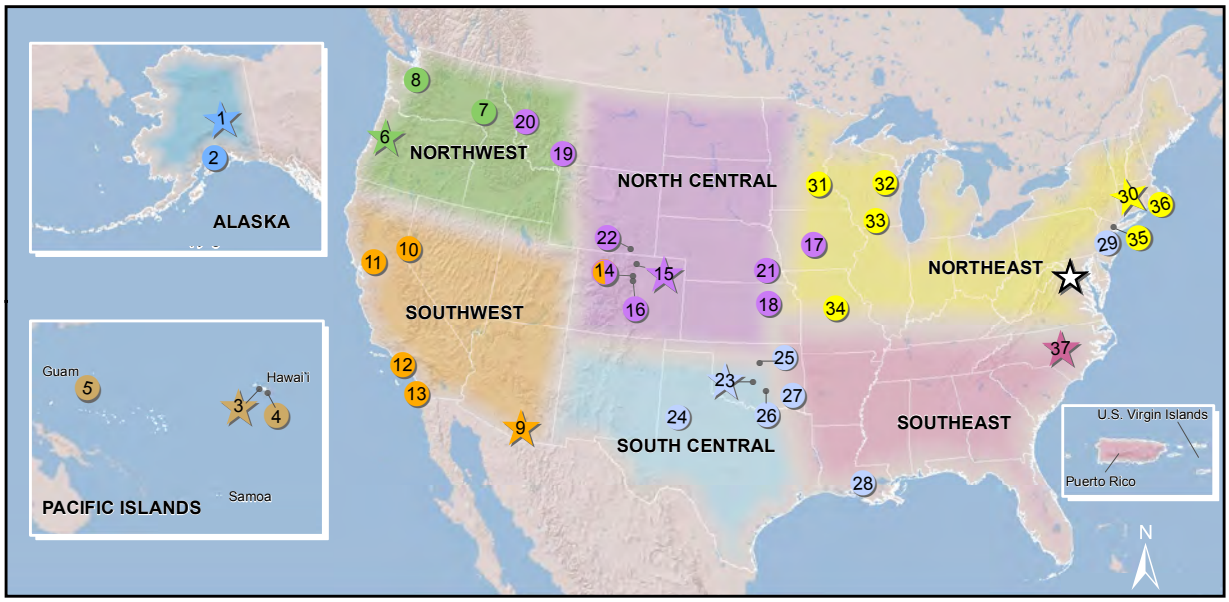
The History of NCCWSC and CSCs

In 2008, Congress created NCCWSC within the USGS. The center was formed to respond to the demands of natural resource managers for rigorous scientific information and effective tools for assessing and responding to climate change. Located at the USGS National Headquarters in Reston, Va., NCCWSC has invested more than $93 million (through FY13) in cutting-edge climate change research and, in response to Secretarial Order No. 3289, established and is managing eight regional DOI CSCs (fig. 1).

The DOI CSCs are located at major universities, have Federal and university staff, train graduate students and post-doctoral researchers, and undertake scientific activities designed to meet the needs of natural and cultural resource managers. Several regions have university-led consortia that include tribes and a Tribal college as well as Federal laboratories that have personnel with key skills and expertise.

The CSC enterprise has been shaped by the following principles:

- Meet the scientific needs of resource managers
- Foster partnerships
- Maximize resources for science
- Utilize the strengths of both university and government
- Focus on ecosystems, not jurisdictions



Base from ESRI, 2009, Albers Equal Area Conic Projection, North American Datum of 1983

EXPLANATION

National Climate Change and Wildlife Science Center

CSC lead institutions

CSC institutions

Alaska CSC
1. University of Alaska Fairbanks
2. University of Alaska Anchorage

Pacific Islands CSC
3. University of Hawai`i at Mānoa
4. University of Hawai`i at Hilo
5. University of Guam

Northwest CSC
6. Oregon State University
7. University of Idaho
8. University of Washington

Southwest CSC
9. University of Arizona
10. Desert Research Institute (Nevada)
11. University of California, Davis
12. University of California, Los Angeles
13. Scripps Institute of Oceanography
14. University of Colorado

North Central CSC
14. University of Colorado
15. Colorado State University
16. Colorado School of Mines
17. Iowa State University
18. Kansas State University
19. Montana State University
20. University of Montana
21. University of Nebraska, Lincoln
22. University of Wyoming

South Central CSC
23. University of Oklahoma
24. Texas Tech University
25. Oklahoma State University
26. Chickasaw Nation
27. Choctaw Nation of Oklahoma
28. Louisiana State University
29. NOAA Geophysical Fluid Dynamics Laboratory

Northeast CSC
30. University of Massachusetts, Amherst
31. University of Minnesota
32. College of Menominee Nation
33. University of Wisconsin, Madison
34. University of Missouri, Columbia
35. Columbia University
36. Marine Biological Laboratory

Southeast CSC
37. North Carolina State University

Figure 1. Locations of the Climate Science Centers and their university-led consortia.

User-Driven Science—Stakeholders, NCCWSC, and CSCs

The NCCWSC enterprise was established to provide scientific information to natural resource managers with respect to a changing climate. NCCWSC and the CSCs rely heavily on input and guidance about what science questions are most pressing and how results need to be presented to be helpful in making decisions. Regional and national advisory committees help with this endeavor.

CSCs and SACs

Each CSC has a formal Stakeholder Advisory Committee (SAC) that includes States, Federal agencies, tribes, and the Landscape Conservation Cooperatives (LCCs) from their region. As SAC members, these partner agencies relate managers' and decision makers' needs to the CSCs. Furthermore, CSCs also seek input from regional conservation and science organizations as well as farmers, foresters, and other producers. This results in the efforts of each CSC being focused on a number of high-priority topics to ensure maximum impact and that science is directly responsive to the needs of decision makers.

NCCWSC and ACCCNRS

In addition, on October 4, 2012, then Secretary of the Interior Ken Salazar announced the establishment of the Advisory Committee on Climate Change and Natural Resource Science (ACCCNRS), a Federal advisory committee to provide input and guidance to NCCWSC. The committee's membership guidelines and procedures are compliant with the Federal Advisory Committee Act (FACA).

The ACCCNRS is composed of 25 members that represent Federal agencies; Tribal, State, and local governments; nongovernment organizations; academic institutions; and the private sector.

Duties of the committee include:

a) Advising on the contents of a national strategy, identifying key science priorities to advance the management of natural resources in the face of climate change.

b) Advising on the nature, extent, and quality of relations with and engagement of key partners at the regional/CSC level.

c) Advising on the nature and effectiveness of mechanisms to ensure the identification of key priorities from management partners and to effectively deliver scientific results in useful forms.

d) Advising on mechanisms that may be employed by NCCWSC to ensure high standards of scientific quality and integrity in its products, and to review and evaluate the performance of individual CSCs, in advance of opportunities to re-establish expiring agreements.

e) Coordinating as appropriate with any Federal Advisory Committee established for the DOI LCCs.

The first meeting of the ACCCNRS was held September 18–19, 2013. Following is a summary of ACCCNRS actions/recommendations that resulted from the meeting:

- The ACCCNRS approved the Operating Procedures and Ground Rules, with one amendment: removal of reference to specific subcommittees in item 8.
- The Committee agreed to defer action on the creation of Science Subcommittee and its related Terms of Reference.
- The Committee decided to establish five initial Committee-member work groups:
  - NCCWSC and CSCs in the Federal Science/Services Landscape
  - Actionable Science
  - Tribal and Indigenous Matters
  - Program Evaluation
  - Communications/Networks (on hold)

The agenda and additional material from the ACCCNRS meetings can be found on the NCCWSC Web site.

NCCWSC and CSC Science Agendas

In the NCCWSC Five Year Planning Strategy (2009–2014), NCCWSC outlined three basic goals: (1) work in close partnership with the natural resource management communities to understand high-priority science needs and what is needed to fill those knowledge gaps; (2) work with the scientific community to develop science information and tools that can be used by managers in the formation of strategies for responding to climate change; (3) work directly with resource managers to use these tools in decision making. From these overarching goals, NCCWSC is now developing a national science agenda that will be managed from the bottom up.

Input from key partners in the SACs shapes the CSC's strategic science agenda and annual project priorities, and provides feedback on the utility, timeliness, and responsiveness of individual research activities and the CSC as a whole. This guidance strengthens the CSC's ability to produce and make available science that is relevant to managers' decision-making needs. The regional science agendas in turn will build toward a national assessment and synthesis.

NCCWSC believes that a national agenda created in this management-driven process will be of use in several ways. The national agenda will primarily guide NCCWSC in designing its national science strategy—projects undertaken at the national level will complement or amalgamate regional science. A second role will be to communicate the most important and large-scale questions arising as the natural and cultural resource management community confronts climate change—with the expressed intent of enlisting stakeholder agencies to assist in answering these large-scale/difficult questions. This process of engagement is in its early stages, and it is likely that the roster of scientific questions will evolve over time. The periodic updating of the national science agenda will allow this evolution to be communicated to science agencies.

The NCCWSC Draft National Science Agenda is under review by the ACCCNRS and will be part of a wider strategic plan guided by the ACCCNRS. The national agenda was drafted on the basis of input from the newly formed CSCs and was presented in initial form in 2012 to NCCWSC stakeholders and USGS Climate and Land Use (CLU) change senior staff. Relevant organizational goals from the USGS Ecosystems and CLU Mission Areas were also incorporated into the document. This agenda is being reviewed by ACCCNRS.

Strategic Growth

In FY13, the NCCWSC-CSC enterprise completed much of its *infrastructure-building phase*:

- CSC host locations were identified and agreements were put in place with university consortia.
- Initial stakeholder advisory consultations were held, staffing and science planning was initiated, and early rounds of science activities were funded.

