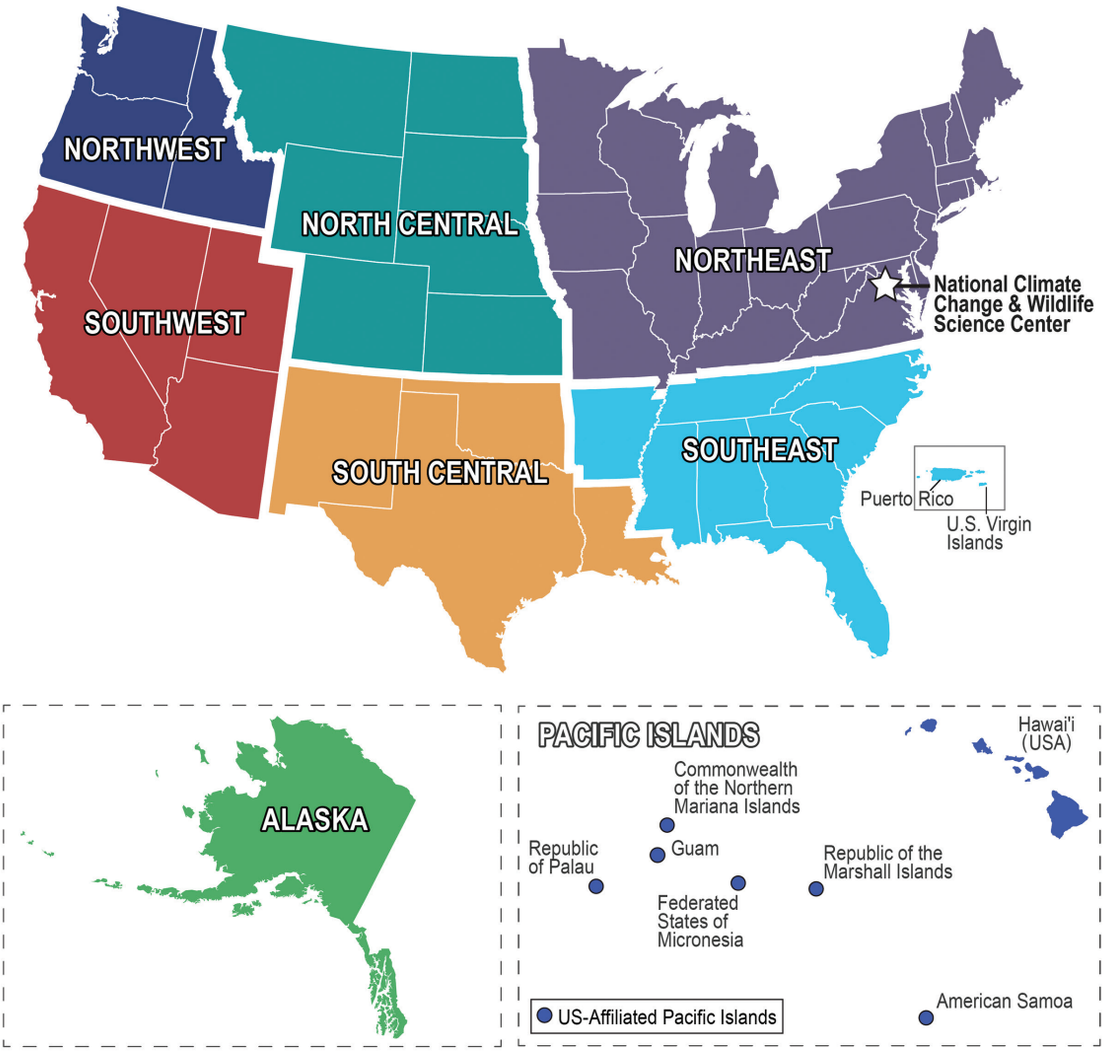
Five-Year External Reviews of the Eight Department of Interior Climate Science Centers

North Central Climate Science Center



Department of the Interior Climate Science Center Regions

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Five-Year External Reviews of the Eight Department of Interior Climate Science Centers

North Central Climate Science Center

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This review involved significant effort and time commitments from numerous individuals, particularly members of the science review team who took time away from their jobs and professional commitments to prepare for the review, conduct a week-long site visit, and assemble their findings into this report. North Central Climate Science Center (NC CSC) staff devoted significant time to compile and provide necessary background material, hosted the onsite review, answered follow-up questions, and provided significant feedback to help improve the final report. In particular, we appreciate the contributions from Jeffrey Morisette, director, U.S. Department of Interior NC CSC; Dennis Ojima, host university director (Colorado State University), NC CSC; Aparna Bamzai-Dodson, deputy director, NC CSC; Robin O'Malley, acting director, NC CSC; and Jill Lackett, Colorado State University; as well as all of the CSC staff and consortium university partners who participated. We greatly appreciate the assistance of the numerous science user stakeholders, and science producers who participated in the survey and focus panels and shared their experiences and opinions. This review was conducted under the guidance of Janet Cushing, deputy chief, National Climate Change and Wildlife Science Center, U.S. Geological Survey.

Executive Summary

In 2008, the U.S. Congress authorized the establishment of the National Climate Change and Wildlife Science Center (NCCWSC) within the U.S. Geological Survey (USGS), with further direction set forth in Secretarial Order 3289 (Salazar 2009). The mission of NCCWSC is to provide natural resource managers with the tools and information they need to develop and execute management strategies that address the impacts of climate change on fish, wildlife, and their habitats. Eight regional Climate Science Centers (CSCs), each a collaborative arrangement between the USGS and a regional host university, form the core mechanism through which this mission is carried out.

The National Climate Change and Wildlife Science Center, with the engagement of the American Fisheries Society and Cornell University, began working with independent science review teams to conduct reviews of individual CSCs in 2016–2017. These reviews evaluate operational and programmatic aspects of each CSC, including the host-university relationship, to ensure that established goals and obligations are being met, as well as to identify obstacles and areas of improvement for future agreements.

The North Central CSC (NC CSC), established in 2011, is based in Fort Collins, Colorado, with Colorado State University (CSU) serving as host university, coordinating a consortium of eight other academic/research entities spread throughout the region. The NC CSC has completed its initial 5-year project cycle and is in its sixth year through a 1-year funding extension.

The geopolitical domain of this region is extensive, encompassing seven states over a vast expanse of the interior continental United States from the northern border with Canada to the southern portion of the Great Plains and from the Rocky Mountains to the eastern margin of the grasslands of the Great Plains. This large area covers dramatic gradients in elevation, hydrology, topography, precipitation, and temperature seasonality, as well as major differences in land ownership, management, and uses.

The NC CSC has identified and justified three core foundational science areas as a premise for their work. The collective science strategy is known as Resource for Vulnerability Assessment, Adaptation and Mitigation Projects (ReVAMP). Broadly, ReVAMP provides a means of producing climate science to link climate drivers to ecological impacts in order to develop and implement adaptation strategies. It is structured to address information needs arising anywhere along the sequence leading to adaptation strategy planning and actions. The NC CSC's ReVAMP strategy is a coherent and well-aimed approach to leveraging the region's research capability to advance climate change adaptation planning and implementation.

The NC CSC's science strategy is highly responsive to stakeholder/end user needs for a resource that provides both targeted products and assistance in applying their products. Of particular note, hiring technicians and service providers, not just researchers, to help with vulnerability assessments, adaptation, and mitigation provides stakeholders with science translation and assistance refining products to meet their particular stakeholder needs. Recognizing that the NC CSC has only been in existence for 5 years, it is currently difficult to evaluate the impact of this science agenda on the ground, and the NC CSC would benefit by developing a defined process and measures that allow evaluation of how products were used (e.g., altering how decisions were made, what decisions are made, etc.) and how the process affected relationships with stakeholders.

From 2011 to 2012, the NC CSC had a Stakeholder Advisory Committee (SAC) (as with all other CSCs). In 2015, the SAC was transitioned into the Joint Stakeholder Advisory Committee (JSAC), a collaboration between the NC CSC and the U.S. Department of Agriculture Northern Plains Climate Hub to maximize communication, awareness, and coordination among regional federal agencies while eliminating redundancy and stakeholder fatigue. This type of coordination with complementary programs is highly efficient and commendable. However, there is a notable absence of social science professionals and state fish and wildlife agency representatives on the JSAC, although state issues may be partially addressed by representatives of the Landscape Conservation Cooperatives (LCCs).

The NC CSC has done an excellent job of reaching out to stakeholders to identify their needs and provide climate science data and information to managers and users. In particular, tribal engagement has been notable and commendable and the NC CSC has been a leader in supporting workshops that enhance the connection between research and Native American management needs. This engagement is very positive but it apparently hinges on the relationship built by a few individuals and could be jeopardized by the departure of individual staff, so the NC CSC should explore means to mitigate the risk of relying on these limited relationships so that the engagement will remain robust even in the event of staff changes.

To strengthen the productivity of the relationship with the LCCs, the NC CSC recently funded liaison teams for each of the LCCs to facilitate three-way coordination: LCC needs, capacities at NC CSC, and capacities at USGS. Although the liaison concept is still in the early stages, the feedback received by the review team from the LCCs during the review process was very favorable. The review team recommends that the NC CSC regularly evaluate the new role being developed for the LCC liaisons to ensure that they are producing the expected level of engagement. Additionally, state fish and wildlife or appropriate natural resources agencies should be contacted to evaluate their understanding of the work being done by the NC CSC and LCCs and their comfort in being represented by the LCCs.

Although the NC CSC indirectly engages nonfederal partners through the LCCs, additional effort should be placed on engaging nonfederal land managers where opportunities exist. The NC CSC has made progress including private lands and landowners in certain locations, even though those are not identified as primary stakeholders, thereby recognizing the importance of engaging these constituents in implementation of adaptation strategies.

The NC CSC stakeholders and end users clearly laud the CSC's efforts in building connections and are very appreciative of the resources that the CSC provides, including the aforementioned strategic hiring of technical staff, providing visualization tools, the integration of end users from the outset in many efforts, and co-learning (e.g., ecologists learning from climate scientists and vice versa). Users appreciated that the NC CSC came to them and met them on their turf, rather than having to go to the NC CSC. Multiple focus group participants commented on the invaluable role that the NC CSC has played in convening and coordinating partners and stakeholders. Stakeholders overwhelmingly felt that NC CSC science was of high quality and can contribute to policy or management. The most common way that science users reported using the NC CSC science was to inform management plans. However, only one-third of NC CSC stakeholders believed that policymakers used climate adaptation science to inform policies; more than two-thirds maintained that what is known about climate adaptation does not necessarily influence actions taken by decision makers in the region.

