

North Central Climate Science Center: 2012 Strategic Planning Workshop report

On April 30-May 2, Montana State University hosted the North Central Climate Science Center's (NC CSC) strategic planning meeting. The meeting brought together for the first time the North Central University Consortium (NCUC), members of the Stakeholder Advisory Committee (SAC), USGS centers within the NC CSC domain, other select and relevant federal research groups, and NC CSC staff. Appendix A provides a complete list of workshop attendees. With this workshop serving as the initial gathering of these groups an implicit, but important, component to the workshop was an introduction to each other and the management needs and research interests of the participants. The specific objective for the workshop was to gather information and input to initiate the five year science agenda and the related implementation plans for the North Central Climate Science Center and allow the NCUC to develop a prospectus for work funded by the NC CSC's 2012 fiscal year budget.

For those not able to attend the workshop in person, a webinar session was held during the morning of the third day to provide an overview of the first two days and allow input and comments from those joining remotely.

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Edited by Jeffrey T. Morisette, USGS

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1. Introductions and overviews

Roughly half of the workshop's agenda and time allocation were dedicated to introduction and overview of the various entities represented at the workshop. This included a general introduction to the North Central Climate Science Center and the strategic plan it is looking to follow, as well as information related to four Landscape Conservation Cooperatives, nine USGS centers, six of the nine universities in the NC CSC consortium, and several other regional efforts.

Overview of the North Central Climate Science Center and its strategic plan

The eight regional DOI Climate Science Centers (CSC) were established through Secretarial Order No. 3289 (Salizar, 2010) and have been set up through the United States Geological Survey's National Climate Change and Wildlife Science Center (NCCWSC). This workshop focused on the North Central Climate Science Center. The NC CSC overview presentation proposed two initial directions for the NC CSC: 1) adopting the framework contained within the "Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment" (Glick et al., 2011) and 2) using the NC CSC to develop a "Resource for Vulnerability Assessment, Adaptation, and Mitigation Planning" (or ReVAMP).

Review of the Scanning the Conservation Horizons framework

Detailed information on the "Scanning the Conservation Horizons" framework was presented by Deborah Finch, USDA Forest Service. The document grew out of an expert working group with representation from multiple agencies and NGOs. That team, and the resulting document, focused on vulnerability assessment as a key tool for informing adaptation planning and enabling resource managers to make judgments about managing resources in light of climate change. The document provides a framework and several case studies. Vulnerability Assessments provide insights into what things are most vulnerable and why they are vulnerable. The framework can be used to identify species and systems most in need of conservation actions due to climate change, develop adaptation strategies, and foster collaboration by providing shared understanding and efficient allocation of scarce resources. The Case Studies contained in the document apply the frameworks to species- or habitat-oriented integrated assessments and can provide "lessons learned" as the NC CSC considers the framework as a way to direct its effort.

While the Glick et al. (2011) document provides a framework for the NC CSC, some of the fundamental elements of that framework are non-trivial and a typical resource manager or management team attempting to apply this framework could use assistance in approaching the fairly complex and varied analysis required. The **Resource for Vulnerability Assessment, Adaptation and Mitigation Planning** (ReVAMP) could help provide such assistance. Discussion at the workshop indicated that stakeholders have a desire for a resource to help interpret and untangle the ever increasing array of climate information. One suggestion was to consider the NC CSC as the North Central Climate **Service** Center. Another suggestion was to consider the CSCs as a climate information extension program. These and other comments indicated that developing something like the ReVAMP concept would be useful to the community. The NC CSC overview presentation proposed four major topics to support the ReVAMP concept:

1. drivers and fundamental climate science
2. impacts and vulnerability
3. adaptive capacity
4. decision and management options

Subsequent discussion at the workshop combined the 3rd and 4th points into one topic. The three resulting topics were revisited throughout the workshop and ultimately formed the three major research elements that the University Consortium decided to develop.

2. Overview of the four LCCs in the NC CSC domain

The National Climate Science Center boundaries are “soft” by design to allow activities coming from the CSCs to cross the boundaries as the science questions dictate (Figure 1). However, the geographic extent of the NC CSC that is perhaps most ecologically and physically meaningful is the Missouri River basin. There are four primary Landscape Conservation Cooperatives (LCC) overlapping this domain: Great Northern, Great Plains, Plains and Prairie Potholes, and Southern Rockies. The LCCs are represented on the NC CSC Stakeholder Advisory Committee and are considered primary clients for the work done through the NC CSC. All four LCCs presented an overview and potential interaction with the NC CSC. And in all cases, the LCCs will look to the NC CSC/NCUC to provide valuable, peer reviewed research applied to their management and conservation needs.