The next phase is viewed as *strategic alignment*, in which CSCs focus on high-priority science questions identified for their region, building toward deeper and more consequential outcomes. CSCs may link together to address common large-scale phenomena, such as sea-level rise and extended drought, and connect to national synthesis and assessment activities. This work may contribute to actionable science:

> "Actionable science provides data, analyses, projections, tools, or approaches that can support decisions regarding assessment or management of the risks and impacts of climate change. It is ideally co-produced by scientists and decision makers, and creates rigorous, understandable, accessible, and usable products to meet the needs of stakeholders."

(Working definition proposed by ACCCNRS, January 2014)

NCCWSC and CSC Science

The scientific work of the NCCWSC-CSC enterprise can be grouped into two categories: *Science Infrastructure and Capacity Building* and *Thematic Science* projects.

Science Infrastructure and Capacity Building projects enable the added value and tangible products of conducting scientific work:

- Collaborate, communicate, and translate science results to managers, stakeholders and the public interested in climate change activity
- Create a shared information and data management platform
- Educate and train climate scientists that will provide expertise in the future
- Evaluate the impacts of the NCCWSC-CSC enterprise

Examples of Science Infrastructure and Capacity Building projects include:

Climate Change and Federal Land Management: Assessing Priorities Using a Social Network Approach

Principal Investigator (PI): Mark Schwartz, Ph.D. (*University of California, Davis*)
(NCCWSC FY11—FY13 Project)

Researchers are seeking to better understand networks among resource managers with respect to developing plans for climate change adaptation. They are pursuing this endeavor through a network analysis based on a survey of Federal resource management staff and scientists in the Southwestern and Midwestern United States.

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

PI: Jana S. Stewart, Ph.D. (*USGS Wisconsin Water Science Center*)
(Northeast CSC FY12—FY14)

Stream data for the Northeastern United States 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, multiagency regional stream temperature framework and database for New England (Maine, Vermont, New Hampshire, Connecticut, Rhode Island, Massachusetts) and the Great Lakes States (Minnesota, Wisconsin, Illinois, Michigan, Indiana, Ohio, Pennsylvania, New York) 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.

Thematic Science Projects adheres to mission relevant areas of research and contain a mix of strategic and tactical science:

- Assess and synthesize our state of knowledge about climate and land-use change impacts to natural and cultural resources
- Perform vulnerability assessments of species and ecosystems
- Understand the social-ecological impacts of climate and land-use change
- Understand the interactions between climate and the physical, biological, and chemical forces that influence the structure and functioning of ecosystems and the goods and services they provide

Examples of Thematic Science projects include:

Assessment of Drought Impacts on Selected Fish and Wildlife Species in the Southwestern United States

PI: James W. Cain, III, Ph.D. (*USGS New Mexico Cooperative Fish and Wildlife Research Unit*)
(NCCWSC FY13—FY16 project)

The responses of individual species to environmental changes can be manifested at multiple levels that range from individual-level (i.e., behavioral responses) to population-level (i.e., demographic) impacts. Major environmental changes that ultimately result in population-level impacts are frequently first detected as individual-level responses. For example, herbivores respond to limited forage availability during drought periods by increasing the duration of foraging periods and expanding home range areas to compensate for the reduction in forage. However, if the individual-level responses are not sufficient to compensate for reduced forage availability, reduced survival and reproductive rates may result. In order to better understand these potential effects, project researchers will study the impacts of drought on desert bighorn sheep, American pronghorn, Rio Grande cutthroat trout, and scaled quail, including assessments of individual-level (for example, desert bighorn sheep) and population-level (for example, pronghorn, cutthroat trout, scaled quail) responses to drought.

Ecological Implications of Mangrove Forest Migration in the Southeastern United States

PI: Michael J. Osland, Ph.D. (*USGS National Wetlands Research Center*)
(Southeast CSC FY12 – FY14)

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.

NCCWSC National Accomplishments

NCCWSC Project Highlights

- The November 2013 issue of the Ecological Society of America's journal *Frontiers in Ecology and the Environment* is devoted to an assessment of climate change effects on ecosystems and the consequences for people. Dr. Shawn Carter, Senior Scientist at NCCWSC, Dr. Michelle Staudinger, Science Coordinator at the NE CSC, and Laura Thompson, Biologist/Population Geneticist at the NCCWSC, were authors of articles in the *Frontiers* issue.
- In cooperation with scientists from the University of Wisconsin-Madison, the NCCWSC supports the "Climate Change and Resilience of Sport Fisheries in Lakes" project in which researchers are assessing climate-driven trends in cool- and warm-water sport fish by studying interactions between walleye and bass populations in the Upper Midwest lakes. Resulting tools are intended for use by management agencies to evaluate potential impacts of climatic change on sport fisheries.
- The NCCWSC sponsors a national webinar series highlighting the research findings of projects funded by the NCCWSC and CSCs. This series is co-sponsored with the U.S. Fish and Wildlife Service's (USFWS)

National Conservation Training Center and features talks highlighting climate impacts and corresponding management issues. In 2013, a total of 14 webinars were hosted with an average of 83 participants per webinar.

- NCCWSC staff is working to create a searchable public database on climate change vulnerability assessments.

Project Spotlight: Vulnerability Assessment Database

Vulnerability assessments (VAs) can provide insights on resources that are most likely to be affected by climate change and why those resources are most vulnerable. Consequently, these assessments are an important tool for informing climate change adaptation planning. Although a large number of vulnerability studies are currently being conducted, there is no available method to identify VAs conducted in specific regions or on specific resources. Thus, it is highly likely that new assessments are being launched without knowledge of relevant ongoing or completed assessments. It is also likely that the data and knowledge gathered by completed assessments are not reaching and being used by managers outside the entity conducting the assessment. Addressing this lack of coordination is necessary for reducing costs and duplication and increasing the value of existing assessment investments.

To address this issue, the NCCWSC as part of the work of the Interagency Land Management Adaptation Group (ILMAG) and member agencies from the U.S. Global Change Research Program (USGCRP) Adaptation Science Work Group, the Association of Fish and Wildlife Agencies (AFWA), and several non-governmental organizations convened a steering group early in 2013 to develop plans for a searchable, public registry on climate change VAs. The goal is to make information about ongoing and completed VAs readily accessible and available, so that resources devoted to such assessments can be used efficiently.

The scope of the assessments housed in the registry will be broad and will incorporate studies pertaining to species and ecosystems, built environments and infrastructure, cultural resources, and socioeconomic systems. The registry will be stored in a central, easily searchable database (fig. 2) and will host information from both Federal and non-governmental partners. The collection of non-federal data, however, is pending approval under the Paperwork Reduction Act. Partnering Federal agencies have agreed to collect these data and keep them current for approximately 5 years as an initial scope.

Users of the registry will be able to enter information that pertains to a suite of basic reporting elements, including contact information, managing agency and partner agencies, project location and scale, assessment target or endpoint, vulnerability assessment components (exposure, sensitivity, adaptive capacity), type of climate, sea-level or hydrological change projections (hazards), methods for determining impact of hazards, and the purpose of the VA.

The registry will be hosted by both Federal and non-governmental partners. The USGS will host a Federal site, and its content will be made available (by way of Web services) through EcoAdapt's Climate Adaptation Knowledge Exchange (CAKE). In addition, the registry may be migrated or linked to the USGCRP Global Change Information System (GCIS) in the future.

Figure 2. Contributing partners to the vulnerability assessment database.

Training the Climate Leaders of Tomorrow

A key part of the NCCWSC and CSC mission is training the climate impact science and management workforce of the future. Each CSC (as is shown in this report) supports multiple graduate students, post-doctoral research students, and, sometimes, undergraduate students. NCCWSC tracks the number of graduate students supported by CSCs. This metric provides feedback, primarily to funders, of the overall performance and productivity of the effort. Because students are such a key "output" of CSCs, such a metric is needed to reflect this investment.

Each CSC has a cadre of graduate students or post-doctoral researchers who, while pursuing their academic training, work on high-priority science needs of conservation managers in their region, gaining valuable insight into how management agencies operate and creating networks that may serve them throughout their careers. Approximately 26 post-doctoral researchers, 60 graduate students, and 10 undergraduates were supported at the CSCs in FY13–FY14. In some CSCs, students trained by CSC-related faculty, but not funded by the CSC, are also contributing valuable time and expertise to our work.

The CSCs also provide career development events. For example, the Northwest (NW) CSC has continued its annual "climate science boot camp" for early career scientists and management professionals. The boot camps include field trips, skill-building exercises, and presentations by leading climate scientists, communications experts, and resource managers to give participants an all-encompassing view of the workings of climate impacts science.

Stemming from the NW CSC bootcamp, the Early Career Climate Forum (ECCF) was launched in 2013 as a network of early career climate science researchers and professionals dedicated to improving research and practice through collaboration and communication. Attendees of the bootcamp came together to create and manage the ECCF and developed a platform that provides an online venue for resource sharing, idea exchange, and improving climate change communication.

Additionally, the SE CSC sent seven new SE CSC graduate students known as the Global Change Fellows to the National Conservation Training Center for a week-long course in Structured Decision Making (SDM) in the summer of 2013. This training will allow the fellows to use SDM as a tool in climate related decision problems. The newly trained cohort will continue to work with SDM and apply SDM to SE CSC funded projects throughout their research.

Funding Overview

Funding for NCCWSC and the CSCs grew steadily from FY08 to FY12 but declined slightly in FY13 and FY14 (fig. 3). The FY15 President's proposed budget proposes a substantial increase. Plans are for each CSC (and NCCWSC) to be funded at approximately $5 to $6 million, meaning a substantial budget growth is anticipated to bring the enterprise to its planned strength.