The NC CSC has employed a number of techniques and technologies to interactively engage stakeholders in the development of adaptation scenarios. One such tool is the Resources for Advanced Modeling Center, which enables sophisticated collaborations among up to 20 scientists and users working simultaneously, displaying the results of various scenarios on a wall of monitors (VisWall). Modelers are able to integrate remote sensing, climate modeling, geographic information systems, and other products seamlessly and to project simulation runs or scenarios on this VisWall, providing an excellent means to communicate complex and sophisticated science/modeling efforts in a format easily understandable to wide ranges of audiences.

The consortium model employed by CSU, as host university, and eight other institutions has had mixed results. The large number of consortium members allows a wide pool for principal investigators and disciplines in response to requests for proposals, but may leave too little funding (under current funding levels) for each institution to have full engagement and impact. This limitation dilutes the potential advantages provided by such a large pool of potential researchers; the review team suggests that each partner's involvement should be re-evaluated to verify his or her interest and level of engagement and affirmed through a memorandum of understanding or some other vehicle. This should include an explicit account-

ing of the past and current roles of each partner in NC CSC activities and a clear definition of the explicit role of each member of the university consortium in future recompetition processes.

The relationship between the USGS NC CSC director and host-university director is key to NC CSC success. Each brought individual networks to the table, which strengthened the CSC. However, there appears to be a lack of full engagement of the upper university administration in the NC CSC. Despite this lack of upper level university engagement, the host university is conducting great science. The roles and responsibilities of the university and USGS should be more clearly defined in the host-university agreement so that there is a shared understanding of the expectations in this partnership.

The NC CSC has done an excellent job of engaging students, postdoctoral associates, and other early-career scientists and managers at the host institution. It has capitalized on existing departmental structure and graduate student networks to expand its reach outside of the USGS and NC CSC proper at CSU. However, multiple opportunities appear to exist for the NC CSC to better engage university departments beyond the Natural Resource Ecology Laboratory, where it is housed at CSU, that would strengthen the integration with complementary disciplines and resources available for such aspects as communication with stakeholders.

The NC CSC should be cognizant of and address the frequent disconnect between the adaptation literature (focus on ecological targets) and the way that agencies actually manage public lands (focus on specific activities—grazing, recreation, forestry, fire management, etc.). Opportunities exist for greater work with partners to develop climate-smart management skills in early-career managers, in addition to the work already being done to develop the next generation of climate scientists.

The high demand for NC CSC services speaks to the strong reputation that has been established, but fulfilling all requests for assistance is limited by funding, personnel, office space, and the size and diversity of the landscape. Typically, these partnership, outreach, and extension services provided by NC CSC staff are not recognized in the traditional performance metrics of a scientist in a research institution. Considering that the CSC network is premised on actionable science, mechanisms should be explored to expand the job-performance metrics to recognize and reward these types of services provided by the researchers to the land stakeholder groups.

In summary, during the 5 years in existence, the NC CSC has developed a solid foundation for meeting core elements of its mission and beyond. Its strong relationship between coproduction of actionable science research and technical assistance to help land managers implement the results of this research contributes to meeting the overall NCCWSC mission of providing natural resource managers “with the tools and information they need to develop and execute management strategies that address the impacts of climate change on fish, wildlife and their habitats.” The full review report expands on the aspects leading to this success and provides recommendations for strengthening the program for the future.

Abbreviations and Acronyms

ACCCNRS	Advisory Committee on Climate Change and Natural Resource Science
AFS	American Fisheries Society
BLM	U.S. Bureau of Land Management
CMC	Colorado School of Mines
CSC	Climate Science Center
CSC-Federal	Federal USGS-staffed component of the CSC
CSC-University	Host-university component of the CSC
CSU	Colorado State University
CU	University of Colorado
DESS	Department of Ecosystem Science and Sustainability
DOI	U.S. Department of Interior
F&A	facilities and administrative
FG	focus group
FORT	Fort Collins Science Center
FSA	foundational science area
FTE	full-time equivalent
FY	fiscal year
HDRU	Cornell University Human Dimensions Research Unit
ISU	Iowa State University
JSAC	Joint Stakeholder Advisory Committee
KSU	Kansas State University
LCC	Landscape Conservation Cooperative
MSU	Montana State University
NC CSC	North Central Climate Science Center
NCCWSC	National Climate Change and Wildlife Science Center
NCPP	National Climate Predictions and Projections Platform
NCTC	National Conservation Training Center
NCUC	North Central University Consortium
NGO	nongovernmental organization
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NREL	Natural Resource Ecology Laboratory at CSU
PI	principal investigator
RAM	Resource for Advanced Modeling (RAM Center)
ReVAMP	Resource for Vulnerability Assessment, Adaptation and Mitigation Planning
RFP	request for proposal
RISA	Regional Integrated Sciences and Assessment
SAC	Stakeholder Advisory Committee
SRT	science review team
UM	University of Montana
UNL	University of Nebraska-Lincoln
USDA	U.S. Department of Agriculture
UW	University of Wyoming
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service

USGS	U.S. Geological Survey
WWA	Western Water Assessment

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Introduction

Review Purpose

In 2008, the U.S. Congress authorized the establishment of the National Climate Change and Wildlife Science Center (NCCWSC) within the U.S Department of Interior (DOI) . Housed administratively within the U.S. Geological Survey (USGS), NCCWSC is part of the DOI's ongoing mission to meet the challenges of climate change and its effects on wildlife and aquatic resources (TWS and ESA 2009). Further direction for NCCWSC was set forth in Secretarial Order 3289, "Addressing the Impacts of Climate Change on America's Water, Land, and Other Natural and Cultural Resources," on September 14, 2009 (amended February 22, 2010; Salazar 2009). Through this order, the original concept of eight "climate hubs" was redefined into the DOI Climate Science Centers (CSCs) and their mission was slightly expanded to "synthesize and integrate climate change impact data and develop tools that the Department's managers and partners can use when managing the Department's land, water, fish and wildlife, and cultural heritage resources" (Salazar 2009). As a result, NCCWSC established eight regional DOI CSCs from 2010 through 2012 (Figure 1) and has responsibility for their management. For the structure of the CSCs, NCCWSC developed a dual-approach model that employs a federal USGS-staffed component (CSC-Federal) and a parallel host-university component (CSC-University), established competitively through a 5-year cooperative agreement with NCCWSC.

The North Central Climate Science Center (NC CSC) was established in 2011, has completed its initial 5-year project cycle, and is in its sixth year through a 1-year funding extension. As such, the university hosting agreement for this CSC region is subject to a recompetition process by USGS for the host university. As part of the recompetition process, NCCWSC, with the engagement of the American Fisheries Society (AFS) and the Cornell University Human Dimensions Research Unit (HDRU), coordinated an operational and programmatic review and evaluation of the CSC to ensure that established goals and obligations of the CSCs were being met, as well as to identify obstacles and areas of improvement for future agreements.

This report covers only the findings from the programmatic evaluation of the NC CSC conducted by AFS and the HDRU and does not include any findings or discussions from the operational review conducted by NCCWSC. This report also does not discuss the goal of developing recompetition recommendations, which were submitted to NCCWSC in a separate report.

NCCWSC and CSC Missions and Guiding Principles

In developing a review for the CSCs, it is important to understand their fundamental roles and audiences, as well as the services that they are expected to provide. The most basic documents for understanding this are the mission statements that NCCWSC and the CSCs have developed, based, in large part, on the directive provided in Secretarial Order 3289 (Salazar 2009). Their mission statements vary only slightly, with the CSCs including cultural resources in addition to the fish and wildlife emphasis of NCCWSC.

The mission of NCCWSC is to provide natural resource managers with the tools and information they need to develop and execute management strategies that address the impacts of climate change on fish, wildlife, and their habitats (USGS 2013).

The mission of the individual DOI CSCs is to provide natural and cultural resource managers with the tools and information they need to develop and execute management strategies that address the impacts of climate change on a broad range of natural and cultural resources (USGS 2013).

The NCCWSC strategic plan (2009–2014) was developed to guide the efforts of the NCCWSC–CSC network (USGS 2009). The plan states three basic goals:

[1] Consolidated Appropriations Act of 2008, Public Law 110–161, 110th Congress (26 December 2007). In this bill, NCCWSC was referred to as the National Global Warming and Wildlife Science Center.