Great Northern

Science needs in the Great Northern Landscape Conservation Cooperative (GNLCC), assembled through LCC Webinars, Advisory Team, and Steering Committee have been organized into five themes for FY2012: Habitat Connectivity, Aquatic Integrity, Data Integration, Climate, Partnerships, and Outreach and Education. The GN LCC has also completed an analysis of species of conservation needs as identified by our state partners and developed a list of 27 fish and wildlife species that shared commonalities across the LCC. The managers represented by the GNLCC feel that what is needed are not intense attempts to reduce specific uncertainties associated with downscaled climate and land use projections, but rather the knowledge of how to make management decisions in the face of uncertainty. There is a need for extension activities, which can include applied modeling, in five areas: (1) effects of climate and land use change on local sites (single or multiple county level); (2) implementation of adaptive management related to climate and land use change for local decisions; (3) one-on-one/few assistance in using decision support models, tools, and other technology for adaptation to change; (4) gathering information on what decisions field managers are making that have a nexus with climate and land use change; and (5) generating statistically sound programs for evaluating management actions. It is clear that all these activities can contribute to the development of adaptive management approaches that include climate data and climate change and why the GNLCC is looking forward to collaborating with the NC CSC, NOAA’s National Climate Projections and Predictions program (mentioned below).

Great Plain LCC

The Great Plains LCC has identified five priority species (Arkansas River shiner, Lesser Prairie-Chicken, Northern Pintail, black-tailed prairie dog and Snowy Plover) as indicators of habitat type and/or guild of species found in the GPLCC. The presence/absence and abundance of these indicator (or umbrella) species denotes a specific environmental condition and relates to the structure and function of various habitats within the GPLCC, many of which are imperiled or likely to be impacted by climate change and/or other stressors. Scientific research and monitoring of the habitats and life cycles of these species will inform conservation activities that will benefit many other species utilizing the same habitats in the Great Plains. The Great Plains LCC wants to interact with the NC CSC to better understand many issues such as: 1) how will future trends in temperature and precipitation impact habitat structure and composition, 2) how will future climatic conditions impact prairie river hydro-period and management, 3) how will future climatic conditions alter playa wetland inundation patterns both spatially and temporally, and 4) which species and habitats are most vulnerable to climate change.

Plains and Prairie Potholes

The fundamental objective of the PPP-LCC is to “increase conservation delivery by reducing scientific uncertainty related to landscape level stressors which are important to our partnership”. The Plains and Prairie Potholes LCC includes three main sub-units, the Prairie Pothole Region, Northern Great Plains, and the riparian corridors of several major river systems including the Missouri, the Yellowstone and the Red River of the North. The PPP LCC has identified the need for research and monitoring of landscape scale stressors such as (1) changes in agricultural policy that could impact fish and wildlife habitats and populations (2) shifts in climate that could result in altered hydrologic regimes, (3) energy development impacts on fish, wildlife and crucial habitats (4) emerging landscape level threats to conservation (5) species life history and response to landscape level stressors (6) information needs important to conservation decision makers.

Landscape conservation efforts are directed at maximizing habitat quality and meeting landscape level objectives within six key ecosystem features identified by the cooperative. Those include 1) palustrine wetlands, native grasslands and restored grasslands of the potholes region, 2) sage prairie of the plains region, and 3) woody draws, riparian habitat and hydrologic systems of rivers. Because the work of the PPP LCC is focused on management relevant, applied science, it will look to the NC CSC to play an important role in developing and disseminating research designed to support the PPP LCC. Research undertaken by the NC CSC should address needs that the PPP LCC is not equipped to address and will complement projects funded by the PPP LCC. (A list of funded projects and descriptions of each can be found at <http://www.plainsandprairiepotholeslcc.org>).

Southern Rockies LCC

The Southern Rockies LCC encompasses large portions of four states: Utah, Colorado, Arizona, and New Mexico, as well as smaller parts of Wyoming, Idaho, and Nevada. The area is geographically complex, including wide elevation and topographic variation; from 14,000 foot peaks to the Grand Canyon and cold desert basins. The governing body or Steering Committee is comprised of six state agencies, 7 federal agencies, two tribes, and four NGOs. Priority areas for the SR LCC, as expressed through its science projects to-date, include riparian habitat assessments; vulnerability assessments in the Gunnison Basin;

crucial habitat mapping in CO, AZ, NM, and UT; habitat connectivity on the Navajo Nation; and vulnerability of small stream low-flow hydrology to climate change. Interaction with the NC CSC will help ensure that the best possible climate information can inform these and future studies and focus areas within the SR LCC.

3. University consortium & USGS Centers in the NC CSC region

The North Central University Consortium (NCUC) is led by Colorado State University (CSU), and includes members from : The University of Colorado (CU), Colorado School of Mines (Mines), University of Nebraska-Lincoln (UNL), University of Wyoming (UW), Montana State University (MSU), University of Montana, Kansas State University (KSU) and Iowa State University (ISU). One of the primary objects of the Climate Science Centers is to use the best available science to address the climate-related management issues expressed through the SAC. To this end, the workshop allowed for an overview of major climate-related science research being done at the NCUC institutions and the USGS Centers within the region from those institutions and centers represented at the meeting.