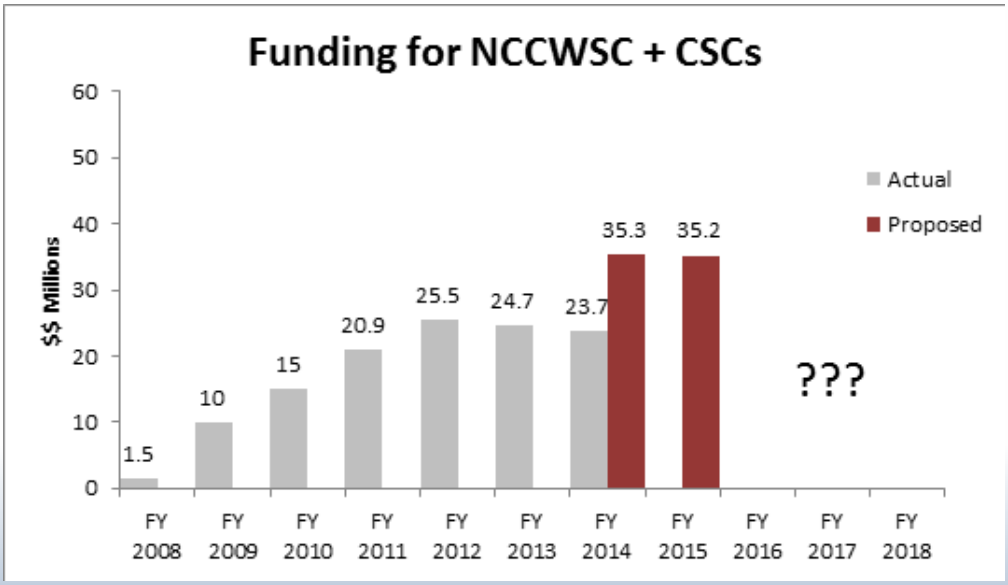


Figure 3. NCCWSC and CSC actual funding from FY 2008 to FY 2014 and the proposed funding amounts for FY 2014 and FY 2015.

Alaska Climate Science Center

Host Institution: University of Alaska Fairbanks
Location: University of Alaska Anchorage
Consortium: University of Alaska System: Fairbanks, Anchorage, and Southeast
Established: March 2010

USGS CSC Director: Steve Gray, Ph.D.
University CSC Director: Scott Rupp, Ph.D.

DOI Web site: *http://www.doi.gov/csc/alaska/index.cfm*
Consortium Web site: *https://csc.alaska.edu/*

SELECTED PROJECT HIGHLIGHTS

Alaska Climate Science Center Glacier Workshop

As climate changes, watersheds along the Gulf of Alaska (GOA) are experiencing some of the highest rates of glacier melting on Earth, causing substantial societal and ecological impacts on the structure and productivity of marine ecosystems, safety hazards related to glaciers, hydropower generation, and sea-level rise. During the past decade, the amount of freshwater that has been added to the ocean as a result of this glacier loss is equal to draining the Great Lakes each and every month for the entire 10-year period. It is very likely that Alaska's glaciers will continue to lose more mass than they gain, which will cause global sea-level to continue to rise. This glacial melting may also impact the natural systems that are closely connected to the glaciers. The GOA is one of the most productive marine ecosystems on Earth. Humans have found many ways to use the wealth of resources it produces. Animals and fish provide food, jobs, recreation, and scenic value. The incredible beauty of the glaciers and glacier-influenced landscapes attract tourists who bring economic benefits to Alaskan communities. Some of the benefits of glaciers, such as steady streamflow for hydropower, are yet to be fully realized. The complete loss of glaciers in Alaska is not imminent, but the current rates of ice loss are likely to continue and perhaps accelerate. The GOA region is heavily influenced by glaciers and the runoff that they deliver to the ocean. Understanding how changes in regional climate will affect glaciers and closely linked systems is a goal among scientists and resource managers in Alaska and beyond.

In their 2012 Action Plan, the AK CSC included "Linking Water Resources, Water Chemistry and Alaska's Glaciers" as a major priority. The plan also recognized the need to better communicate research findings on glacier change to the management community and public at large. In response to this priority, the AK CSC held a Glacier Workshop, March 5–6, 2013, at the Mendenhall Glacier Visitor Center in Juneau, Alaska. The workshop brought together scientists and land and resource managers to establish a cross-disciplinary framework for developing new tools to monitor and anticipate future changes in glacier runoff along the GOA. The workshop resulted in a coordinated strategy for studying glacier change in Alaska and addressed key outstanding questions related to glacier change. The impacts of glacier change in the coastal temperate rainforest were explored through several presentations that highlighted the state of the science from various components of the glacier system, including glacier change, hydrology, ocean interactions, biology, and biogeochemistry. Working groups and discussions explored system interactions, information deficits, and resource management implications. The 2-day workshop was concluded with two public presentations in Juneau.

In addition, a public fact sheet about the "Icefield to Ocean" system is available at https://csc.alaska.edu/resource/icefield-ocean. An interdisciplinary team of conference attendees is presently working on a synthesis paper for peer review. The workshop agenda, presentations, and related publications are available online.

Soil Surface Organic Layers in Alaska's Arctic Foothills: Distribution, Development, and Microclimatic Feedbacks

Alaska's Brooks Range makes for a difficult research environment, but graduate student Carson Baughman embraced the challenge as part of his master's work, studying soil processes in the region. Baughman studied the soil surface organic layer—the layer of accumulated dead plant material that builds up and decomposes, becoming a critical part of the soil. Field sampling and statistical methods were used to determine where the soil surface organic layer is accumulating within a 50-kilometer study area in the Brooks Range. Topographic properties, including exposure to sunlight, slope, and aspect, were used to predict the location of soil surface organic layers. On the basis of work at a series of sites with similar topographic properties but different soil ages, Baughman explored how long it takes for the soil surface organic layer to form and how the accumulation of this layer affects the underlying mineral soils and permafrost layer.

This work relates directly to the AK CSC's Strategic Plan and its call for "Identification of key drivers and response variables" related to ecosystem change in the Alaska region. This is a primary focus for the AK CSC because of its significance to informing decision making, resource management, adaptation, and planning in the face of disturbance and climate change. When the soil surface organic layer is subject to disturbances, such as a tundra fire, it can release large amounts of stored carbon, while also triggering a host of other landscape changes. This research will help increase understanding of linked climate, fire, and landscape change across the entire Arctic Foothills region. Baughman successfully defended his thesis in September of 2013.

POST-DOCTORAL RESEARCHERS AND STUDENTS

University of Alaska Fairbanks

Peter Bieniek, Ph.D.: Post-Doctoral Fellow, International Arctic Research Center (IARC), Regional climate modeling

Stephanie McAfee, Ph.D.: Post- Doctoral Fellow, IARC, Climate model downscaling

Alessio Gusmeroli, Ph.D.: Post-Doctoral Fellow, IARC, Permafrost hydrology

Nathan Kettle, Ph.D.: Post-Doctoral Fellow, IARC, Network analysis of climate science research, applications, and services in Alaska

James Powell, Ph.D.: Post-Doctoral Fellow, IARC, Community resilience and adaptive capacity

Jane Wolken, Ph.D.: Post-Doctoral Fellow, IARC, Climate change impacts on forest ecosystems

Jennifer Schmidt, Ph.D.: Post-Doctoral Fellow, IARC, Changing wildlife habitat patterns

Katrina Bennett: Ph.D. Candidate, IARC, Influence of climate change on regional hydrologic extremes in interior sub-arctic Alaskan watersheds

Yekaterina Kontar: Ph.D. Candidate, IARC, Natural hazards and science communication

Simon Filhol: Ph.D. Candidate, IARC, Snow physics

Carson Baughman: M.S., Natural Resource and Agricultural Sciences, Controls and consequences of peat in a permafrost landscape on Alaska's North Slope

Greg Deemer: M.S., IARC, High resolution sea-ice modeling in the Bering and Chukchi Seas

Winslow Hansen: M.S., Natural Resource & Agricultural Sciences, Linked Disturbance interactions in Alaska: Implications for ecosystems and people

Rick Lader: M.S., IARC, Intercomparison and validation study of reanalysis models for Alaska

Earnest Eckerson: Undergraduate Research Assistant, Freshwater discharge from Alaska glaciers

Brittany Bennett: Undergraduate Research Assistant, Population-level responses of Alaska wildlife species to short- and long-term effects of climate change on the environment

North Central Climate Science Center

Location: Colorado State University—Fort Collins
Consortium: Colorado State University (CSU), Fort Collins (lead institute); University of Colorado; Colorado School of Mines; University of Nebraska, Lincoln; Montana State University (MSU); University of Wyoming; University of Montana; Kansas State University; and Iowa State University
Established: 2011

USGS CSC Director: Jeff Morisette, Ph.D.
University CSC Director: Dennis Ojima, Ph.D.

DOI Web site: *http://www.doi.gov/csc/northcentral/index.cfm*
Consortium Web site: *http://revampclimate.colostate.edu/*

SELECTED PROJECT HIGHLIGHTS

In the North Central Climate Science Center's (NC CSC) five-year science agenda, published in late 2012, NC CSC dedicated itself to be a "Resource for Vulnerability Assessment, Adaptation, and Mitigation Planning" (ReVAMP) for Department of Interior (and other) resource managers in the Missouri River Basin. To fulfill that commitment, the NC CSC funded two separate but complementary areas in 2013— its Foundational Science Areas and three decision-focused resource management projects.