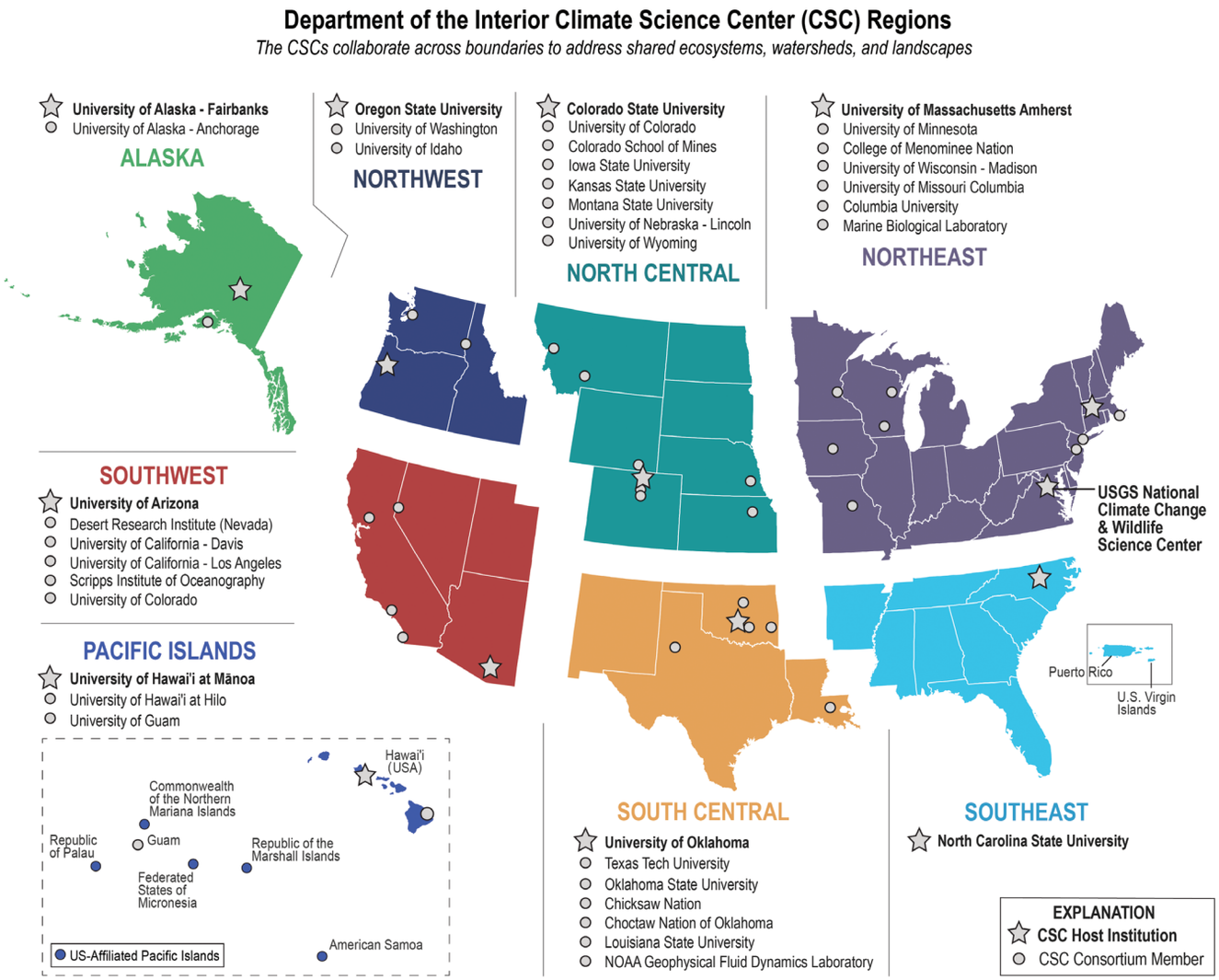

Figure 1. Map of the eight Climate Science Centers and consortia.

- Work in close partnership with the natural resource management communities to understand their highest priority science needs regarding climate change impacts, and determine what is needed to fill those knowledge gaps.
- Work with the scientific community to develop the science information and tools in such a way that they can be readily used to generate management strategies for responding to climate change.
- Deliver these relevant tools and information in a timely and useful way directly to resource managers.

The NCCWSC strategic plan also identifies priority scientific activities to help meet its mission and goals:

- Use and create high-resolution climate modeling information and derivative products in order to produce key information that is needed to forecast ecological and population response at national, region al, and local levels.
- Integrate physical climate models with ecological, habitat, and population response models.
- Forecast fish and wildlife population and habitat changes in response to climate change.
- Assess the vulnerability and risk of species and habitats to climate change.
- Develop standardized approaches to modeling and monitoring techniques in order to facilitate the linkage of existing monitoring efforts to climate models and ecological/biological response models.

The purpose of the Climate Science Center review was to

- Evaluate the effectiveness in meeting the project goals;
- Assess the level of scientific contribution and achievement with respect to climate modeling, climate change impacts assessments, vulnerability and adaptation of fish, wildlife, and habitats, and collaborative development of adaptation strategies for regional stakeholders;
- Evaluate the competencies and efficiencies of each Climate Science Center host university in managing the administrative and program requirements; and
- Aid the National Climate Change and Wildlife Science Center in developing improved requirements for recompetition of the next university hosting agreements.

The NCCWSC strategic plan states that a key component of the NCCWSC–CSC network is to work with partners. Two major groupings of partners include (1) science partners (e.g., federal agencies, universities, scientific societies, and other nongovernmental organizations [NGOs]) and (2) conservation partners, which cover a broad category of those working to apply conservation (e.g., state and federal natural resources agencies, conservation NGOs). It is important to note that these two primary partner groups are not discrete and sometimes have overlapping membership. For example, many conservation partners are also science producers (e.g., Ph.D.-level U.S. Fish and Wildlife Service [USFWS] biologists). A major indicator of success of the NCCWSC–CSC network is, therefore, the degree to which partners are effectively engaged and benefit from the work of the NCCWSC–CSC network.

Recognizing that no single agency or organization has the capacity to effectively address the challenges of climate change, the DOI, through Secretarial Order 3289 (Salazar 2009), launched a network of Landscape Conservation Cooperatives (LCCs) around the same time period as the establishment of NCCWSC and then the CSCs. The LCCs were developed to organize and coordinate large-scale conservation efforts through a partnership approach. The LCCs are primary CSC partners and consist of natural and cultural resource managers from federal, state, tribal, and other entities whose mandate is to work collectively to identify key resource issues and provide information and other support for integrated, landscape-scale conservation planning. The LCC network currently includes 22 geographic units across North America, the Caribbean, and U.S.-affiliated Pacific Islands, delivering substantial collaboration across jurisdictional boundaries (Figure 2). A recent review of the LCCs by the National Academy of Sciences provides substantial additional information on the LCCs and clarifies the significant and important relationship with the CSCs (National Academies of Sciences, Engineering, and Medicine 2016).

The process of identifying the CSCs began in fiscal year 2010 with the identification of the University of Alaska as the location for the first CSC, after which the USGS initiated a competitive selection of host institutions for the additional centers (NCCWSC 2011). The Alaska, Northwest, and Southeast CSCs were formally established in September 2010, with fiscal year 2010 funds (NCCWSC 2011). Implementation of the Southwest and North Central CSCs was delayed by the late passage of appropriations legislation for fiscal year 2011, and these centers were established in June 2011 (NCCWSC 2011). The final three CSCs were established formally in March 2012 (Northeast, South Central, and Pacific Islands), completing the planned suite of eight regional CSCs (Varela-Acevedo and O'Malley 2013).

The NCCWSC–CSC network is committed to a partnership-driven model (NCCWSC 2011). As such, the CSC scientific agenda is not driven by an a priori national science agenda, but rather through the identified needs of the LCCs, as well as individual land, water, wildlife, and other natural and cultural resource managers (NCCWSC 2011). All of the CSCs employ some form of a Stakeholder Advisory Committee (SAC) as a means of formally engaging partners in the strategic direction of the CSC. The SAC

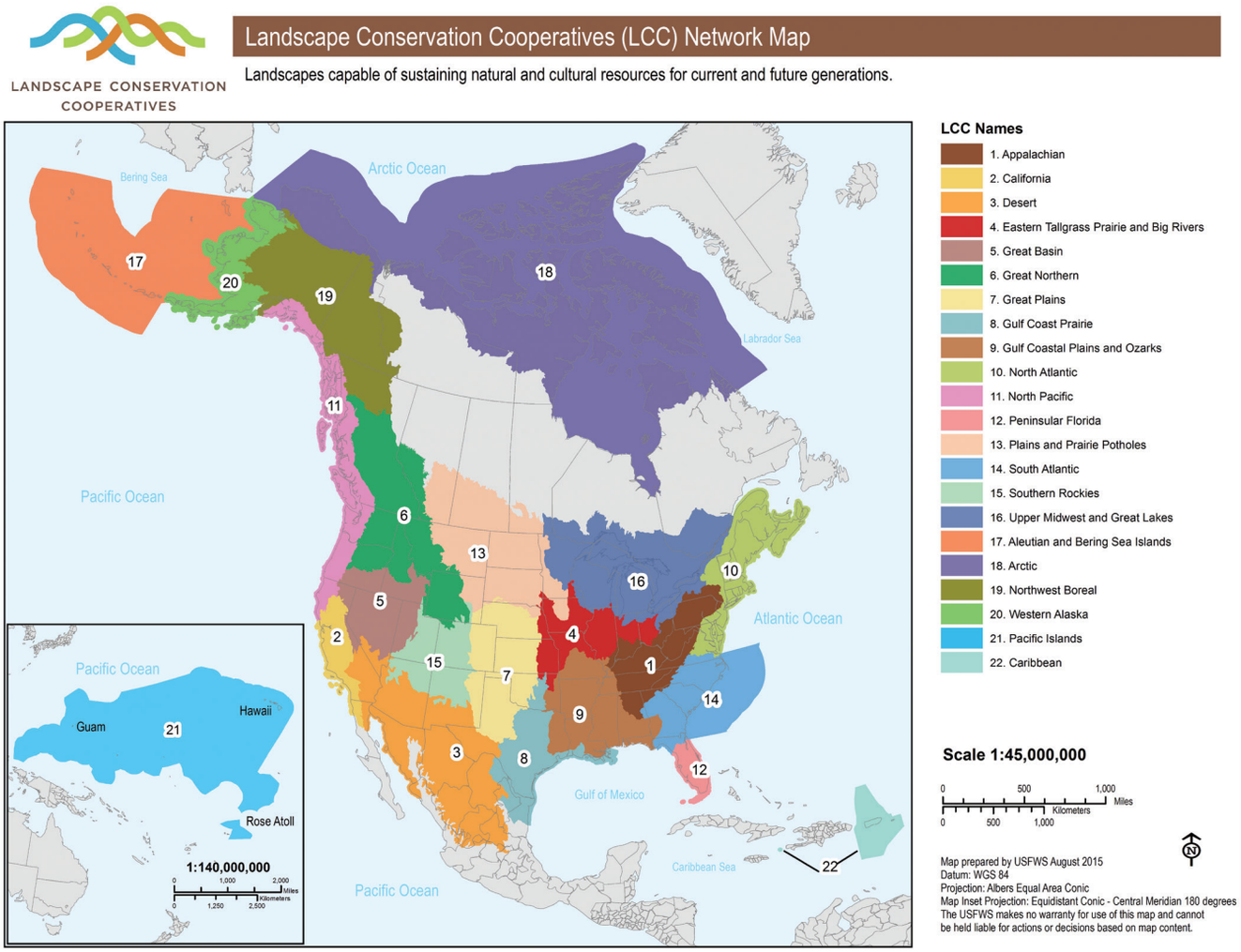

Figure 2. Map of the 22 Landscape Conservation Cooperatives.

provides a vehicle for building collaborative partnerships and identifying key regional science priorities. The National Climate Change and Wildlife Science Center established a set of guidelines (CSC Stakeholder Advisory Committee Terms of Reference) for the SACs, which defines membership, primary purpose, and other operating guidance (NCCWSC 2014). The CSC federal director, with input and guidance from the SAC, develops a 5-year strategic plan, as well as annual work plans, that drive science priorities and requests for proposals (RFPs; Jones and Dalton 2012). Regional priorities are similarly reconciled with input from NCCWSC, advisory committees, and other CSCs to build a higher-level national-scale agenda. This supports the identification of multi-CSC needs and ideas in addition to the opportunity to more effectively leverage resources. Together, the NCCWSC–CSC network forms the cornerstones of DOI's integrated approach to climate change science and adaptation and assesses climate impacts that typically extend beyond the borders of any federal or state park, refuge, conservation, or other land management unit or geopolitical boundary.