Colorado State University

Colorado State University brings together a broad range of stakeholders to collaborate with researchers to expand basic climate and ecological understanding and to incorporate this into applicable management decisions. CSU research, education, and outreach efforts in climate change science, impact analysis, and outreach is broad cutting and includes efforts in climate analysis and impact assessments, ecosystem and wildlife research and management applications, and human dimensions research related to climate change adaptation and reducing emissions associated with climate change. CSU has strong relationships with a broad set of stakeholder groups and works closely with federal and state agencies in their research, educational, and outreach efforts. The NC CSC is hosted within the Natural Resource Ecology Lab (NREL); which is located in The Warner College of Natural Resources. The Warner College is well represented in research and natural resource and cultural management expertise through its departments of Ecosystem Science and Sustainability; Fish, Wildlife, and Conservation Biology; Forest and Range Stewardship; Geosciences; and Human Dimensions of Natural Resources; and units such as the Natural Resource Ecology Laboratory (NREL), Center for Environmental Management of Military Lands (CEMML), and the Colorado Cooperative Fish and Wildlife Research Unit. In addition, CSU has on-going educational and research opportunities related to the Graduate Degree Program in Ecology, the School of Global Environmental Sustainability, NSF funded Interdisciplinary Graduate Education, Research, and Training (IGERT) programs in water and bioenergy, and NSF supported climate science technology center (STC) Center for Multi-scale Modeling of Atmospheric Processes (CMMAP). These programs at CSU provide breadth and interdisciplinary research, training, and outreach opportunities for the North Central Climate Center as it links climate science to wildlife and natural resource management across the region.

Iowa State University

Iowa State University has active research in regional climate and ecosystem science. Ecosystem science research has focused on how grasslands change in response to climate variability as well as how

agricultural decisions impact wildlife populations and species diversity. This research has considered how precipitation deficits can impact montane meadows in the Greater Yellowstone Ecosystem. ISU has also focused on how biodiversity is affected as grasslands in the Midwest are shaped by agricultural land use decisions. This is a primary question of two field experiments: (1) the Science-based Trials of Rowcrops Integrated with Prairies project (STRIPs), a field experiment in which strategically integrating small amounts of perennial vegetation (reconstructed prairie) within row-cropped watersheds is examined for enhancements of the health and diversity of Midwestern agricultural landscapes (www.nrem.iastate.edu/research/STRIPs/index.php), and (2) the Prairie Restoration within Patch Burn Grazing field program (<http://www.nrem.iastate.edu/research/patchburn/index.html>). Regional climate science research at ISU has considered rainfall systems throughout the Great Plains region and how the atmospheric regimes supportive of widespread heavy rainfall vary across the region. These systems are absent in global climate model simulations, but dynamical downscaling simulations lead by ISU, with 20 km grid spacing, are capable of capturing these systems and the regional variability. The connection between grassland ecosystems, agriculture, and rainfall patterns provide important information to the NC CSC. ISU's experience with these issues will provide important research capacity in these areas.

Montana State University and the Montana Institute on Ecosystems

A unique and powerful component of the NCUC is that both Montana State University and the University of Montana have established a statewide collaboration that will complement the efforts of these two institutions as part of the NCUC. The Montana Institute on Ecosystems (IoE) is a statewide community of scholars and partners with a shared vision to advance integrated environmental science and related fields focused on mountains and high plains ecosystems (<http://www.montanaioe.org>). IoE faculty draw on the extraordinary landscapes of Montana, including the Greater Yellowstone and Crown of the Continent ecosystems, to better understand the interconnectedness of people and nature. Through funding from NSF, other grants, and partnership activities, the IoE supports research focused on critical ecosystem processes at scales ranging from microbes to watersheds and on human-environment interactions within the region and beyond. IoE is also home of the Montana Water Center, which advances water research, information, education, and problem-solving partnerships throughout Montana and beyond. The IoE expertise could contribute to the NC CSC with its research on the examination of past climate events to better understand ecosystem consequences of abrupt climate change. IoE could also help the NC CSC in developing a protocol and framework for modeling vegetation type and species response to climate and land-use change by evaluating and applying statistical niche modeling and/or simulation modeling methods.

University of Montana

In addition to being a partner in the Montana Institute on Ecosystems, the University of Montana brings a long history of landscape and regional scale ecosystem analysis to NCUC. UM is also strong in wildland tourism and recreation issues and sustainable natural resource management. The Numerical Terradynamic Simulation Group at UM has led in the development of satellite driven algorithms to calculate ecosystem carbon and water balances over local to global scales. Part of this work has also included a long history of building gridded datasets of surface meteorology such as DAYMET, and the ecosystem process model Biome-BGC that is used world-wide. Their work focusing on disturbance

analysis, improving hydrologic models for water management, and integrating socioeconomic considerations into land management decision-making are all relevant to the NC CSC.