Foundational Science Areas

The overall goal of the ReVAMP activity is to develop a platform to enhance integration across the foundational areas and to facilitate the synthesis and integration of the resulting research into management tools to guide responses to climate change effects on the region's natural resources. The ReVAMP concept will serve as a centralizing theme to coordinate research done through the NC CSC and will also provide the mechanism by which the NC CSC can help serve stakeholder needs. Starting with directed funding in 2012, and continuing with funds from 2013, the research efforts of the University Consortium have been organized around the three foundational research themes (see figure 5). These Foundational Science Areas were established to provide an integrated science delivery to research and management communities across the North Central region:

- Physical Climate: Understanding and quantifying drivers of regional climate changes (Team lead: Joe Barsugli, Ph.D., University of Colorado, Boulder)
- Ecological Impacts: Assessing impacts of climate change on the natural resources of the region and the resulting vulnerability of social-ecological system components (Team lead: Andrew Hansen, Ph.D., MSU)
- Adaptation and Mitigation: Characterizing adaptive capacity of communities and natural resources (Team lead: Dennis Ojima, Ph.D., CSU)

Decision-focused resource management projects

In addition to the foundational science work, the NC CSC also solicited projects with a clear "articulation of (a) decision that is being considered and how it addresses important Department of the Interior land, water, fish and wildlife, or cultural heritage resources in the region" and inclusion of resource management decision makers as collaborators and (or) investigators. Funded projects will develop products (such as reports, workshops, and analyses) appropriate for the integration of the work being done into a decision and (or) a decision-making process. The three selected projects are:

- Informing implementation of the Greater Yellowstone Coordinating Committee's Whitebark Pine Strategy (PIs: Cathy Whitlock, Ph.D., and Andy Hansen, Ph.D., MSU)
- Surrogate species for wetland-dependent birds in the prairie pothole region: selection, evaluation, and management application in the face of climate change (PIs: Susan Skagen, Ph.D., USGS; and Barry Noon, Ph.D., CSU)
- Building social-ecological resilience in southwestern Colorado (Project team lead: Nina Burkart, Ph.D., USGS)

In addition to bringing climate science to the specific management issues, a secondary, but critical, objective of the solicited projects was to help direct the configuration of ReVAMP. The NC CSC selected projects involved willingness from the PIs to both use and help define ReVAMP. In this capacity, and to complement the foundational science areas, it is the intention that these three projects focus on the intersection of the latest science on climate drivers, ecological impacts, and adaptation and mitigation (represented as the central, maroon-colored intersection of the Venn diagram, fig. 4).

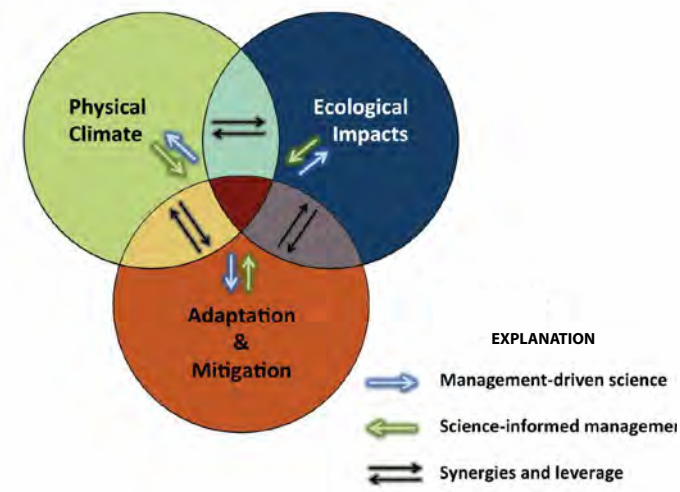


Figure 4. The Foundational Science Areas of the NC CSC, with decision-focused, resource management projects meeting at the intersection of these areas.

POST-DOCTORAL RESEARCHERS AND STUDENTS

Shannon McNeeley, Ph.D.: Post-Doctoral Fellow, CSU, Water scarcity and sustainability in the context of climate variability and change

Brian Miller, Ph.D.: Post-Doctoral Fellow, CSU, Development of climate change scenario planning tools

Nathan Piekielek, Ph.D.: Post-Doctoral Fellow, MSU, Vulnerability Assessment of ecological systems and species to climate and land use change

Renee Curry: Ph.D. candidate, CSU, Analysis of climate change impacts on Phenology using phenocameras and remote sensing

Jared Oyler: Ph.D. candidate, University of Montana, Development and analysis of historical landscape-scale climate datasets

Kelli Groy: Undergraduate, CSU, Young Professional for National Aeronautics and Space Administration (NASA) DEVELOP National Program

Amber Weimer: Undergraduate, CSU, Analysis of climate change impacts on phenology using phenocameras and remote sensing

Linnet Agnes Jose: Undergraduate, CSU, Analysis of climate change impacts on phenology using phenocameras and remote sensing

Northeast Climate Science Center

Location: University of Massachusetts, Amherst
Consortium: University of Massachusetts (UMass), Amherst; College of Menominee Nation; Columbia University; Marine Biological Laboratory; University of Minnesota; University of Missouri, Columbia; and the University of Wisconsin, Madison
Established: 2012

USGS CSC Director: Mary J. Ratnaswamy, Ph.D.
University CSC Director: Richard Palmer, Ph.D.

DOI Web site: *http://www.doi.gov/csc/northeast/index.cfm*
Consortium Web site: *http://necsc.umass.edu/*

SELECTED PROJECT HIGHLIGHTS

NorEaST - Stream Temperature Web Portal Demonstration, Application, and Modeling

PI: Jana Stewart, Ph.D.,USGS Wisconsin Water Science Center

In the coming decades, climate change will increasingly alter stream temperature and flow regimes. Consequently, conservation and management practitioners will need access to the best available data and tools to make decisions on how these physical changes will influence the distribution of aquatic species in freshwater ecosystems. To address this need, Dr. Jana Stewart of the USGS Wisconsin Water Science Center and Dr. Austin Polebitski of the UMass and University of Wisconsin-Platteville have developed the NorEaST project, a community-driven data portal to serve as a coordinated, multiagency framework to map and store continuous stream temperature locations and data for the NE CSC region.

The project has involved collaborative work with the Wisconsin Department of Natural Resources, U.S. Forest Service (USFS) Districts, and Trout Unlimited New England Chapter to deploy data loggers for stream temperature monitoring and record all Federal and State stream temperature monitoring sites (fig. 5). In addition, the project is identifying gaps in stream monitoring sites and comparing different stream temperature modeling techniques. A literature review of existing stream temperature models is in preparation and will describe the current status of stream temperature modeling in the NE CSC region. The review has already informed the selection of three initial stream temperature modeling frameworks that will undergo further evaluation and climate change analysis as the project progresses. Project results will be made available through the NorEaST Web portal. This research responds to the NE CSC science theme of "Climate impacts on freshwater resources and ecosystems," an issue included in the NE CSC Strategic Science Agenda because "the impacts of climate change on water resources (both surface and groundwater) will be one of the most important and far reaching impacts felt by individuals, ecosystems, and institutions." Potential applications include calculating stream thermal metrics to facilitate regional comparisons, analysis, and modeling, as well as determining relations between stream thermal metrics and fish assemblages to identify thermally responsive fishes and temperature regimes for use in designing adaptation strategies.

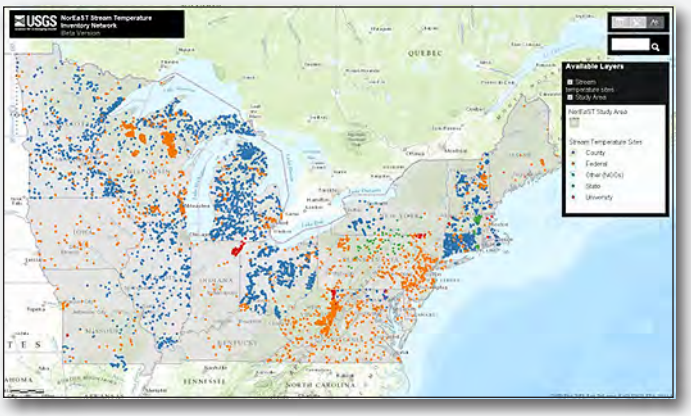


Figure 5. The NorEaST Web portal currently is mapping more than 9,000 continuous stream temperature monitoring locations and associated metadata contributed by 41 different organizations across 22 States. Federal, State, and university stream temperature monitoring sites are shown in orange, blue, and red, respectively.

Assessing management strategies for resilience of forest ecosystems to climate and disturbance impacts

PI: Anthony D'Amato, Ph.D., University of Minnesota

Antony D'Amato and his team at the University of Minnesota are quantifying the range in variability in forest dynamics and climate responses for range-margin populations of jack pine and black spruce trees to generate management guidelines for conserving these forests on the landscape in an uncertain climatic future. They are using tree-ring patterns and long-term data collections from natural and managed forests across New England and Great Lakes States to identify forest management strategies and forest conditions that have conferred the greatest levels of resistance and resilience to past stressors and their relevance in addressing future environmental change. They also combine long-term forest and bird population data to develop tools to identify refugia sites most likely to support spruce-fir forest and its associated high-priority obligate bird assemblages over the long term under projected climate change scenarios. These findings will result in monitoring protocols and papers/publications that can be used to assist managers in planning for climate change. Finally, they are examining strategies for mitigating the combined impacts of the invasive emerald ash borer and climate change on ash-dominated wetlands across the Great Lake States.