Review Process

Roles of AFS, the HDRU, and NCCWSC

The CSC evaluations consisted of two parts: an external programmatic review led by AFS and the HDRU and an internal operational review led by NCCWSC, which is not addressed in this report. To evaluate the performance of the CSC, AFS and the HDRU established a science review team (SRT) for each CSC.

An SRT consisted of a team of five non-CSC affiliated experts selected through a national solicitation and review of credentials, as well as a nonvoting USGS science center director who served as chair and a CSC federal director from outside the reviewed CSC (both selected by the NCCWSC deputy chief; Appendix A). The American Fisheries Society was tasked with assembling the SRTs, developing review metrics, managing the on-site review process (data collection, interviews, and discussions), and developing review reports from evaluation findings, as well as logistical planning (travel, lodging, and food).

Human Dimensions Research Unit investigators focused on the evaluation of CSC partnerships. During on-site reviews, the HDRU interviewed stakeholders and partners to assess the quality and extent of partnership involvement with the respective CSC. Using the interview data, the HDRU constructed a standardized survey that was sent out to a broad array of current and past CSC partners in each region to identify patterns of engagement with the CSCs, as well as barriers to engagement.

The NC CSC on-site review was conducted over a period of 3 days in Fort Collins, at the USGS science center and on the campus of Colorado State University (CSU) (Appendix B). The review process was designed to develop a full understanding of the NC CSC. The review included the administrative structure, foundational documents and processes (e.g., strategic and science planning), research projects, communications of results, and engagement of stakeholders and others in an actionable science pathway approach that includes assessment of the utility of the science products.

Program Evaluation Measures for CSCs

Currently, no satisfactory systemwide CSC performance measures (e.g., specific deliverables or activities completed by given dates) exist. Each CSC was established within the general frameworks of both the NCCWSC and CSC missions and in response to the needs of their region. As described below, the NC CSC developed a strategic science plan, which defined six strategic priorities, operational plan, and annual work plans. These annual work plans establish objectives for the fiscal year (FY) within the six strategic science plan priorities. While these six science themes and the related annual work plan objectives could provide a basis for assessment, they are not consistent across the CSCs and are more reflective of activities than measures of impact. As a result, the construction of the CSC reviews sought other models upon which to construct the review process.

The Advisory Committee on Climate Change and Natural Resource Science (ACCCNRS) is a multi-stakeholder federal advisory committee established by the DOI in 2012, chartered under the Federal Advisory Committee Act, to provide guidance and input on the overall NCCWSC–CSC network (USGS 2012). The committee has 25 members from the DOI, other federal agencies, state and local governments, tribal nations and partners, NGOs, academia, and the private sector (USGS 2012). ACCCNRS's charter expired in June 2017 and a new charter and membership have not been announced.

In the "Report to the Secretary of the Interior, March 30, 2015" (ACCCNRS 2015), ACCCNRS provided recommendations to the Secretary of the Interior to enhance the CSC program, including program evaluation. The committee recommended that the following four-part framework be used when developing new CSC agreements and conducting CSC program evaluations:

- Institutional development: These measures are intended to capture the overall health of the CSC as an institution, with an emphasis on planning processes, management and operations, finances, and institutional coordination.
- Actionable science: These measures are intended to capture the performance of the center in providing relevant and useful scientific products and services, with an emphasis on the relevance, quality, processes, accessibility, and impact of research and science products and services carried out directly by the CSC and through its external grant funding.
- Capacity building: These measures are intended to capture how well the CSC is building capacity for conducting and applying actionable science, with an emphasis on formal training (e.g., of graduate

students and postdoctoral fellows) and providing training and capacity building to the broader community in how to use and apply climate science and services.

- Partnerships: These measures are intended to capture how well the CSC is working with partner organizations beyond the CSC consortium itself, which is included under institutional development, with an emphasis on breadth and scope of engagements and leverage.

HDRU Methodologies[2]

The partnership evaluation component of the CSC review was designed to measure the quality and extent of partnership involvement at each CSC. The activity focused on the following questions:

- To what extent are science users and producers involved with the CSC?
- What are the predictors of this involvement? What limits involvement?
- To what extent do partners believe the CSC is producing actionable science?
- To what extent are CSC-affiliated science users and producers involved in coproduction? What are the predictors of this involvement?
- To what extent does the CSC play a role as a boundary organization, facilitating the coproduction of actionable science? What characterizes that role?

This component of the CSC review consisted of two activities: a series of group interviews and a standardized Web-based survey.

Group interviews.—Two group interviews were conducted with partners of the NC CSC during the site visit. The purpose of the group interviews was to understand the range of perspectives and experiences of CSC partners in relation to their work with the NC CSC. Two groups were included: science producers (or science partners) and science users (or conservation partners).

Participants were recruited by the NC CSC with guidance from the HDRU and included individuals who represented a diversity of organizations and regions. Participants in the science producers group included faculty members, graduate students, and/or postdoctoral associates that had received research funding from the NC CSC. Participants in the science users group included representatives of agencies intended to benefit from the science produced by the NC CSC, including LCCs, federal natural resource agencies, state fish and wildlife agencies, tribal organizations, and NGOs. A total of 26 individuals participated in the two group interviews during the on-site visit, including 12 science producers and 14 science users.

Each interview consisted of a semi-structured conversation guided by a series of open-ended questions (Appendix C) and lasted approximately 2 hours. The questions were designed to explore how partners contributed to the work of the NC CSC and the factors that influenced the ability of the NC CSC to work with their partners. The specific topics of questions focused on how participants have worked with the NC CSC, reasons for becoming involved with the NC CSC, benefits of involvement with the NC CSC, challenges to involvement, and what the NC CSC could do to promote even more benefits from involvement.

Additionally, we specifically explored how the NC CSC contributed to the coproduction of science and the generation of actionable science, with questions about interactions between science producers and science users and the role of the NC CSC in connecting them.

Web-based survey.—A standardized, Web-based survey of partners and potential partners of the CSCs was conducted (referred to in this report as "HDRU survey"). An initial sample for the survey was compiled from science producers and science users identified by each CSC, LCC staff and steering committee members within each CSC region, and members of the Association of Fish and Wildlife Agencies Climate Science Committee. An abbreviated telephone survey was conducted with nonrespondents to the Web-

[2] The material in this section is a modified version of material presented in Dayer et al. (2016).

based survey. A total of 445 individuals were included in the survey sample, with 215 total respondents from the North Central region. Results in this report are based on respondents to the Web-based survey, but these respondents differed in some ways from the Web survey nonrespondents who were reached subsequently through the phone survey. Nonrespondents tended to be less interested in and engaged with the CSCs than respondents.

The survey documented the ways in which partners were engaged with the NC CSC and the factors affecting their engagement. The survey questions (Appendix C) were developed based on insights from the group interviews and a review of the scholarly literature. The question topics included

- Nature of respondents' work
- Perspectives on the importance of addressing climate change
- Extent of involvement with the CSC
- Benefits of involvement with the CSC
- Limitations on involvement with the CSC
- Perceptions of climate adaptation science
- For science users,
    - Use of climate adaptation science
    - Limitations on use of climate adaptation science
    - Importance of and engagement in coproduction of science
    - Limitations on coproduction of science
- For science producers,
    - Use of climate adaptation science produced by others
    - Limitations on others' use of climate adaptation science
    - Importance of and engagement in coproduction of science
    - Perceptions of the role of the CSC

The same survey instrument was used for all the CSCs, with minor changes to reflect the region referenced.

Individuals were e-mailed at the initiation of the survey and provided with a link to a Web-based questionnaire. Individuals who did not respond to the first request received up to five additional requests to complete the questionnaire by e-mail. The Web-based survey instrument was programmed and administered using Qualtrics, which provides a means of soliciting participation in a survey via e-mail and recording responses. Qualtrics assigns each individual a unique Web link to prevent individuals outside the study population from participating in the survey and prevent access to survey data by anyone other than the research team. Implementation of survey began on January 9, 2017 and concluded February 7, 2017.

Institutional Development

Institutional development measures the overall health of the NC CSC with regard to planning processes (e.g., 5-year strategic plans, annual science plans, advisory committees, and stakeholder engagement), management and operations (e.g., staffing, physical assets), finances (e.g., budget, hosting agreement), and institutional coordination (e.g., between CSC-Federal and CSC-University, among other consortia members, and with other federal agencies; ACCCNRS 2015).

Overview of the NC CSC

The NC CSC is hosted by CSU in Fort Collins, Colorado. The host university is a land-grant institution with capacity for extensive climate change research and services. Eight additional universities are part of the North Central University Consortium (NCUC) covered under the NC CSC host agreement:

Colorado State University (CSU; host university)
University of Colorado (CU)
Colorado School of Mines (CMC)
University of Nebraska-Lincoln (UNL)
Iowa State University (ISU)
University of Wyoming (UW)
Montana State University (MSU)
University of Montana (UM)
Kansas State University (KSU)

The NC CSC is physically housed within the CSU Natural Resource Ecology Laboratory (NREL). The geographic area covered by the NC CSC spans seven states (Figure 1) encompassing a vast expanse of the interior continental United States from the northern border with Canada to the upper portion of the Southern Plains and from the heart of the northern Rocky Mountains in the United States to the eastern margin of the grasslands of the Great Plains.