University of Colorado

In collaboration with the University of Colorado Cooperative Institute for Research in Environmental Sciences (CIRES), the Western Water Assessment RISA program (WWA), and the Institute for Arctic and Alpine Research (INSTAAR), CU brings an ongoing legacy of research that transcends the climate sciences, as well as the social and physical science realms. Particular expertise applicable to NC CSC needs includes: 1) Analysis of the uptake and use of climate information by decision makers, and 2) Coupled climate and hydrologic modeling.

CU's capacity in science and decision making analysis (through CIRES' Center for Science and Technology Policy Research, and WWA) may be able to help the NC CSC move beyond identifying "major science questions" in the region by seeking to understand the processes through which science has actually informed decision making in the region. The identification of pathways by which existing climate information and new climate research become successfully integrated into decision making can better fine-tune the manner in which climate research and synthesis efforts address stakeholder needs. This could also feed into formal evaluation of NCCSC research and products – by understanding more about how information becomes relevant to decision making in the basin, we would be able to do a better job of evaluating the efficacy and relevance of the physical and natural science work done by other researchers.

In addition, CU (CIRES, INSTAAR, WWA) has significant capacity in coupling climate modeling with hydrology. Ongoing research projects include an effort to understand how bark beetle infestations, dust-on-snow, and meteorological conditions influence patterns of snow accumulation and melt. CU researchers have also worked to reconstruct natural stream flow patterns in order to understand how future climate changes might affect the availability of ecological flows in given surface water bodies. Post-fire impacts on freshwater systems is also an ongoing component of research within CIRES.

University of Nebraska-Lincoln

The University of Nebraska provides two areas of active research to the NC-CSC: 1) Well-established expertise in the use of regional climate models for dynamical downscaling of global climate model simulations and 2) An integrated research framework to develop climate, environmental, and human issues affecting the Greater Platte River Basin (GPRB). The regional climate modeling work involves both projections of future climate change, as well as key issues related to land use and land cover changes. In addition to considerable experience in the central US (including the Great Plains and the Rocky Mountains), UNL has worked in other regions with complex topography and/or land use patterns, including the SW and NE US, as well as Mesoamerica and South and Southeast Asia. The integrated research framework involves a 'natural laboratory' in which environmental, agricultural, and public land issues meet. The laboratory involves integrated modeling and measurements at a variety of spatial and temporal scales. For example, the Platte headwaters are strongly dependent on seasonal snowpack in the central Rockies, while the Nebraska Sandhills provide a significant buffering of the Ogallala aquifer and provide a more constant supply of water to the lower Platte. At UNL a wide range of expertise,

including climate and hydrologic modeling, field observations, and ecosystem analyses are being used to expand federal, state, tribal, and local partnerships in pursuit of science-based decision support strategies for sustainability of natural and human resources within the GPRB.

University of Wyoming

The University of Wyoming is engaged with the NC-CSC through two colleges and five departments and includes ecologists, climate scientists, hydrologists and natural resource managers. The University of Wyoming interdisciplinary Program in Ecology that currently has 28 faculty members also unites the majority of this group of scientists and provides a deep organizational resource for the work needed by the NC CSC. Another major resource for the NC CSC that is available through the University of Wyoming, and its partnership with the National Center for Atmospheric Research (NCAR) is the supercomputer (Yellowstone) being built at a new center in Cheyenne, Wyoming. Relevant expertise at UoW includes high resolution climate change precipitation modeling through the Yellowstone supercomputer as well as extensive experience with species distribution modeling of sagebrush and cheatgrass regeneration at the leading and trailing edges of sagebrush's predicted distribution under climate change.

Colorado School of Mines

Representatives from the Colorado School of Mines (CSM) were unable to attend the workshop, but subsequently were able to provide this information. The Colorado School of Mines has active research in the many aspects of climate science as it relates to engineering and earth sciences with a particular emphasis on hydrology and hydrogeology. Active research areas include the response and feedbacks of groundwater to changes in precipitation and temperature, development of integrated hydrologic models that include land surface processes and coupling to mesoscale atmospheric models. Additionally, active research includes understanding the effects of large-scale land cover changes, such as the Mountain Pine Beetle epidemic and forest fire, on both water quality and quantity. Research at CSM is focused at a range of spatial and temporal scales, from event to decadal and from watershed to continental. Strong collaborative ties exist between CSM, NCAR, CU-Boulder, CSU and NREL on a range of projects. Research at CSM also focuses on carbon management (<http://www.carbonmanagementcenter.org/>), such as CO₂ sequestration, and alternative energy technology, such as wind power and solar (<http://ceri-mines.org/>). For more information on activities at CSM see the Integrated Ground Water Modeling Center (igwmc.mines.edu) and the hydrology program (hydrology.mines.edu).