This research responds to the science theme "Climate impacts on land use and land-cover" in the NE CSC Strategic Science Agenda, which highlights that "A key element of this science theme is the development of models which incorporate the response of the species that constitute diverse natural communities (forests, shrublands, grasslands, and inland and coastal wetlands), human responses (urban and residential development, agricultural, forestry, wildlife management practices, mining impacts, and bioenergy development), and changes in natural disturbance regimes (fire, wind, flood, drought, and insects and disease)." This research is in close collaboration with scientists from the USFS Northern Research Station and will benefit a range of stakeholders, including State land managers in the Great Lakes States, New England, and New York; National Forests in the upper Midwest and New England States; Tribal land management organizations; the National Park Service (NPS); the Upper Midwest and Great Lakes, Plains and Prairie Pothole, Appalachian, and North Atlantic LCCs; and the USFWS.

An example of an adaptation strategy for black ash forests. Researchers are underplanting Emerald Ash Borer (EAB) on non-host species in an attempt to increase the resilience of these wetland areas to EAB and other stressors. (Photograph by Mitch Slater, U.S. Forest Service)

Red Pine forest. (Photograph by Anthony D'Amato, University of Minnesota)

POST-DOCTORAL RESEARCHERS AND STUDENTS

Eleonora Demaria, Ph.D.: Post-Doctoral Fellow, Department of Civil and Environmental Engineering, UMass Amherst, Climate change impacts on streamflow extremes in the Northeast U.S.A.

Liang Ning, Ph.D.: Post-Doctoral Fellow, Climate System Research Center and Geosciences, UMass Amherst, Climate change and climate variability through application modeling and statistical methods

Wenjuan Wang, Ph.D.: Post-Doctoral Fellow, Forestry Department, University of Missouri, Forest landscape modeling, disturbance, climate change and Geographic information Systems (GIS) application

Jane Foster, Ph.D.: Post-Doctoral Fellow, Department of Forest Resources, University of Minnesota, Tree growth response to climatic variability and simulating montane spruce-fir refugia under climate change

James Nelson, Ph.D.: Post-Doctoral Fellow, The Ecosystems Center, Marine Biological Laboratory, Impact of nutrient pollution on saltwater marshes and fish

Paul Damkot: Ph.D. Student, Department of Environmental Conservation, UMass Amherst, Climate change and brook trout

Kristopher Winiarski: Ph.D. Student, Department of Environmental Conservation, UMass Amherst, Demographic modeling to project future marine bird populations in the northeast

Evan Murdock: Ph.D. Student, Water Resources Management, University of Wisconsin, Climate change impacts on winter/spring hydrology in the Midwest

Zachary Schuster: Ph.D. Student, The Nelson Institute for Environmental Studies, University of Wisconsin, Impacts of climate change on high-class trout streams in the Driftless Area of Wisconsin

Thomas Bonnot: Ph.D. Student, Fisheries and Wildlife Sciences, University of Missouri, Quantitative and population ecology applied to conserving wildlife populations

Jacob Fraser: Ph.D. Student, Forestry Department, University of Missouri, Adaptation and resiliency of species in Eastern deciduous forests under different climate scenarios using a forest landscape model

Wenchi Jin: Ph.D. Student, Department of Forestry, University of Missouri, Forest landscape ecology

Jaymi LeBrun: Ph.D. Student, Fisheries and Wildlife Department, University of Missouri, Assessing the impacts of land cover and climate on avian abundance

Ethan Coffel: Ph.D. Student, Columbia University, Climate modeling of extreme weather events

Lynn Brennan: Master's Student, Department of Civil and Environmental Engineering, UMass Amherst, Modeling stream temperature to assess climate change impacts and guide decision makers

Dan Miller: Master's Student, Geosciences Department, UMass Amherst, Paleo-limnological data from lakes throughout the Northeast

Nicholas Hayden: Master's Student, Water Resources Engineering, University of Wisconsin, Investigating the relationship between climate variability and flood frequency using statistical and GIS analyses

Kyle Gill: Master's Student, Department of Forest Resources, University of Minnesota, Climatic and disturbance-related drivers of forest dynamics on a southern range-margin

Kenny Latender: Undergraduate, Sustainable Development Institute, College of Menominee Nation, Climate change impacts on foresters.

Sprague River Basin, Oregon. Photograph by the U.S. Geological Survey.

Northwest Climate Science Center

Location: Oregon State University
Consortium: Oregon State University (OSU), University of Washington (UW), and University of Idaho
Established: 2010

USGS CSC Director: Gustavo Bisbal, Ph.D.
University CSC Director: Philip W. Mote, Ph.D.

DOI Web site: *http://www.doi.gov/csc/northwest/index.cfm*
Consortium Web site: *http://nwclimatescience.org/*

SELECTED PROJECT HIGHLIGHTS

Improving understanding of threats to whitebark pine in the Western United States: Quantifying climate change effects on Mountain Pine beetle outbreaks

PI: Jeffrey A. Hicke, Ph.D., University of Idaho

Whitebark pines are a high-elevation keystone tree species that are critical habitat for wildlife such as grizzly bears and influence soil and snow processes. These trees are currently subjected to multiple threats including attack by mountain pine beetles, an aggressive bark beetle that has recently killed whitebark pines over hundreds of thousands of acres in the Western United States (fig. 6). Climate is an important factor in outbreaks of this beetle through effects on the beetle via warming and on the host tree via stress associated with warming and drought. Future climate change is expected to increase the number, frequency, and (or) severity of these epidemics.

To better understand this outbreak, Jeff Hicke from the University of Idaho (UI) and his partners from UI, USFS, and USGS are developing a model of mountain pine beetle outbreaks in whitebark pine using observations of beetle-killed trees, climate, and stand conditions. The model has been applied in the Western United States using current climate and downscaled climate change projections to identify locations of whitebark pine where mountain pine beetle attacks are likely to occur. The intended users of the project's products include land managers from the USFS, NPS, and other relevant agencies who manage whitebark pine, as well as the USFWS, which is responsible for endangered and threatened species listing decisions and has considered whitebark pine for listing

Figure 6. Whitebark pines killed by mountain pine beetles, Yellowstone National Park. (Photograph by Jeff Hicke, University of Idaho).

as an endangered species status under the Endangered Species Act. Representatives from these agencies have served on an external advisory committee during the course of the project to provide feedback about the research, offer guidance about products most useful to whitebark pine managers, and establish connections with additional end users who could benefit from knowing the project's results. The team is currently developing a Web site that describes their results and provides whitebark pine related maps and data.

This project meets the NW CSC science need for investigating the "Response of Biological Systems to Climate Change," which includes advancing understanding of the ecology and potential impacts of epidemic insect infestations as stated in the NW CSC Science Agenda. It also addresses the Science Agenda need to assess the vulnerabilities of individual species and populations to climate change and non-climate change stressors.

Vulnerability of traditional women's foods to climate change on the Olympic Peninsula, Washington: Management projections and implications for Tribal perspectives on Usual and Accustomed gathering areas

PI: Jesse Ford, Ph.D., OSU

Elders and wisdom keepers from tribes of the Point No Point Treaty Council (Olympic Peninsula, Wash.) express deep concerns that climate change will diminish or eliminate plant species of key cultural significance (KCS) species from Usual and Accustomed (U&A) gathering areas, which have static, legally defined borders. The potential loss of KCS species is a pressing cultural issue, because plants have important dietary and medicinal uses as well as being used for a diversity of cultural items (for example: baskets, cages and traps, ceremonial items, cordage, tools and utensils, and musical instruments). Through this project, researcher Jesse Ford and her team at OSU and the University of Arizona are responding to this concern by documenting historical, current, and potential future distributions of KCS plants in the Point No Point U&A gathering areas, particularly those of the Port Gamble S'Klallam Tribe.

The project approach has two threads. First, the project team will work closely with Tribal elders, resource managers, and wisdom keepers to document (1) historic distributions of KCS species and (2) elder/manager/wisdom keeper assessments of the impacts of such potential changes for contemporary cultural practices. Second, the team will apply conventional scientific tools to analyze past and projected future changes in the distribution of selected KCS plants. These two threads will be combined in an iterative process with Tribal elders, wisdom keepers, and resource managers to produce a range of specific management options (such as conventional restoration activities in habitats deemed to be relatively resilient, targeted hydrologic manipulations, etc.) for addressing likely changes in access to KCS species as a result of climate change. A fundamental assumption in this work is that a larger range of creative and useful management options can be developed for the Port Gamble S'Klallam Tribe by collaboratively and respectfully engaging both traditional and scientific ecological knowledge in a complementary fashion to address issues related to potential changes in access to KCS species.

This work addresses the NW CSC's science need of "Vulnerability and Adaptation," which seeks to "identify vulnerabilities of physical and biological systems and landscape characteristics critical to Native American Tribes. These efforts must consider the unique relation between Tribes and the landscape, and the large degree to which Tribes rely on the landscape for their economic well-being and cultural identity" as stated in the NW CSC Science Agenda.

STUDENTS

Isabel Guerrero: Ph.D., Applied Economics, OSU, Identifying vulnerabilities of specific physical systems, ecosystems, human health, cultural resources, and infrastructure to climate change, and identifying actions or practices that may improve prospects for adaptation

Sarah Hadley: Ph.D., Forest Ecosystems and Society, OSU, Relative contributions of microclimate, vegetation cover type, and species interactions in determining bird distributions in complex terrain

Sihan Li: Ph.D., College of Earth, Ocean, and Atmospheric Sciences, OSU, Superensemble regional climate modeling for the western United States

Lindsey Thurman: Ph.D., Wildlife Science, OSU, A metacommunity framework for evaluating amphibian response to climate change at high elevations

Jesse Langdon: Ph.D., Environment, UW, Assessing future ecological change by analyzing three impact measures: Temperature and precipitation, shifts in major vegetation systems, and species turnover

David Lawrence: Ph.D., Aquatic and Fishery Sciences, UW, Contemporary controls and future predictions of non-native smallmouth bass range expansion into salmon-rearing habitat

Ronda Strauch: Ph.D. Environmental Engineering, UW, Transportation impacts and adaptation to climate change on Federal lands in north-central Washington

Brittany Jones: M.S., Aquatic and Fishery Sciences, UW, "Adaptive capacity of tidal wetlands to future climate change in Puget Sound: Implications for strategic restoration"

Collette Gantenbein: M.S., Geography, University of Idaho, "Disaggregating climatology, climate variability, and disturbance influences on land cover change in the Pacific Northwest"

Pacific Islands Climate Science Center

Location: University of Hawai'i, Mānoa
Consortium: University of Hawai'i (UH), Mānoa, the UH Hilo, and the University of Guam
Established: 2012

USGS CSC Director: David Helweg, Ph.D.
University CSC Director: Kevin Hamilton, Ph.D.