Funding for the NC CSC consists of two sources: (1) an annual allocation from USGS to support strategically important scientific activities that address regional science priorities at CSU (and consortium partners) and USGS science centers, either through RFPs or directed research projects (this allocation also covers salaries of the NC CSC federal staff and a portion of the NC CSC federal director's salary); and (2) the cooperative agreement with the host university (hosting agreement), which is used for components of university support, including partial faculty salaries and associated expenses, overhead costs, stipends for students and postdoctoral researchers, and other aspects of university research administration and management. A portion of the hosting agreement funds may be applied to research funding for NCUC scientists.

Stakeholder Advisory Committee

From 2011 to 2012, the NC CSC had a SAC as all other CSCs did. In 2015, the Joint Stakeholder Advisory Committee (JSAC) was formed through collaboration between the NC CSC and the U.S. Department of Agriculture (USDA) USDA Northern Plains Climate Hub. The purpose of the JSAC is defined in the JSAC charter[3]:

> The purpose of the Joint USDA/DOI Stakeholder Committee (JSC) for Federal agencies in the North Central US pursuing climate science and service activities is to provide an effective and cost-efficient mechanism for robust climate science and services to the broad group of stakeholders in this part of the US.

This arrangement was initiated to maximize communication, awareness and coordination among regional federal agencies while eliminating redundancy and stakeholder fatigue. The guiding principles are to coordinate and realize efficiencies, develop trust relationships and seize opportunities to develop holistic understanding and solutions. In practice, this allows for shared personnel and expertise. They also hold biannual retreats to discuss details of the ongoing research and identify additional research needs.

The JSAC is made up of 24 individual representatives from federal and state agencies and tribal nations (and five ex officio members). Initial JSAC membership included the USGS, USFWS, National Park Service (NPS), U.S. Bureau of Land Management (BLM), National Oceanic and Atmospheric Administration (NOAA), U.S. Forest Service (USFS), USEPA, U.S. Bureau of Reclamation, USACE, DOE, the Flandreau Santee Sioux Tribe, the Northern Arapaho Tribe, and the following LCCs: Plains and Prairie Pothole, Great Northern, Great Plains, and the Southern Rockies. The five ex officio mem-

[3] The JSAC charter is found at http://nccsc.colostate.edu/joint-stakeholder-committee.

bers include liaisons from NCCWSC, the USDA Climate Hub, the Western Water Assessment (WWA) Regional Integrated Sciences and Assessment (RISA) program, National Center for Atmospheric Research, and the NCUC.

Membership on the JSAC is voluntary and is co-chaired by the USGS and USDA representatives. The NC CSC is committed to hosting at least one in-person meeting per year, with webinars and conference calls on an as-needed basis throughout the year. Among professional disciplines represented on the JSAC, a notable absence is that of a professional from a social science discipline. The other notable group not involved in the JSAC is the state fish and wildlife or natural resources agencies. The decision not to directly engage states was predicated upon their input being conveyed by the LCCs.

Biannual retreats of the JSAC to discuss details of the ongoing research and identify additional research needs helps to build a stronger research agenda.

The LCCs are an important component of the JSAC, helping to identify key research needs of the many other federal, state, NGO, and tribal entities. In 2017, the NC CSC began funding an individual designated liaison for each of the LCCs to facilitate three-way coordination: LCC needs, capacities at NC CSC, and capacities at USGS. This system is expected to improve identifying research needs as well as leveraging existing efforts and expertise of the USGS staff and the NC CSC university consortium partners to contribute climate science collaboration and support to priority LCC activities. These liaison are focusing on communication between leadership of the LCC and NC CSC to enhance the development of collaborative work and to integrate climate science with management needs for the coproduction of information. The liaisons will help to leverage existing efforts and expertise of the USGS, staff at the NC CSC, and the NCUC to contribute more directly to climate science collaboration and support priority LCC activities and topics. Although the liaison concept is still in the early stages, the feedback received by the SRT from the LCCs during the review process was very favorable.

There is a notable absence of social science professionals and state fish and wildlife agency representatives on the JSAC, although state issues may be partially addressed by LCC representatives.

Other Advisory Groups and Collaboration

Native Americans.—Native Americans (and other indigenous peoples) are members of the JSAC but also are engaged with the NC CSC in more extensive ways. Their interest and relationships to the environment are an important element of the NC CSC work. They have developed relationships with the Intertribal Council on Utility Policy, Inter-Tribal Buffalo Council, Wind River Reservation, Haskell Indian Nations University, Indigenous Peoples Climate Change Working Group, and Rising Voices: Collaborative Science with Indigenous Knowledge for Climate Solutions (https://risingvoices.ucar.edu), thereby facilitating cross-cultural approaches for adaptation solutions to extreme weather and climate events, climate variability, and climate change. These relationships have led to contributions to the Third National Climate Assessment's Indigenous Peoples' Chapter. Ongoing activities at the Wind River Reservation have enabled the tribe to improve their drought planning, engage youth, and enhance tribal capacity. It was clear during the on-site review that these partners placed a high value on the NC CSC relationship, tools, and research. The NC CSC has been a leader in supporting workshops that enhance the connection between research and Native American management needs.

NC CSC Operational and Strategic Planning

Planning process.—In its inaugural year, the NC CSC began the process of requesting input on science priorities from partners. The first priorities were developed under the direction of Dr. Jay

Hestbeck (USGS), who served as the interim director in 2011. This involved a smaller group of partners that could identify science needs in order to develop the first RFPs. Following the initial year, an effort was made to develop an NC CSC 5-year science agenda. The operational and strategic planning undertaken by the NC CSC resulted in a document titled "North Central Climate Science Center—science agenda 2012–2017." The development of this agenda involved the NC CSC SAC, USGS science centers, and the NC CSC university consortium. The science agenda was meant to be a high-level guide to the framework that the center would use to develop and apply the science to inform management decisions.

Plan implementation.—It is currently difficult to evaluate the level of success or impact of this science agenda. Many projects have been completed and several are ongoing, but no process for evaluating the use of the products has been developed. One key issue that the SRT noted is that many years may pass before the impact of key science or research is fully understood, and even longer before the impact on the system can be measured. These observations were echoed by respondents to the partners' survey and on-site panel interviews (discussed later). This deficiency is neither unique to the NC CSC (National Academies of Sciences, Engineering, and Medicine 2016) nor limited to formal, defined projects. Ad hoc activities, informal consulting, advising, and training efforts appear to consume NC CSC staff effort and may be quite valuable and considerable in volume, but their short-term or long-term impacts are very difficult to assess.

> *The NC CSC would benefit by developing a defined process and measures allowing evaluation on how products were used (e.g., altering how decisions were made, what decisions are made, etc.) and how the process impacted relationships with stakeholders.*

Process for annual plan updates.—While there is no specific process for annual review and update of the plan, there has been an annual science meeting with the JSAC members with the NCUC invited to participate. Each year this group has held discussions on progress made on specific science areas and plans for the next year's activities.

Recommendations for NC CSC Institutional Development

- The role of the JSAC should be specifically assessed to determine its value and effectiveness, particularly regarding the representation of state agency views.
- The NC CSC should regularly evaluate the new role being developed for the LCC liaisons to ensure that they are producing the expected level of engagement.
- State fish and wildlife or appropriate natural resources agencies should be contacted to evaluate their understanding of the work being done by the CSCs and LCCs and their comfort in being represented by the LCCs.
- The extensive nature of the NC CSC university consortium has led to uneven engagement by these partners, due in part to low levels of research funding available. Each partner involvement should be re-evaluated to verify their interest and level of engagement and affirmed through a memorandum of understanding or some other vehicle. This should include an explicit accounting of the past and current roles of each partner in NC CSC activities and plans for future involvement.

Institutional Coordination

Summary

The NC CSC institutional coordination includes coordination between USGS staff at the NC CSC and the host university (CSU), as well as coordination with other consortium institutions. The USGS and CSU CSC directors have a collaborative and collegial relationship, facilitating advancing the mission of the

NC CSC. This relationship is strengthened by constructive interactions with the many climate science and climate impact institutions in the region, including the USDA Climate Hub and the NOAA RISA. The NC CSC has done an excellent job of reaching out to stakeholders to identify their needs and provide climate science data and information to managers and users. Tribal engagement has been notable and commendable. A few negative issues related to space and responsibilities occurred early during NC CSC start-up and interaction with the host institution, but most issues have been resolved.

Coordination between USGS and CSU

Physical environment.—U.S. Geological Survey staff are physically located on the CSU campus near the CSU NC CSC staff. The CSU staff offices are part of the NREL and the Department of Ecosystem Science and Sustainability (DESS), the CSU institution housing the NC CSC. The SRT toured the CSC space, which was set up to facilitate communication among staff while providing quiet spaces. The USGS Fort Collins Science Center (FORT) is located very close and is used by the NC CSC staff for meetings and to house the Resource for Advanced Modeling (RAM) facility.

Academic environment.—The NREL has existed for 50 years and has been a successful and productive laboratory, primarily funded through external sources; DESS is much more recent. A large number of students (10 undergraduates, 27 graduates) and postdoctoral associates (21), as well as an early-career scientist, have received support from the NC CSC, due in part to the fact that the hosting agreement was only funded at half of the level of what was proposed. Two seminar series (2012, 2016) have been hosted by the NC CSC in conjunction with CSU and the NREL. The CSU director noted that the NC CSC mission regarding training academics and nonacademics has evolved over time; initially, trainings were not encouraged because the focus was on project-specific objectives, but in the past 3 years, the role of such trainings has become more apparent and useful to the CSCs. The CSU director noted that the NC CSC brings to the NREL/CSU broader connections to land management agencies. The NC CSC has a better understanding of management issues and needs, and exposes students and faculty across the university to these issues and needs.

> *The relationship between the USGS NC CSC director and host-university director is key to NC CSC success. Each brings their individual networks to the table, which has strengthened the CSC.*

Interactions between USGS and CSU staff and administration.—The USGS and CSU directors meet every other week (formally or informally) and clearly have a productive and constructive relationship. Colorado State University has engaged with the NC CSC in several other ways. First, the university agreed to a lower overhead rate on the host agreement. However, some concern was expressed that the host agreement is viewed by the NREL and CSU as "just another PI project" and that there is not as much visibility and support at CSU for the NC CSC (as is apparent at other CSCs' host institutions). Additionally, the commitment to additional full-time equivalents (FTEs) that was outlined in the host agreement (up to three additional FTEs) has been very minimally met. Raising awareness of the NC CSC to the CSU upper administration would be an initial step to rectifying some of these deficiencies and might result in additional leveraging and program expansion (this process began in late 2016 with meetings with university administration). The SRT noted several indications that perhaps the large number of universities in the consortium diluted the effect and impact at CSU in an effort to provide balance to the consortium members, which may be a negative aspect of the consortium model. Considering the apparent strength of CSU in climate-related topics across campus, the SRT did not observe many interactions to integrate the work of the NC CSC with these other compatible institutions/programs in either research or extension. Despite these deficiencies, the host university is doing great science despite the lack of full engagement of the university.