USGS Columbia Environmental Research Center

The Columbia Environmental Research Center (CERC, <http://www.cerc.usgs.gov/>) has conducted a range of studies on climate-change related issues over the last decade. Recent examples include examining riverine fish communities, fate and transport of environmental contaminants, and coordination of large-scale conservation efforts. The riverine fish community work incorporates multi-scale climate models and the uncertainty that is present at all levels of the spatial and temporal hierarchy. This research uses the Missouri River Basin and the endangered pallid sturgeon example to develop an approach in which climate projections made by coarse-resolution global climate models are downscaled by regional climate models to obtain regional projections that are linked with watershed, river hydraulics, and population models. The environmental contaminants work has focused on how changes in factors such

as global air and water temperatures, salinity, and UV exposure will influence the fate and dynamics of chemicals as well as the pathways and toxicological mechanisms that affect species, populations and communities. CERC scientists have also served on a steering team that developed a Society of Environmental Toxicology and Chemistry (SETAC) Pellston Workshop and Review Publication Series. This series identified ways that global climate change will affect the foundations and applications of environmental toxicology with emphasis on individual, population, and community responses, redefining baseline conditions, conducting ecological and human risk assessments, and adapting methods for mitigation and restoration of historically contaminated areas. In the face of climate change and the needs of the NC CSC, this effort will provide land and resource managers the ability to better anticipate chemical impacts before they occur, to evaluate resource injury when they are released into the environment, and to successfully plan and implement ecological restorations.

USGS Fort Collins Science Center

The Fort Collins Science Center (FORT, <http://www.fort.usgs.gov/>) is a multi-disciplinary research and development center. FORT research focuses on needs of the land and water management bureaus within the U.S. Department of the Interior (DOI), other Federal agencies, and the needs of State and non-government organizations. The emphasis at FORT is toward a multi-disciplinary science approach to provide information for resource management decision-making. Some key focus areas include: Data, data management & high throughput computing; habitat modeling & modeling support; social and economic analysis and decision sciences; as well as fundamental ecological and biological research. All of these areas can either contribute to or interact with climate. As such, the FORT has a fairly wide array of science that can contribute to the efforts of the NC CSC.

USGS National Research Program and Water Science Center

The National Research Program (NRP, <http://water.usgs.gov/nrp/>) is a national capability of the USGS Water Mission Area with 3 Branches headquartered in Denver/Boulder, Menlo Park, and Reston. NRP scientists conduct basic and applied hydrologic research, using hydrology, mathematics, chemistry, physics, ecology, biology, geology, and engineering to gain a fundamental understanding of the processes that affect the availability, movement, and quality of the Nation's water resources. NRP's long-term research investigations often lead to the development of new concepts, techniques, and approaches that are applicable to the solution of current and future issues related to water and other natural resources. Basic tools of hydrology that have been developed by the NRP include watershed modeling, hydrodynamic and sediment transport modeling, ground water flow modeling, geochemical modeling, and regional flood frequency analysis. In collaboration with other USGS Science Centers (including the newly established DOI Climate Science Centers), NRP applies these tools to many problems related to climate change and climate variability, including water availability, water quality, hazards, and aquatic habitats.

The USGS South Dakota Water Science Center (SDWSC, <http://sd.water.usgs.gov>), like Water Science Centers in each state, have the capability to collect hydrologic data (all around the hydrologic cycle) and conduct research investigations. Each center operates a network of streamflow and precipitation gages and groundwater observation wells. Some centers develop specialized technical expertise with scientists conducting research on surface water, groundwater and water quality research topics. SDWSC

has developed expertise in climate modeling and streamflow trend analyses as the result of climate change. A major SDWSC project relevant to the NC CSC is the dynamical Weather Research and Forecasting (WRF) climate model simulations of projected climate for North America based on emission scenarios, with emphasis on changes in the Missouri River Basin. Several subbasins such as the Yellowstone River and James River have been studied in detail with significant changes noted in the observed record and with observations aligning well with WRF projections of climate. While the NCUC does not include either North Dakota or South Dakota, the SDWSC and the Northern Prairie Wildlife Science Center have close cooperative working relationships with SD School of Mines and Technology, SD State University, and ND State University and, thus, can provide a venue to utilize the research being done at those institutions. In addition, the SDWSC and SD School of Mines and Technology have a working relationship with the University of Colorado, which provides access to high-performance computing facilities. These connections present an opportunity to extend the impact of the NC CSC into the Dakotas.