DOI Web site: *http://apdrc.soest.hawaii.edu/PICSC/*

In FY13 David Helweg was selected as the first permanent director of the DOI PI CSC, headquartered at the UH, Mānoa.

Prior to assuming his role leading the PI CSC, Dr. Helweg was the deputy director of the USGS Pacific Island Ecosystems Research Center for more than 10 years. Since 2002, Helweg has put his expertise in multidisciplinary science and experience with strategic program development to work on terrestrial, coastal, and nearshore resource management issues. Before joining the USGS, Dr. Helweg held positions at the U.S. Navy's Space and Naval Warfare Systems Center in San Diego and the University of Auckland in New Zealand. He is an expert in behavioral biology, ecology, bioacoustics, and signal processing. Prior to his position as director of the PI CSC, Dr. Helweg served as the center's interim director since early 2013.

SELECTED PROJECT HIGHLIGHTS

Reconstruction of West Pacific Climate History—Water & Environmental Research Institute of the Western Pacific (WERI), University of Guam (UOG)

PI: John Jenson, Ph.D., Water and Environmental Research Institute (WERI) of the Western Pacific

Guam's position at the northeastern edge of the West Pacific Warm Pool (WPWP), which experiences strong seasonality, offers the potential of proxy records on Guam to preserve important cyclical and long-term advances and recessions of rainfall.

Scientists at WERI and the University of Texas-Austin began a collaborative study of geologic proxy records from cave and coral deposits in 2008 to better identify the timing and magnitudes of climate cycles affecting the West Pacific region. PI CSC support has since allowed for expanded collaboration and broadened the study's goals to include rigorous assessment of environmental factors that can affect the reliability of proxy records. Studies of stalagmites from caves in the uplifted limestone bedrock of northern and southeastern Guam are providing insights into the duration and severity of rainfall and drought cycles associated with El Niño-Southern Oscillation (ENSO) and other multidecadal and long-term variations. Geochemical data on cave dripwaters, calcite precipitation, cave atmosphere, and the cave responses to meteorological conditions are helping to improve the reliability of interpretations of the proxy records.

Understanding the wet-dry climatic history for the West Pacific region provides local and regional managers of natural resources, especially agricultural and water resource managers, with a more reliable basis for forecasting the onset, duration, intensity, and effects of wet or drought periods on farming, water production, and other economic activities. The cave studies are yielding important insights into the hydrogeologic process of infiltration, storage, and percolation of groundwater through the young limestone bedrock on Guam, which is similar to limestones of Florida and other low-lying coastal and island locations. One of the ultimate objectives that is thus being served by the project is to gain a better understanding of how Guam's major aquifer, which supplies 80 percent of the drinking water for its 260,000 residents, responds to drought, wet periods, and tropical cyclones and how vulnerable it might

be to contamination from surface sources. This research is already producing important insights into amounts and rates at which water can be captured and stored and the kinds of pathways by which groundwater moves through the aquifer.

Coral core sampling by WERI and UOG Marine Laboratory field team outside of Haputo Bay on Guam's northwest coast, August 2010: Marine laboratory boat captain and technician, Jason Miller, operating drill. WERI graduate research assistant Tomoko Bell in foreground, assisted by her husband, Ryan Bell, behind. Coral colonies grow in annual bands that can provide seasonal to monthly records of temperature, salinity, and sedimentation. Ages of Guam's live corals can extend to nearly 300 years.

WERI graduate research assistants, Leena Muller and Nathan van Oort, collecting data and servicing instruments in one of the research caves inside the Guam National Wildlife Refuge, October 2013. Hydrological, meteorological, and geochemical data have been collected continually in this cave since August 2008. Stalagmites collected in the cave so far have bottom dates of 11,000 to 28,000 years.

Epiphytes as an Indicator of Climate Change

PI: Jonathan Price, Ph.D., Associate Professor, UH at Hilo

This study investigates patterns of epiphyte communities at forest sites on the windward side of Hawaii Island. Epiphytes are specialized plants that anchor on a host tree (but are not parasites) and typically have no soil contact. Interestingly, little is known about epiphytic communities in Hawaii. Jonathan Price, an associate professor at the UH at Hilo, and his team examine patterns of epiphyte communities on ʻŌhiʻa Lehua host trees at forest sites of varying elevation and precipitation. The team seeks to scrutinize a topic little explored in Hawaii by (1) investigating patterns of epiphyte abundance and species composition across an elevation and precipitation gradient on windward Hawaii Island and (2) using physiological measurements to determine the relative importance of fog across these gradients.

This perspective is an avenue for improving our understanding of how the ecophysiological characteristics of plants are shaped by and respond to the environments they inhabit. Because epiphytes effectively increase watershed yield by increasing cloud forest area and net precipitation through the interception of cloud and fog water, understanding their community structure is vital for watershed management. Because these distinctively adapted plants depend on the atmosphere for required moisture and nutrients, they are exceptionally sensitive to air quality and climate. Examining which epiphytic communities occupy certain climate areas may, therefore, be important because the epiphyte community may provide early indications of vegetation response to climate change. In addition, this group of organisms is likely diverse, thus promoting a more detailed and thorough estimate of forest biodiversity.

Results suggest that fog is an important determinant of how ecophysiological characteristics of epiphytes respond to the environments they inhabit. Researchers plan to further evaluate these results with respect to fine-scale climate models that are based on statistical downsampling of GCMs. Researchers hypothesize that because Hawaiian epiphytes are small, short lived, highly dispersible species (especially filmy ferns), they are likely to exhibit the most rapid response to Hawaii's changing climate whereas larger, longer lived species are likely to respond more slowly.

STUDENTS

Ryan Longman: Ph.D. student, Department of Geography, College of Social Sciences, UH Mānoa, Monitoring and analysis of climate variability and change in Hawai‘i

Jordie Ocenar: Ph.D. student, Department of Plant and Environmental Protection Sciences College of Tropical Agriculture and Human Resources, UH Mānoa, Modeling endemic parasitic wasp elevational range shift as a result of climate change

Alison Ainsworth: Ph.D. student, Department of Botany, College of Natural Sciences, UH Mānoa, Predicting future changes in high elevation vegetation in Hawai‘i based on climatic predictions including the shifting trade wind inversion height

Casey Jones: Ph.D. student, Department of Botany, College of Natural Sciences, UH Mānoa, Demography of ‘ōhi’a lehua: Examination of the threats of climate and invasive species

Scarlett Kettwich, M.S., Department of Tropical Conservation Biology and Environmental Science, UH Hilo, Epiphytes as an indicator of climate change

Tishanna Ben, M.S., Tropical Conservation Biology and Environmental Science, UH Hilo, Reconstructing pre-historic climate variability in the tropical Pacific using tree rings

Sarah C. McCann, M.S., Department of Geosciences, Mississippi State University, Jinapsan Cave, Guam: A drip rate analysis

Vivianna Bendixson, M.S., Environmental Science, WERI, UOG, A comprehensive database for the Northern Guam Lens Aquifer

Leena Muller, M.S., Environmental Science, WERI, UOG, GIS-screening of cumulative and secondary impacts from development projects in northern Guam

Amanda deVillers, M.S., Biology, Marine Laboratory, UOG, Testing the SR/CA proxy for sea surface temperature (SST) reconstruction in the coral porites lutea in Guam, Micronesia

Nathan van Oort, M.S., Environmental Science, WERI, UOG, A geochemical inventory of the groundwater in the Northern Guam Lens Aquifer

Michelle Hulewicz, M.S., Geological Sciences, University of Texas, Austin, Assessing control of climate variability on seasonal variations in cave drip-water compositions

Mckayla Meyer, B.S., Department of Biology, UH Hilo, Reconstructing pre-historic climate variability in the tropical Pacific using tree rings

Robyn Rector, B.S., Department of Biology, UH Hilo, Reconstructing pre-historic climate variability in the tropical Pacific using tree rings

William Ray, B.S., Department of Biology, Humbolt State University, Reconstructing pre-historic climate variability in the tropical Pacific using tree rings

Mark Moore, B.S., Environmental Science, Natural Sciences, University of Texas, Austin, Oxygen isotope variations in drip-water and modern speleothem calcite from Jinapsen Cave, Guam

Graduate student Scarlett Kettwich examines a tree rich in epiphytic growth. Despite having very similar forest structure (ōhi'a canopy and a tree fern understory) to forests in drier areas, the diversity and abundance of epiphytes in this forest clearly indicate a much wetter climate.

A mark surveying pole is placed against a tree trunk for surveying. Many epiphytic species are very small (such as the ferns visible at the lower left), and so a detailed inventory of each trunk in discrete sections ensures that all species are accounted for and quantified.

Turner Falls near Davis, Oklahoma. Photograph by the U.S. Geological Survey.

South Central Climate Science Center

Location: University of Oklahoma
Consortium: University of Oklahoma (OU) with Texas Tech University (TTU), Louisiana State University (LSU), The Chickasaw Nation, The Choctaw Nation of Oklahoma, Oklahoma State University (OKState), and NOAA's Geophysical Fluid Dynamics Laboratory
Established: 2012

USGS CSC Director: Kim Winton, Ph.D.
University CSC Director: Berrien Moore, III, Ph.D.