Interactions between the NC CSC and the university consortium.—Each member of the university consortium has a main liaison to the NC CSC, as well as two alternates. Members of the NCUC (the university consortium) are allowed to submit project proposals to an RFP announced by the NC CSC. To evaluate the capacity of proposals to fulfill manager needs, the NC CSC relies on support from the LCCs, as well as on letters of support submitted with the grant proposals. Past selections have included many members of the consortium. Although a breakdown by university was not provided, the distribution of funded university investigators included almost all states in the region (Kansas was the exception). The NC CSC and principal investigators (PIs) of awarded projects from this solicitation report their progress and identify needs via monthly phone calls. North Central University Consortium members can also engage with the NC CSC through the annual meetings of the NC CSC, monthly webinars, and inclusion on papers, projects, and proposals. The SRT heard little about the activities and projects of NCUC members other than those present during the on-site review (Montana State University, University of Colorado, University of Montana [via phone during the science producers' panel] and CSU).

The SRT feels that the host university is doing great science despite the university administration's lack of full engagement. Roles and responsibilities are not clearly defined in the host-university agreement and need to be more explicit.

Based on input during this review, the SRT is concerned that the large number of universities in the consortium leaves too little funding for each to have full impact and engagement. Additionally, there is a lack of clarity on the explicit role of each member within the consortium. However, the large number of consortium members allows a wide pool for project opportunities in response to RFPs, providing diversity in discipline, expertise, focus, and other attributes that may not be available under a single university structure. A survey or substantial discussion with the university partners would be needed to better understand their involvement and desire for involvement with the NC CSC.

Interactions with other institutions.—The NC CSC has worked to improve interactions with two other important science providers in the region: the USDA Climate Hub and the WWA-RISA funded by NOAA. There is a fairly clear distinction in responsibilities and mission among the three institutions, with the NC CSC covering climate change effects in natural resources, the USDA Climate Hub covering effects on USDA-managed working lands, and WWA covering effects on water resources. There was evidence of overlap, such as the implications of climate change effects on private agricultural lands studies by NC CSC-related projects, which was viewed positively by the SRT. The three groups share personnel, engage via retreats, and have produced a table describing differences among the organizations (Table 1).

The large number of consortium members allows a wide pool of project opportunities in response to RFPs but may leave too little funding for each to have full impact and engagement.

Interactions between the NC CSC and LCCs have been positive. Landscape Conservation Cooperative representatives commended the NC CSC during the SRT visit for reaching out and involving the LCCs. As described previously, the NC CSC has invested in improving communication with the LCCs through the addition of liaisons to further strengthen the productivity of this relationship.

Recommendations for Institutional Coordination

- Additional focus by CSU in the form of financial support, visibility of the NC CSC program across campus, and meaningful interactions with institutions beyond the NREL would strengthen the NC CSC.
- The explicit role of each member of the university consortium should be clearly defined in the upcoming recompetition process.

Table 1. Characteristics of the National Oceanic and Atmospheric Administration (NOAA)-sponsored Western Water Assessment (WWA), North Central Climate Science Center (NC CSC), and U.S. Department of Agriculture (USDA) Northern Plains Regional Climate Hub (NPRCH; NC CSC 2016).

	WWA	NC CSC	NPRCH
Primary users, stakeholders, constituents	Mixed federal, city, regional, residential water users, and water resource managers	U.S. Department of Interior (DOI) and state land managers and tribal environmental professionals	Agricultural and natural resource managers (ranchers, farmers, and forest landowners)
Sectoral focus	Water resources, urban, hazards, and science policy	Land, water, fish, and wildlife, and cultural heritage resources	Agriculture and forestry
Direct agency support	US$730,000	$2.0 million	Reallocation
Budget line	NOAA Climate Program Office, Office of Oceans and Atmospheric Research	U.S. Geological Survey's (USGS) National Climate Change Wildlife Science Center (NCCWSC)	USDA department level across six agencies
Start year	1999	2011	2013
Mission	Making climate science more usable in decision making, more research-oriented	To provide the best possible climate science to DOI land managers and to provide university and USGS researchers with an opportunity to work with an engaged and proactive applied management community	To develop and deliver science-based, region-specific information and technologies to agricultural and natural resource managers, and communities, that enable climate-smart decision making
Research to operations continuum	Research	Research and applied	More applied; transfer information and knowledge to end users for reducing risk and increasing resilience
Operations and staff	Director, program manager, and two regional engagement experts	USGS director, university director, and USGS staff	Agricultural Research Service director, with support of U.S. Forest Service and national Resources Conservation Service staff
Federal–university partnership	Single university with NOAA Earth System Research Laboratory	North Central University Consortium (nine universities) with USGS's NCCWSC	USDA collaborations with Agricultural Experiment Stations and Cooperative Extension
Funding model	Through NOAA Oceanic and Atmospheric Research	Through USGS's NCCWSC	Across six USDA agencies

Table 1. Continued.

	WWA	NC CSC	NPRCH
Stakeholder Advisory Committee	Eight members from academia, federal agencies, and nonprofit sectors drawn from outside of our direct stakeholder pool, for the most part	Federal employees and tribal representative, run jointly with the NPRCH	Federal employees and tribal representatives, run jointly with the the NCCSC

Science Strategy and Actionability Pathway

Summary

The NC CSC's science strategy seeks to provide integrative science services that help their stakeholders develop "climate responsive management and adaptation strategies" (Morisette 2012; NC CSC 2016), a broadly recognized regional need of their stakeholders (Morisette 2012). The NC CSC achieves this through a thoughtfully developed and well-aimed merging of (1) key recommendations for "informing decisions in a changing climate" (NRC 2009; Table 1), (2) more focused guidance for conducting climate change vulnerability assessments (Glick et al. 2011), and (3) a strong vision for an integrative, multidisciplinary team approach targeting whole socioecological systems à la Chapin et al. (2009) (Morisette 2012; NC CSC 2016). The NC CSC refers to their collective strategy as Resource for Vulnerability Assessment, Adaptation and Mitigation Projects or ReVAMP (nccsc.colostate.edu/revamp; Morisette 2012).

ReVAMP

ReVAMP focuses on stakeholder desire for a resource to help interpret and untangle the increasing array and complexity of climate information to focus on management relevance of research and products. Broadly, ReVAMP provides a means of producing translational climate science to better link climate drivers to ecological impacts in order to develop and implement adaptation strategies (NC CSC 2016). The ReVAMP strategy defines a foundational process for adaptation planning and actions, providing a strong potential for an underlying integration to activities. It is structured to address information needs arising anywhere along the sequence leading to adaptation strategy planning and actions.

ReVAMP provides a means of producing translational climate science to better link climate drivers to ecological impacts in order to develop and implement adaptation strategies.

Foundational science areas.—Early on, the NC CSC defined three foundational science areas (FSAs) upon which to focus: climate drivers, ecological impacts, and adaptation. These form the focus of standing teams of researchers and technicians (FSA teams) composed of NC CSC staff, students, and researchers from NCUC institutions. These standing teams provide consultation to the NC CSC on management-focused projects and science delivery and conduct research in response to stakeholder needs. The teams also provide a forum for coordination with other national and regional initiatives, such as NOAA's WWA, the LCCs, NOAA's National Climate Projection and Prediction program, the Greater Yellowstone Coordinating Committee, and the USDA Climate Hub (Ojima et al. 2012). The NC CSC

The NC CSC has done a good job justifying core foundational science areas.

supports these activities through consistent and ongoing directed investment, with the level of investment reflecting the needs and demands arising from NC CSC-solicited projects (Ojima et al. 2012). The teams determine the best expenditures of the funds. A key objective of the teams is to support sustained, iterative engagement with stakeholders for necessary processes to ensure coproduction of usable science products, as well as further steps in operationalizing productions of some of the resulting products. For FY2013 through FY2015, the topical focus of the teams narrowed to a centralizing theme of drought—drivers, impacts, and adaptation, ensuring better integration of science activities (Ojima et al. 2013).

Solicited projects.—The NC CSC conducted RFPs in FY2012, FY2013, and FY2015. The FY2012 RFP identified pilot projects that leveraged the information available from the National Climate Projections and Prediction Platform to "prototype...deliver[y] of needed climate information products" crafted to meet the needs of stakeholder decision makers (Varela-Acevedo and O'Malley 2013). A key objective in selecting these short-term translational science efforts was the provision of foundational guidance for later, more intensive NC CSC efforts.

The FY2013 and FY2015 RFPs focused on projects with a clear "articulation of [a] decision that is being considered and how it addresses important DOI land, water, fish and wildlife, or cultural heritage resources in the region," with the requirement that the targeted end users (resource management decision makers) be actively integrated as project collaborators and/or investigators (Varela-Acevedo 2014). Projects were chosen that "apply the foundational building blocks of ReVAMP...to real world issues in the north central domain" and "strengthen...regional partner-ships by utilizing tools developed at the NC CSC to strengthen resource management" (NC CSC Network News Spring 2015). Three case study projects were selected in FY2013 and five in FY2015.

Other science delivery services.—Complementary to the planned strategic activities of the FSA teams and the solicited projects are additional translational and science support services provided by NC CSC, NCUC, and researchers to NC CSC stakeholders and the larger climate change adaptation science community. These include capacity-building efforts such as collaborations with the National Conservation Training Center (NCTC), workflow development and trainings employing the RAM Center, the development of tools for communicating climate change (including visualization tools), and other outreach efforts and ad hoc support (NC CSC 2016).

> *The SRT applauds the application of the ReVAMP concept to integrate information into actionable tools to achieve adaptation strategies.*

SRT Observations on Science Strategy

The NC CSC's ReVAMP strategy is a coherent and well-aimed approach to leveraging the region's research capability to advance climate change adaptation planning and implementation. Adoption of the integrative socioecological systems perspective provides an essential grounding and strong linkage to natural and cultural resource management decision makers in the region. Additional comments that follow are structured around each element required for effective decision support for informing responses to a changing climate (Table 2). Observations are based on the NC CSC-provided review materials and on-site presentations, focus group discussions, and interviews.