The USGS Montana Water Science Center (MYWSC, <http://mt.water.usgs.gov/>) is studying the impacts of climate variability on watersheds through trend analyses of perennial and ephemeral streams and through the construction of watershed models and application of various scenarios using downscaled climate data. In addition, geospatial tools have been developed that interpret remotely sensed variables for quantifying historical snow extent and basin evapotranspiration. The MTWSC collaborates on various hydrologic and water resource investigations with the University of Montana, Montana State University, and Montana Tech.

USGS Northern Prairie Wildlife Research Center

The Northern Prairie Wildlife Research Center (NPWRC) was established in 1965 to conduct research needed for management and conservation of migratory grassland-nesting birds, with emphasis on waterfowl and wetland habitats within the Prairie Pothole Region. The Center is located on 600 acres along the James River Valley near Jamestown, North Dakota. During the center's 40+ year history, scientists have earned an international reputation for leadership and expertise on the biology of waterfowl and grassland birds, wetland ecology and classification, mammalian behavior and ecology, grassland ecosystems, and application of statistics and geographic information systems. Strengths of NPWRC include long term partnerships with the U.S. Fish and Wildlife Service and National Park Service, as well as University and State partnerships in the northern Great Plains. Major science programs focus on (1) wetlands and associated ecosystem services in response to land use and climate change, studies, (2) migratory birds, (3) National Park and Forest oriented research, (4) management of habitats on DOI lands, and (5) endangered species and large river systems; all of which can contribute information and tools to the LCCs and the NC CSC.

USGS Rocky Mountain Geographic Science Center

The USGS Rocky Mountain Geographic Science Center (RMGSC, <http://rmgsc.cr.usgs.gov/rmgsc/>) is a leading authority in evaluating and understanding the causes, and consequences of landscape change, as well as, predicting the risks and vulnerabilities associated with landscape change to biological, physical, and human systems. Scientists at RMGSC have expertise in a number of areas including: monitoring landscape change with satellite, airborne, and unmanned aerial systems; assessing and

modeling ecosystem services and the impacts of energy development; evaluating the consequences of wildland fire management and insect disturbances at landscape scales; and assessing and modeling wildland fire and their emissions in response to climate change. RMGSC actively seeks out, and engages in, partnerships and collaborations with academic, federal, state, and local partners. The RMGSC could collaborate with the NC CSC on issues of landscape change in conjunction with climate change and climate variability as major forcings on landscapes and ecosystems/ecosystem services.

USGS Northern Rocky Mountain Science Center

The Northern Rocky Mountain Science Center (NOROCK, www.nrmsc.usgs.gov) is a multi-disciplinary research organization that works closely with state and federal partners throughout the Northern Rockies. Several members of the GN LCC are co-located at NOROCK, due to this and the relevance of much of NOROCK's research, the center works very closely with the GN LCC. NOROCK brings expertise in climate science, paleo ecology, terrestrial and aquatic ecology, invasive species, and decision support science. In addition, NOROCK has a very active climate science program that is focused on dynamic mountain landscapes (Western Mountain Initiative), potential climate effects on aquatic ecosystems, the role of climate in influencing the dynamics of invasive species, and climate science related to potential changes in sage grouse habitat. In addition, our researchers work very closely with our colleagues at Montana IoE on climate related issues throughout the state of Montana. In addition, the NCCWSC has funded four climate related projects that are ongoing at the Northern Rocky Mountain Science Center that could contribute directly to on-going work at the NCCSC.

USGS Earth Resources Observation and Science Center

The USGS Earth Resources Observation and Science (EROS, eros.usgs.gov) Center has primary mission functions in science, data access, and data archives. EROS is probably best known for its Landsat and MODIS archive. In addition to responsibilities for safeguarding and expanding the national archive of remotely sensed land data, and making these data sets readily available to the public, there is also a substantial applied science component at the Center. A principle thrust of research at EROS includes expanding knowledge of the patterns, processes, and consequences of changes in land-use, land-cover, and land condition, at multiple spatial and temporal scales. Scientists at EROS have interests and expertise in land characterization and trends, landscape dynamics and global change, fire science, early warning and hazards, ecological carbon sequestration, topographic science and Lidar; all of which can contribute to the research needs of the NC CSC, especially broad-scale and region-wide analysis.

The USGS Tribal Liaison for the Climate and Land Use Change (CLU) Mission Area of USGS is also located at EROS, and is involved in a number of Tribal climate change initiatives including education and research with Tribal Colleges and Universities and with Tribal government resource management agencies involved in vulnerability assessment and adaptation planning. This liaison position presents significance experience and a valuable resource for the CSC's to engage with Tribal issues.

4. Other related national and regional efforts

Beyond the NCUC and the USGS Centers, the NC CSC is committed to working with and leveraging off of other regional initiatives. Even in its early stages, the NC CSC has established a connection with the NOAA National Climate Prediction and Projection (NCCP) platform and has funded four pilot projects to connect the NCCP platform with USGS-lead climate impacts research. The NC CSC is also engaged with the regional tribal partner during its initial stages through the Intertribal Council on Utility Policy. Finally, with the objective of considering end users and making the NC CSC science relevant to their decision process, the workshop included representation from the USGS's Science and Decisions Center as well as the NCCWSC-funded Social Network Analysis project. Presentations were given for each of these initiatives.