DOI Web site: *http://www.doi.gov/csc/southcentral/index.cfm*
Consortium Web site: *http://www.southcentralclimate.org/index.php*

SELECTED PROJECT HIGHLIGHTS

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

PI: Shannon Brewer, Ph.D., USGS Oklahoma Cooperative Fish and Wildlife Research Unit

Hydrological, hydraulics, and ecological models generally have been developed independently, making their application particularly challenging for interdisciplinary studies. Additionally, the number of models available has grown considerably, making it difficult for managers to decide which models are most applicable to the questions being investigated. As more complex research and management issues are being addressed, it is imperative to identify how models may be combined to provide answers to increasingly complex questions or hypotheses. The objective of this study was to conduct a complete systematic review and synthesis of the prevailing hydrological, hydraulics, and ecological models; their data requirements; and the suitability of each model to simulate the hydrologic regime while addressing changes in the ecology of stream systems. Attention has been paid to how these models can be integrated at various spatial and temporal scales to address watershed management issues particularly in the face of future climate and land-use change.

Researcher Shannon Brewer of the Oklahoma Cooperative Fish and Wildlife Research Unit and partners from OKState and the University of Southampton systematically reviewed current ecohydrology and ecohydraulic models, using a two-stage approach. First, a list of recent, prevailing hydrological, hydraulics, and ecological models was developed by reviewing four electronic bibliographic databases: Web of Science, Science Direct, Water Resources Abstracts, and Agricola. Models were assigned to categories on the basis of their primary use(s). To balance model use relative to when the model was developed, an index was created to more quantitatively address the popularity of each model. A final set of models was retained for extensive review by identifying those models with an index in the upper quantile (25 percent) from each category with the following exception. Only two models were specifically used for fish-habitat studies (models related to those search terms) in the ecology model group so both were retained. The second stage of the search was to compile the final pool of literature by searching Web of Science using specified search terms. A subset of retrieved papers was reviewed to investigate how the models were used and the specific spatial and temporal scales addressed by each. An attribute list was developed to examine particular hydrologic, hydraulic, water quality, and ecological traits addressed by each model (such as evapotranspiration, fish habitat, etc.). A weight-of-evidence approach was used to populate the model attributes list so that statements about the models were supported by the reviewed literature. The research findings will be presented as a report and then condensed and submitted to a peer-reviewed journal. A bibliography of the literature search will be provided with the report.

This project primarily responds to the South Central Climate Science Center's (SC CSC) science priorities of "Hydrologic Response to Climate" as it evaluates "the effects of climate change on aquatic systems, including stream temperature, water availability, water quality, aquatic health, ecohydrology, and management alternatives" as found in the SC CSC Strategic Science Plan.

Inter-Tribal Workshops on Climate Variability and Change

PI: Laurel Smith, Ph.D., OU

With the support of the SC CSC and the Southern Climate Impacts Planning Program (SCIPP), five Intertribal Workshops on Climate Variability and Change were held in summer 2013 (four in Oklahoma and one in New Mexico) under the leadership of Laurel C. Smith, an assistant professor in the Department of Geography and Environmental Sustainability at the OU with the help of colleagues from OU, Chickasaw Nation, and the USGS. These one day events introduced Tribal representatives to the SC CSC, the Landscape Conservation Cooperatives (LCCs) that service its region (Oklahoma, Texas, Louisiana, New Mexico), and a couple of drought history tools that may help communities understand and plan for drought, one of the most costly conditions characterizing the climate of the Southern Plains. These workshops also featured a presentation on a participatory video approach to climate education and impacts followed by a screening and discussion about two videos, one that explored climate change from a participatory perspective and another that did not. Some workshop participants also consented to on-camera interviews about their understanding of and concerns about the impacts of climate change.

At the heart of this project is the research of Paulette Blanchard, who is a graduate of Haskell Indian Nations Universityand is now a Masters student in OU's Department of Geography and Environmental Sustainability. Blanchard seeks to blend Tribal perspectives with climate science in ways that might respect, enrich, and sustain the natural and cultural resources distinguishing the places Native Peoples call home. She studies how video-mediated climate data might be used to document the impacts of environmental transformations, as well as the capabilities and needs of the region's Tribal nations. Blanchard's research commitments also inform the videos concurrently being produced by two Native film makers, Filoteo Gómez Martínez and Jeffery Palmer, who are part of this project. These videos will showcase lessons about climate change learned from research participants.

This project responds to the SC CSC science priority for "Climate Change Effect on Human Populations, Socioeconomics, Urbanization, Cultural Resources, and Agricultural Issues" as found in the SC CSC Strategic Science Plan,which includes evaluating "the extent to which climate change will impact Native American Communities, including associated populations of plant and animal species and water resources."

POST-DOCTORAL RESEARCHERS AND STUDENTS

Tom Worthington, Ph.D.: Post-Doctoral Fellow, Cooperative Research Units (CRU), OKState, Effects of flow regime alterations on fish communities

Elena Lopez Zozaya, Ph.D.: Post-Doctoral Fellow, Department of Zoology, OKState, Terrestrial connectivity across the South Central United States

Lei Qiao, Ph.D.: Post-Doctoral Fellow, Department of Natural Resource Ecology and Management, OKState, Impact of climate variability on regional ecohydrological systems in the southern Great Plains

Xin Jin, Ph.D.: Post-Doctoral Fellow, CRU, OKState, Synthesis of ecohydrological models

Xuguang Sun, Ph.D.: Post-Doctoral Research Associate, School of Meteorology, OU, dynamical downscaling of climate data

Sharmistha Swain, Ph.D.: Post-Doctoral Research Associate, Department of Political Science, TTU, Impacts of precipitation variability and climate change on agriculture and water resources in the United States Great Plains

Anne Marie Koch Stoner, Ph.D.: Post-Doctoral Research Associate, Department of Political Science, TTU, Expanding a standardized framework for the evaluation and intercomparison of statistically downscaled climate projections

Asher William: Ph.D. student, Department of Oceanography and Coastal Sciences, LSU, Assessing mangrove expansion in coastal Louisiana and the Florida Everglades as indication of Climate change in the Gulf of Mexico

Ben Daly: M.S., Department of Natural Resource Ecology and Management; OKState, Effects of fire on savanna/grassland nutrient dynamics and carbon sequestration

Joseph Dale: M.S., Department of Natural Resource Ecology and Management, OKState, Climate variability, land-surface change and streamflow decrease in Cimarron River

William C. Tollefson: M.S., Department of Geography and Anthropology, LSU, Effect of atmospheric boundary layer conditions on agricultural spray drift, study site is Winnsboro, Louisiana

Paulette Blanchard: M.A., Department of Geography and Environmental Sustainability, OU, Indigenous peoples and climate change impacts

Emma Fagan: M.A., Department of Geography and Environmental Sustainability, OU, Societal adaptation to climate change impacts

Participants working together during the intertribal workshop.

Southeast Climate Science Center

DEPARTMENT of the INTERIOR
SE CLIMATE SCIENCE CENTER

Location: North Carolina State University
Established: 2012

USGS CSC Director: Gerard McMahon, Ph.D.
University CSC Director: Damian Shea, Ph.D.

DOI Web site: *http://www.doi.gov/csc/southeast/index.cfm*
Consortium Web site: *http://globalchange.ncsu.edu/secsc/*

SELECTED PROJECT HIGHLIGHTS

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

PI: Ilsa B. Kuffner, Ph.D., Research Ecologist, USGS
St. Petersburg Coastal and Marine Geology Science Center

Coral reef ecosystems are degrading quickly due to a variety of factors (fig. 7). Two substantial contributing factors are increasing ocean surface temperatures and decreasing ocean pH (ocean acidification). However, there are few empirical data at this time to make educated predictions on the impact of changing temperature and ocean pH on coral reef ecosystems. The objectives of this study were to help identify differences in climate vulnerability among three important reef-building coral species. The information may be relevant in making resource management decisions regarding reef restoration and species protection policies. The focus site of investigation of this study was the Territory of the U.S. Virgin Islands (USVI).

This was a retrospective study using coral cores to examine variability in ocean temperature and coral growth over the past century. The research team, led by Ilsa Kuffner from the USGS St. Petersburg Coastal and Marine Geology Science Center, sought to document the response of coral growth to the increasing sea surface temperatures, temperature anomaly events, and decreasing ocean pH that have occurred over the last ~150 years. This study was part of a larger effort to investigate the response of corals to changing ocean conditions in the Florida/Caribbean region.

Figure 7. Healthy coral (left) and degraded coral reef (right) in the Flat Cays in St. Thomas, U.S. Virgin Islands (Photograph by Ilsa B. Kuffner, U.S. Geological Survey).

Eight corals cores of three species were obtained from the USVI (fig. 8) (see USGS core archive for collection and repository data) in order to measure their Strontium-to-calcium ratios (Sr/Ca) as a proxy for historical sea surface temperature. The influence of the terrestrial fingerprint on local seawater chemistry makes using Sr/Ca as a SST proxy in near-shore environments in the USVI difficult, but conducting additional trace metal analyses (for example: barium, yttrium) could render these samples highly valuable to disentangle the effects of climate and land-use change.

This project addresses the SE CSC's science themes "Impacts of Climate Change on Coastal and Nearshore Marine Environments" and "Provide Support in Assessing Potential Impacts on Highly Vulnerable Coastal and Marine Habitats" as defined in the SE CSC Science Plan.

Figure 8. Core sampling at Flat Cays in St. Thomas, U.S. Virgin Islands (Photograph by Ilsa B. Kuffner, U.S. Geological Survey).