Table 2. Necessary elements of effective decision support for informing responses to a changing climate (NRC 2009).

1. Begin with users' needs	4. Build connections across disciplines and organizations
2. Give priority to process over products	5. Seek institutional stability
3. Link information producers and users	6. Design processes for learning

Begin with Users' Needs

The NC CSC's science strategy is highly responsive to stakeholder/end user needs for a resource that provides both targeted products and assistance in employing them (Morisette 2012; NC CSC 2016). The incorporation of a socioecological focus ensures that activities are cross-sector and appropriately scaled, further ensuring that activities and products strongly align with user's needs (NC CSC 2016). A clear example of the priority given to addressing end user needs is the NC CSC's decision to hire technicians and service providers, not just researchers, to help with vulnerability assessments, adaptation, and mitigation by providing stakeholders with science translation and assistance with refining products to meet their needs (NC CSC 2016). In addition, the NC CSC has been very proactive in engaging with stakeholders to identify their needs; this outreach was noted by stakeholders during the SRT visit and is a strength of the CSC.

Hiring technicians and service providers, not just researchers, to help with vulnerability assessments, adaptation, and mitigation provides stakeholders with science translation and assistance refining products to meet their needs.

The topics of the initial (FY2012) project solicitation and priority activities of the foundational science area teams were developed through discussions with "consortium members, LCC staff, and other federal and Tribal partners associated with the Stakeholder Advisory Committee" (Ojima et al. 2012), with a strong consideration given to leveraging existing efforts associated with NOAA's National Climate Projection and Prediction program project. The topics of the FY2013 and FY2015 solicitations and priority activities were identified through similar discussions and further refinement at regional research planning workshops involving the consortium institutions (Ojima et al. 2012, 2013; Varela-Acevedo 2014; NC CSC Network News Spring 2015). Of note was the strategic decision to focus on drought as a centralizing topic common across key stakeholders and end users.

Give Priority to Process over Products

The funded projects reviewed on site demonstrated a strong focus on engaging in the full adaptation planning and implementation process and thus actively modeling and promoting these processes regionwide. The NC CSC is actively using the lessons learned from their efforts in formulating a more detailed process for integrating the modeling tools available in each component of the ReVAMP process (Miller and Morisette 2014). The NC CSC's attention to this perspective is further illustrated by their efforts at operationalizing production of some of the most useful research products to serve the broadening stakeholder community beyond just those targeted by the initial case studies (e.g., development of climate primers for the Forest Service Rocky Mountain and Intermountain Regions and similar efforts to meet the needs of the NPS). The NC CSC is focusing not just on products, but also on technology transfer.

The initial FY2012 project solicitation emphasized leveraging existing efforts, thereby reducing redundancies and duplication of effort, creating synergies with ongoing programs.

Link Information Producers and Users

At the strategic planning phase, both the JSAC, which provides input and feedback on RFP topics and questions/priority needs, and the newly instituted LCC liaisons are useful mechanisms for ensuring these linkages.

At the operational phase, the ReVAMP strategy explicitly acknowledges the iterative, multidisciplinary interactions required for effective adaptation planning and actions. The strong socioecological focus fa-

cilitates active coproduction, and colearning, from the beginning of problem framing, through supporting the iterative engagement required to align final products and tools with information needs of decision makers (NC CSC 2016; focus group interviews, on-site presentations). Multiple focus group participants commented on the invaluable role the NC CSC has played in convening and coordinating partners and stakeholders; the responsiveness of the Foundational Science teams to understanding and meeting stakeholder needs, providing interpretation and refinement of products, clarifying uncertainties, and helping to refine policy maker expectations as to strengths, weaknesses, and robustness of results; and, on the climate science side, helping to clarify how stakeholders were using (or misusing) existing products and identifying their unmet needs, and so forth. A key example is "Lessons Learned" from the FY2012 pilot project, better linking National Climate Predictions and Projections Platform (NCPP) products with end user information needs (on-site presentation by Andrea Ray, NOAA), which have informed subsequent foundational science area investments and improved applicability and framing of stakeholder requests. The case studies (solicited projects) illustrate a strong emphasis on collaborative and collegial modes of science coproduction (Biggs 1989, summarized in Meadow et al. 2015).

Build Connections across Disciplines and Organizations

> Agencies don't collaborate, people do. [John Gross, NPS Climate Change Response Program and CSC collaborator, on-site review panel discussions.]

> [We] had no contacts in that realm [social science], let alone [knew] how to incorporate [it]. Now [we are] developing meaningful adaptation strategies on the ground to ensure ecosystems and livelihoods that rely on those ecosystems. [Bruce Ritenhouse, BLM, on-site review panel discussions.]

End users and stakeholders.—The NC CSC stakeholders and end users clearly applaud the NC CSC's efforts in building connections and a *community of practice* in adaptation (discussed later under Partnerships). The socioecological systems perspective adopted by ReVAMP ensures that multi- and transdisciplinary collaborative science is implemented in an integrated planning framework. The NC CSC-funded studies have brought together diverse stakeholders, science providers, and social science specialists in developing *practical* adaptation strategies. The studies and other projects provide a platform for engaging the foundational science teams in iterative coproduction processes. The monthly project calls, biannual JSAC meetings, NC CSC-supported workshops promoting regional collaboration (indirectly if not directly, e.g., the 2015 Open Science Conference), and other NC CSC/NCUC outreach efforts are clearly helping build a community with shared understanding and common foundational understanding of potential future climate pathways and impacts. During the review, multiple discussants commented on the networking benefits of the NC CSC's decision to force the integration of multiple competing but somewhat overlapping proposals into a more unified and synergistic project.

> *Multiple focus group participants commented on the invaluable role that the NC CSC has played in convening and coordinating partners and stakeholders.*

NCUC.—The PIs engaged in specific funded projects recognize the networking benefits that they are receiving from engagement with the NC CSC via the monthly webinars, communications with members of the foundational science areas teams, annual meetings, and conferences. Currently, it is unclear how broadly these benefits are recognized or accruing to members of the NCUC that are not currently PIs of NC CSC-funded projects or actively engaged in crafting collaborative proposals. A recognized barrier to engagement is the imbalance between the size of the NCUC and the funding available for projects that advance the NC CSC's goals, as described earlier, raising the question

> *The NC CSC-funded case studies have brought together diverse stakeholders, science providers, and social science specialists in developing practical adaptation strategies.*

of the appropriate level of resources allocated to promote long-term engagement and growth of the organization versus meeting near-term needs. This is one concern that may best be addressed through capacity building and extending activities such as workshops or student exchanges, rather than direct research funding.

The NC CSC stakeholders and end users clearly laud the CSC's efforts in building connections and a community of practice in adaptation and are very appreciative of the resources that the CSC provides, including the strategic hiring of technical people not just researchers, providing visualization tools, end users being integrated from the outset, and colearning (e.g., ecologists learning from climate scientists and vis versa.). Users appreciated that the CSC came to them and met them on their turf rather than having to go to the CSC.

RISA, Climate Science Hub, and other regional partners.—Members of both the RISA and Northern Plains Climate Hub acknowledged the efforts of the NC CSC in linking and greatly expanding the networks and stakeholders of each of these boundary organizations. A key area of success has been the integration across organizations in strategic coproduction efforts stemming from the case studies and directed projects by the FSA teams. The biannual meetings are a key mechanism for identifying synergistic collaboration opportunities and avoiding duplication of effort.

Intra-CSU and with NCUC.—While strategic engagement by the NC CSC with other CSU entities remains in early stages of development, the NC CSC's adoption of a focus on the organizing theme of drought and associated critical management issues provides a clearer nexus for identifying leveraging opportunities and linkages within the NC CSC, as well as across the NCUC. The focus on drought should engender stronger strategic engagement across the NC CSC and NCUC. This will help further the NC CSC's efforts to develop critical mass and momentum in having a recognizable impact on the region's stakeholders, thus promoting long-term engagement and development of NC CSC champions.

Given the outsized demand and sheer size of the NCUC, clarifying the considerations and organizational priorities would help the NC CSC ensure stability across change in leadership and also help to advance consideration of how best to assess performance and ensure greatest return on investment.

The strategic considerations and priorities used in determining the resource allocations across foundational science areas versus solicited projects and other efforts are unclear (although it is clear that the final allocation to FSA teams is determined by needs of projects selected from the solicitations). While the decisions are clearly challenging, given the outsized demand and sheer size of the NCUC, clarifying the considerations and organizational priorities would help the NC CSC ensure stability across (eventual) change in leadership and also help to advance consideration of how best to assess performance and ensure greatest return on investment over the long term (e.g., current stakeholder needs versus capacity growth, etc.).

Design processes for learning.—The NC CSC's ReVAMP strategy and activities provide a unique opportunity for explicitly speeding learning regarding adaptation planning and implementation, and thus for iteratively improving the NC CSC's whole strategy (as well as that of the rest of the CSC network, the LCC network, and other similarly focused entities). Such explicit learning is not currently an objective of the strategy, a situation shared by the LCCs (NRC 2016). North Central Climate Science Center participants and stakeholders commented on this lack of a specific objective, recognizing the need to develop performance metrics to assess outcomes and impacts of the NC CSC's efforts at promoting on the ground adaptation strategies in order to "really learn if you are really making a difference in reducing impacts/building resilience" (anonymous focus group discussant).

Reporting on lessons learned and impacts on outcomes is a challenging task faced by many groups. This activity is therefore a prime candidate for seeking additional or outside resources (perhaps from NCCWSC) to fund the costs associated with developing appropriate and feasible metrics. The task includes clarifying the priorities and strategic considerations underlying allocation of NC CSC resources across the activity areas (mentioned above) and across the added activity area of performance assessment. It also includes developing, piloting, and identifying feasible metrics to capture the diverse outputs, outcomes, and impacts of the NC CSC's activities and end user leveraging of those activities so as to better inform future NC CSC planning and decision making. Metrics should capture the extensive ad hoc or informal engagement activities. Clearly, the feasible aspect is crucial given the limited operational resources of the NC CSC.