NOAA National Climate Prediction and Projection (NCCP) Pilot program

In an attempt to leverage existing federal activities, the DOI and NOAA have initiated a joint pilot study between the North Central Climate Science Center (NC CSC) and the NOAA/NCAR- National Climate Predictions and Projections (NCCP) Platform. The mission of NCCP is to support state-of-the-art approaches to develop and deliver comprehensive regional climate information and facilitate its use in decision making and adaptation planning. NCCP believes that the best way to develop this translational information is to work with users, such as those funded through this pilot program. The overarching goal of the NCCP/NC CSC pilot is to explore together the "best available climate information" to support key land management questions and how to provide that information. The projects funded through this pilot will develop a deliberate, ongoing interaction to prototype how NCCP will work with CSCs to develop and deliver needed climate information product. It will build capacity in the NC CSC by providing NCCP's translational information for climate data used as input to USGS-based ecological modeling efforts. The ultimate goals of this pilot project are: 1) to explore ways in which the climate information can help inform land management decisions through ecological response models, 2) develop approaches for ecological response modeling to be informed and enhanced by the translational climate information provided by NCCP. Detailed information on the four sub-projects funded through this pilot project are given at <http://www.doi.gov/csc/northcentral/NCCP-Pilot-Project.cfm>.

Intertribal Council on Utility Policy

The Intertribal Council On Utility Policy (COUP) is a consortium of 15 Indian Tribes in the Northern Great Plains, primarily in the Dakotas, with other member Tribes in Nebraska and Wyoming. The Intertribal COUP received a Congressional Appropriation for a multi-tribal wind feasibility study for a 450 MW project on nine reservations. This proposed Intertribal Wind Project (IWP) is a large scale, regionally distributed generation model designed to inter-connect to respective Western Area Power Administration's (WAPA) substations on or near tribal trust lands. In preparation for this project COUP is in need of:

- Wide area climate and weather forecasts and wind energy assessments;
- Regional climate variability and change analysis (30 years);
- Regional wind energy assessment;
- Wind energy assessment of proposed tribal wind energy generation sites;

- Projected wind energy capacity of distributed tribal wind generation networks;
- An integrated water resource planning study in the Missouri River Basin.

The Integrated Water Resource Planning Study will analyze the present and projected weather climate impacts in the Missouri River Basin, including hydro power generation, agriculture, non-agriculture, and municipal (human) usage, navigation and other water uses over the 30 year project period for several selected climate scenarios. COUP has engaged the Nation Center for Atmospheric Research (NCAR) in this endeavor and is also looking to engage the NC CSC and its partners. The mission of the NC CSC and the mandates of the DOI Secretarial Order that established the CSCs and LCCs seem very much aligned with serving the needs of the Intertribal COUP member Tribes.

The USGS Science and Decision Center

USGS Science and Decisions Center (SDC, <http://www.usgs.gov/sdc/>) is an interdisciplinary organization advancing the use of science in natural resource decision making. The Center serves as an institutional voice in USGS for three focus areas – decision science, ecosystem services, and resilience – which together form a scientific basis for decision making. The Center works with partners in DOI and other government agencies, universities, and nongovernmental organizations to develop methods, capacity, and institutional structures to integrate science more effectively with resource management. A comprehensive framework for SDC includes identifying and valuing ecosystem services, incorporating these values into management objectives, comparing tradeoffs, evaluating the consequences of management decisions, and folding what is learned into ongoing management through adaptive decision making. The DOI climate Science Center are addressing complex issues that require expertise in science areas that span energy, minerals, environmental health, ecosystem change, land use, climate change, hydrology, and natural hazards. The SDC can help with CSCs by providing a cross-cutting framework to link the USGS mission areas to each center’s natural resource decision making.

Social Network Analysis

The USGS NCCWSC is funding a collaborative study between researchers at University of California Davis and the Climate Science Centers. The goal of this study is to understand the networks of information exchange regarding climate science in federal land management agencies. The project is focusing on characterizing the communication networks for agencies operating in the Southwest and North Central CSC regions. Resource management decision-making for adaptation to a changing environment is complex and uncertain. Thus, it is critical to understand how stakeholders connect to one another in order gain needed information regarding resource management decisions. This team will be conducting surveys of the personnel who are integrating climate change into federal land management and planning; looking to address a list of relevant questions: Who do resource managers consult regarding climate science information? What types of climate science are being used to inform management? Does the integration of climate science information increase the adaptive capacity of management? Where are there information gaps? Do certain factors, such as perceived risk of climate change, correlate with network characteristics like network density? The study will provide a baseline to measure the progress and value of the science that will come from the NC CSC and LCC efforts can be measured.