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

PI: Brian Irwin, Ph.D., USGS Georgia Cooperative Fish and Wildlife Research Unit

Conservation practitioners must navigate many challenges to advance effective natural resource management in the presence of multiple uncertainties. Numerous climatic and ecological changes remain on the horizon, and the eventual consequences of these changes are not completely understood. Even so, their influences are expected to impact important resources and the people that depend on them across local, regional, and sometimes global scales. Although forecasts of future conditions are almost always imperfect, decision makers are increasingly expected to communicate and use uncertain information when making policy choices that affect multiple user groups. The degree to which management objectives are met can depend on (1) how critical uncertainties are identified and accounted for and (2) effective communication among user groups, scientists, and resource managers. The objective of this project is to help facilitate strategic decision support and synthesize the state of the science related to communicating and using uncertain information in conservation decision making. By providing a forum on the communication of scientific uncertainty, we aim to traverse traditional disciplinary boundaries, with a focus on climate change in the Southeastern United States. We expect this process to generate transferable guidance that will directly assist resource managers across agencies to identify common goals and shared research priorities.

A project workshop, titled *Communicating and Using Uncertain Information in Conservation Decision Making*, was held during February 27–28, 2013, on the campus of the University of Georgia. The workshop consisted of four sessions: (1) problem scoping, (2) definitions and treatment of uncertainty, (3) the role of science in decision making, and (4) developing recommendations.

The workshop was intended, in part, to identify research and strategic-planning needs for effective delivery of regional conservation policy with an emphasis on providing science-based decision support in the presence of uncertainty and climate change.

This project addresses the SE CSC's science themes "Develop Climate Projections and Determine Appropriate Projections to Use for Resource Management" as defined in the SE CSC science plan.

POST-DOCTORAL RESEARCHERS AND STUDENTS

North Carolina State University Global Change Fellows

Carlos Botero, Ph.D.: Post-Doctoral Fellow, Biocomplexity Initiative and Global Change Center, Ecological processes influence on micro- and macro-evolution

Michael Just: Ph.D., Department of Plant and Microbial Biology, Fire ecology

Jennifer Niemuth: Ph.D., Fisheries, Wildlife, and Conservation Biology, Wildlife health and conservation medicine

Steven Grodsky: Ph.D., Wildlife Ecology, Impacts of renewable energy on wildlife

Kara Smith: Ph.D., Meteorology, Evaluation of climate models and development of climate information products for use in adaptation, conservation, and other planning strategies

Tyson Wepprich: Ph.D., Biological Sciences, Effects of global change on conservation strategies

Ayse Karanci: Ph.D., Department of Civil Engineering, Modeling and predicting the impacts of extreme storm events such as hurricanes and sea-level rise on coastal landforms

David Zietlow: M.S., Forestry and Marine Earth and Atmospheric Sciences, Water resources and the role of hydrology as a driver for ecosystem structure and processes

Southwest Climate Science Center

Southwest Climate Science Center

Location: University of Arizona, Tucson
Consortium: University of Arizona (UA), Tucson; University of California, Davis; University of California, Los Angeles (UCLA); Desert Research Institute, Reno; University of Colorado, Boulder; and the Scripps Institution of Oceanography at the University of California, San Diego
Established: Spring 2011

USGS CSC Director: Stephen Jackson, Ph.D.
University CSC Director: Jonathan Overpeck, Ph.D.

DOI Web site: *http://www.doi.gov/csc/southwest/index.cfm*
Consortium Web site: *http://www.swcsc.arizona.edu/*

SELECTED PROJECT HIGHLIGHTS

Climate Change Vulnerability of Native Americans in the Southwest

PI: Karletta Chief, Ph.D., UA, Department of Soil, Water, and Environmental Sciences

Native Americans in the Southwest United States are thought to be particularly vulnerable to climate change, because Tribal resiliency can be affected by multiple climate-related threats and by the close reliance of Tribal communities on natural resources for sustenance, economic development, and maintenance of cultural traditions. In response to a pressing need across southwestern landscapes for a scientifically rigorous assessment of such threats to Native Americans, Karletta Chief and her team are examining environmental factors affecting Native American tribes. These factors include water rights for fish and wildlife, protection of wetlands, enhancement and recovery of the Pyramid Lake and Nevada fishery, and the 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 (SW CSC) region.

After an extensive literature review of socioecological dynamics in the Pyramid Lake system, the survival of the endangered Cui-ui, a lake sucker fish, and the threatened Lahontan cutthroat trout and the associated ecosystem dynamics were identified as extremely important for the Pyramid Lake Paiute Tribe. For that reason, an effort has been made to develop ecological indicators that monitor conditions influencing the well-being and thriving of these species. Additionally, a "Climate Change Planning Workshop" with Tribal members was held on Tribal land in Nixon, Nevada, in order to gain better insight to climate change challenges from the perspective of Tribal members. The workshop served to identify some management alternatives and solutions that address the challenges. It also resulted in the socioeconomic vulnerability assessment of the Pyramid Lake Paiute Tribe, *Climate change in arid lands and Native American socioeconomic vulnerability—The case of the Pyramid Lake Paiute Tribe*, which was published in October 2013 in "Climatic Change."

Pyramid Lake shoreline September 2013 (Photograph from the University of Arizona).

The research team will distill the results of the workshop into summarized details that can be incorporated into a project report. This task will entail transcribing audio recordings and transferring the categorized and ranked issues that participants

identified during the workshop (fig. 9) into Microsoft Word™ documents. The research team will work closely with the tribe to identify individuals who would be ideal for followup interviews.

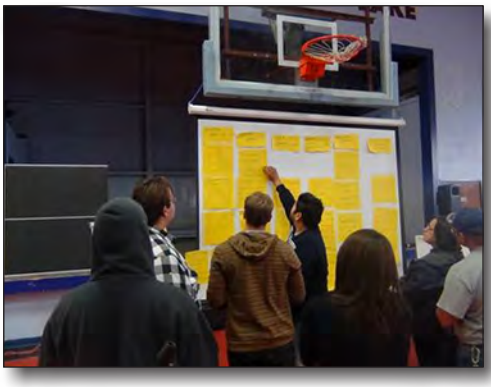


Figure 9. Tribal members categorizing and ranking issues at the Climate Change Planning Workshop, September 2013. (Photograph from the University of Arizona)

This project addresses research themes "Ecological responses and vulnerabilities" and "Establishing best information exchange practices" from the SW CSC Strategic Science Agenda.

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

PI: John Y. Takekawa, Ph.D., Emeritus scientist with the USGS Western Ecological Research Center

Glen M. MacDonald, Ph.D., UCLA Institute of the Environment

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 may be changed in the future. The goals of this project are to investigate the complexity of climate-induced changes (both physical and biological) along the California coast. Specifically, the objectives are to (1) downscale physical processes and climate projections to local scales, (2) measure morphological and ecological characteristics (such as elevation, tidal range, geomorphology, hydrology, vegetation) across the habitat continuum of tidal marsh, intertidal mud flat, and subtidal shoals, (3) model vulnerability of indicator wildlife species within these habitats, and (4) examine spatial variability along a coastal latitudinal gradient.

The research team has completed the field work for the initial characterization of baseline conditions across all study sites. Field work includes coring, elevation and vegetation surveys, bathymetric surveys, and water-level and salinity logger deployment as well as surface elevation table (SET) installment. Substantial insight is expected to be gained from the sediment cores regarding historic rates of sediment accumulation and present accretion from the SETs. Data from the cores will be used to parameterize the Wetland Accretion Rate Model of Ecosystem Resilience (WARMER) model to assess sea-level rise risk for marshes in the future. The results of the WARMER model are in addition to the proposed products and will further inform the vulnerability assessment.

This project addresses research themes "Climate Science and Forecasting" and "Ecological Responses and Vulnerabilities" from the SW CSC Strategic Science Agenda.

Surface elevation table (SET) installation at Point Mugu, California. (Photograph from the U.S. Geological Survey)

Federally endangered California clapper rail. (Photograph by W. Naruo)

POST-DOCTORAL RESEARCHERS AND STUDENTS

Suraj Polade, Ph.D.: Post-Doctoral Researcher, Scripps Institution of Oceanography, University of California San Diego, Climate model downscaling and evaluation

Amber Wright, Ph.D.: Post-Doctoral Researcher at University of California, Davis, Ecological niche models to predict how California's reptiles and amphibians will respond to climate change

Kristin Guirguis, Ph.D.: Post-Doctoral Scholar whose work with Alexander Gershonov at Scripps Institution of Oceanography has been partially funded through a SW CSC research award, Guirguis has been actively conducting research focused on temperature extremes and human health impacts

Connor Nolan, Ph.D. Student, Department of Geosciences, UA, Inferring decadal to centennial climate variability during the past 3,000 years on the basis of studies of lake and peatland sediments

Neil Berg: Ph.D. Student, UCLA's Atmospheric and Oceanic Sciences Department, Climate change impacts to the hydrological cycle over southern California

Daniel Walton, Ph.D. Student, UCLA's Atmospheric and Oceanic Sciences Department, Regional climate modeling through dynamical and statistical downscaling in coastal regions

Matt Williamson: Ph.D., Department of Environmental Science and Policy, University of California, Davis, Challenges and opportunities for incorporating climate change projections into Federal land management decision making

A stand of Saguaro cacti in the dry mountains surrounding Tuscon, Arizona. Photograph by Randolph Femmer, the U.S. Geological Survey.

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Prepared by:
USGS Science Publishing Network
Raleigh Publishing Service Center
3916 Sunset Ridge Road
Raleigh, NC 27607

ISSN 2330-5703 (online)
http://dx.doi.org/10.3133/cir1402