5. Conclusions and next steps

The workshop was successful in bringing the various participants together and providing useful feedback as the NC CSC works to develop its five year science plan. The NC CSC will use feedback and conversations from the meeting to help draft its five year strategic science plan. The NC CSC will continue to iterate with its Stakeholder Advisory Committee on that plan with the hope of having a final version by the fall of 2012. The university consortium used the time together to develop a solid outline for an initial 18 month research plan that was developed in the month following the workshop.

6. Appendix A: Workshop Attendees (listed alphabetically)

First Name	Last Name	Institution/Organization	Phone Number	Email
Christopher	Anderson	Iowa State University	515-294-9948	cjames@iastate.edu
Mark	Anderson	USGS - South Dakota	605-394-3220	manders@usgs.gov
Nikki	Blanken	Colorado State University	970-491-5589	nikki.blanken@colostate.edu
Kyle	Blasch	Montana Water Sci.Cnt.	406-457-5901	kblasch@usgs.gov
Zachary	Bowen	USGS Fort Collins Sci.Cnt.	970-226-9218	bowenz@usgs.gov
James	Broska	Great Plains LCC	505-248-6279	James_Broska@fws.gov
Craig	Carr	Montana State University	406-994-3282	craig.carr@montana.edu
Gary	Davis	Bureau of Reclamation	406-247-7717	jgdavis@usbr.gov
Diane	Debinski	Iowa State University	515-294-2460	Debinski@iastate.edu
Frank	D'Erchia	USGS Rocky Mountain Area	303-236-1460	fderchia@usgs.gov
Deborah	Finch	USDA Forest Service	505-724-3671	dfinch@fs.fed.us
Robert	Gleason	USGS Northern Prairie Wildlife Res.Cnt.	701-253-5546	rgleason@usgs.gov
Bob	Gough	Intertribal Council on Utility Policy	605 441 8316	gough.bob@gmail.com
Andrew	Hansen	Montana State University	406 994 6046	hansen@montana.edu
Todd	Hawbaker	USGS Rocky Mountain Geographic Sci.Cnt.	303-202-4303	tjhawbaker@usgs.gov
Lauren	Hay	USGS National Research Program	303 236 7279	lhay@usgs.gov
Steven	Hostetler	USGS	541 737-8928	swhostet@usgs.gov
Kevin	Johnson	Southern Rockies LCC	303-236-4404	kevin_m_johnson@fws.gov
Jeff	Kershner	USGS NOROCK	406 994 5304	jkershner@usgs.gov
Todd	Kipfer	Montana Institute on Ecosystems	406-994-7977	tkipfer@montana.edu
Kate	Kitchell	Bureau of Land Management	406-896-5012	kkitchell@blm.gov
Doug	Kluck	NOAA/Regional Climate Services Director	816-564-2417	doug.kluck@noaa.gov
William	Lauenroth	University of Wyoming	307-766-4353	wlauenro@uwyo.edu
Jeff	Morisette	DOI North Central Climate Science Center	970-691-8197	morisettej@usgs.gov
Rick	Nelson	U.S. Fish and Wildlife Service	701-355-8509	Richard_D_Nelson@fws.gov
Barry	Noon	Colorado State University	970-491-7905	brnoon@cnr.colostate.edu
Robert	Oglesby	University of Nebraska, Lincoln	402-472-1507	roglesby2@unl.edu
Dennis	Ojima	Colorado State University	970-491-1976	dennis.ojima@colostate.edu
Tom	Olliff	Great Northern LCC	406.994.7920	Tom_Olliff@nps.gov
Robin	O'Malley	USGS NCCWSC	703-648-4086	romalley@usgs.gov
Casey	Peters	UC Davis	707-292-8485	caseypeters@yahoo.com
Max	Post van der Burg	USGS Northern Prairie Wildlife Res.Cnt.	701-253-5574	maxpostvanderburg@usgs.gov
Andrea	Ray	NOAA/EARth System Research Lab	303-497-6434	Andrea.ray@noaa.gov
Steve	Running	University of Montana	406-243-6311	swr@ntsg.umt.edu
Liz	Shanahan	Montana State University	406.994.5167	shanahan@montana.edu
Rick	Sojda	USGS; Great Northern LCC	406.994.1820	sojda@usgs.gov
Cathy	Thomas	USGS	970-226-9164	ccullinanethomas@usgs.gov
Jim	Vogelmann	USGS/EROS	605-594-6062	vogel@usgs.gov
Cathy	Whitlock	Montana Institute on Ecosystems	406-994-6910	whitlock@montana.edu
Mark	Wildhaber	USGS Columbia Environmental Res.Cnt.	573-876-1847	mwildhaber@usgs.gov