Regional research and resource management assets.—Although the NC CSC has engaged some regional entities, additional opportunities exist that will advance adaptation strategy development and actions. This will require greater clarity in specifying measures of success, including a focus on processes (planning and peer review), inputs, and extending outputs, outcomes, and long-term impacts (NRC 2005). Stakeholder and end user discussions during the review raised the need to operationalize some of the products and processes provided by the NC CSC, acknowledging the progress in streamlining specific workflows to allow more directly usable products (e.g., graphics productions of climate projections). Metrics that promote strategic analysis without incurring diminishing returns and escalating costs of assessment will need to be developed. A broad suite of potentially applicable metrics includes

- A strategy for setting priorities and allocating resources among different elements of the program.
- Procedures that enable or facilitate the use or understanding of the results by others, thereby promoting partnerships.
- Transition to operational activities where warranted.
- Monitoring the outcomes from the various outreach and capacity building activities to learn what worked and what did not. Specifically, a follow-up survey might identify specific and concrete actions taken as a result of NC CSC involvement, as identified by the users.
- Indicators and metrics for
    - Evaluating coproduction of usable climate science (Wall et al. 2017). Provides list of 45 indicators focused on components of context (inputs and external factors), process, outputs, outcomes, and impacts.
    - Looking for unexpected outcomes—such as impact on climate science participants; nascent development of networks through connections established via the case study or through ad hoc and informal activities.

The development and implementation of performance metrics targeting the intended outputs, outcomes and impacts of the NC CSC activities should help in securing future funding.

Next Generation of Scientists and Managers

The NC CSC demonstrated success in training the next generation of climate scientists and climate science users. One major contribution of the NC CSC is exposing the next generation to research questions that have been generated by on-the-ground management concerns. The NC CSC provides a stronger connection between young researchers and land managers than they had prior to the existence of the NC CSC (as noted by the CSU director). This can change the career-long trajectory of research that young scientists pursue towards more actionable, ground-relevant work. The NC CSC has fully or partially funded a sizable cohort of students and early-career scientists considering the funding and the limited support for staff from CSU.

The NC CSC has leveraged connections to reach a larger number of students, working with students in the NASA DEVELOP program. This program funds 5–10 students per year. Through work with the

NC CSC, students take state-of-the-art climate science skills and connections to land managers with them as they enter the professional workforce.

The NC CSC has also hosted and organized training sessions for students and early-career researchers on key climate-science application skills. These were initially not the focus of the NC CSC; rather, the focus was on research projects. However, demand for these training opportunities has been high and they have provided valuable networking time for participants. The NC CSC plans to continue this training in the future.

The NC CSC has done an excellent job of engaging students, postdoctoral associates, and other early-career scientists and managers at the host institution. It has capitalized on existing departmental structure and graduate student networks to expand its reach outside of the USGS and NC CSC proper at CSU.

Work with partners to engage future generations.—The SRT noted the partner enthusiasm for work that the NC CSC has done to engage the next generation outside of the university setting. The NC CSC has been working with school students in various settings and has partnered with the USFWS as well as the tribal agencies on education programs. In partner descriptions of the Rising Voices program, a priority was conveyed for working with the next generation of leaders to integrate traditional ecological knowledge with western science.

The NC CSC does work directly with many management agencies, but there does not seem to be an emphasis on developing early-career managers. The NC CSC director discussed the possibility of formalizing an internship program with agencies and perhaps following an IGERT (National Science Foundation's Integrative Graduate Education and Research Traineeship program)-like model (graduate student training) with this approach. The idea was floated for a series of short trainings for managers that could help the next generation to be better adapted to applying climate science information. One suggestion for this would be to make sure such a program has high-level agency support so that young professionals feel empowered to use this information.

In addition to broadening the career horizons of students and postdoctoral associates, one of the benefits provided by the NC CSC to students (of all stages) is explicit recognition of the interdisciplinary needs of climate adaptation work and the value of meaningful integration of physical, biological, and social sciences in the production of actionable knowledge. Several observations and recommendations may strengthen this even more:

- The consortium network is underused. There is an opportunity to capitalize on the university members to engage a greater number of early-career scientists and managers outside of the host institution.
- The SRT commends the workshops and training sessions on climate science for early-career scientists supported by the NC CSC. Although this is a recent addition, it seems important to continue.
- Opportunities exist for greater work with partners to develop climate-smart management skills in early-career managers in addition to the work being done to develop the next generation of climate scientists. The directors mentioned the idea of formalizing agreements with management agencies for an internship program; the SRT believes that this would be a good idea.
- The SRT commends efforts to reach outside of academia to the next generation, such as the engagement with the Rising Voices program. Additional efforts like this would help the NC CSC be more successful in its mission.
- Opportunities are evident to use early-career scientists and managers to strengthen and build networks around existing relationships. Much of the success of the NC CSC work is based on the relationships of a few people. Building redundancy into these partnerships is important so that this work continues when important players retire or move on.

Recommendations for Science Strategy and Actionability Pathway

Based on the observations and the input received during the review process, the SRT feels that several actions can be taken to improve and strengthen the science strategy of the NC CSC.

A. Document and clarify processes and criteria for
   i. Establishing priority topics or activities for solicitations and directed funding (current selections seem well chosen, but *explicit guidance* will aid successional planning for NC CSC leadership transitions). The rationale for selected topics and activities should be documented.
   ii. Guiding the selection of other science delivery services, including ad hoc translation and product refinement (e.g., attempt to define categories of these activities, develop broad resource demands/allocation to such activities to improve future staffing decisions and work planning, and identify key product and process objectives to guide prioritization of activities, especially ad hoc requests).
   iii. Allocating resources (funding, staff time, etc.) across the three main implementation activity areas (directed foundational teams, solicited projects, and other science delivery services) in a way that both documents recent learning and aids successional planning for transitions in CSC leadership;
   iv. Addressing the implicit process objective of improving engagement and collaboration across the NCUC.

B. Extend the ReVAMP strategy to incorporate explicit learning processes for long-term improvement of effectiveness of science strategy and selection of NC CSC activities. An initial step may be to consider approaching NCCWSC or some other entity for additional funds to explicitly design the necessary performance metrics that could also provide a basis for use by other CSCs, the LCCs, and similar boundary organizations engaged in these sorts of activities. At minimum, the NC CSC should incorporate an explicit assessment of stakeholders involved in the case-study projects, once projects have evolved to an adequate state, to determine how the NC CSC-funded activities have impacted their
   i. Professional networks and relationships across entities,
   ii. Application of information and products associated with the NC CSC in decision making,
   iii. Framing of management decisions to account for potential climate impacts,
   iv. Incorporation of adaptive management processes into their management activities, and/or
   v. Other metrics capturing broader impacts of the NC CSC's activities in promoting regional collaboration networks, improved understanding of and reaction to expected climate impacts, improved efficiencies in decision-making processes, and so forth.

C. Continue current processes for seeking input from the JSAC, LCCs, and other regional collaborators in formulating priority information needs and science activities.

D. Define explicit objectives regarding the focus on drought to provide a target for knowing when to consider other potential central organizing topics.

E. Consider when to reconvene regional research planning workshops to assess and revise planning processes.

Implementation of Science Activities

The SRT felt that the projects selected by the NC CSC in the initial years and the subsequent FSA approach and framework were very appropriate. The projects were impactful and addressed important issues. Projects directed by the NC CSC (i.e., not announced for competition through an RFP process) occurred in two phases. During the initial years of the NC CSC, 1-year projects were funded; an example was support of the NOAA-based project called the NCPP. The NCPP provided climate information to several efforts such as studies of riparian corridors and sage-grouse.

In a second phase starting in FY2014, 3-year projects were funded within three FSAs. The "Climate Science" FSA produced climate information for subsequent use by impacts studies. The initial series of funded projects ranged from evaluation of methods to incorporate climate information into decision making (Post van der Burg et al. 2016) to modeling climate impacts on ecological systems (vegetation, sage-grouse habitat) with all PIs affiliated with USGS science centers. In the second round of funding, the NC CSC continued its focus on climate-impacts research through support of more intensive investigations of two systems: whitebark pine ecosystem in the Greater Yellowstone Ecosystem and wetland birds in a portion of the Prairie Pothole region. Principal investigators were affiliated with USGS science centers, CSU, and Montana State University. The third project was a more expansive effort spanning federal lands in the southwestern portion of the domain, again with a lead PI housed at a USGS science center. The latter project focused on vulnerability assessment and adaptation strategies to aid communities and stakeholders in planning for future climate scenarios. The final round of funding expanded research on climate impacts on specific ecosystems (sagebrush and Northern Rockies), and most notably on adaptation to drought on federal lands (BLM) and the Wind River Reservation, adding a significant sociological dimension to the CSC's scope or work. These areas were described in the NC CSC's 5-year plan, and projects were selected to address these areas.

The strategic plan goals outlined in the original science agenda (Morisette 2012) included compilation and improvement of climate information, understanding climate impacts, vulnerability assessment, and development of decision support tools. The essential theme of these components was to provide useful and comprehensive guidance to managers, decision makers, and the public about the nature of the problem (climate change) and potential strategies for adaptation. This work would necessarily be multidisciplinary, building on prior and existing efforts, coordinated among ongoing initiatives, and pragmatic, in the sense of producing usable products for stakeholders. Due to the geographic extent and heterogeneity of the domain, the NC CSC chose to identify and focus on key climate drivers and impacts, most notably drought. These projects have produced an impressive list of publications, presentations, workshops, and other deliverables (NC CSC 2016, appendices).

The most conspicuous themes shared among the funded projects are the focus on altered precipitation patterns (drought) and a bias towards federal lands, especially those managed by the NPS, but neither of these is bad. As noted repeatedly in documentation and during the on-site visit, drought is certainly a critically important regional concern, and a large proportion of the region is under federal jurisdiction. Moreover, the NC CSC has only been operating for a short time period with a limited amount of funds, and prioritization is essential to getting any work underway. For a few of the projects (e.g., the Greater Yellowstone Ecosystem), research has been very productive, yielding a strong list of publications, an edited volume, and many presentations. The work with the tribal nations is also impressive, providing a model for identification of socially important climate vulnerabilities and adaptation strategies. All of these funded projects are visible and easily documented products of the NC CSC and clearly what the NC CSC chose to highlight in their report and during the site visit. The appendix to the 5-year report (NC CSC 2016) also illuminates the considerable investment the NC CSC has made in developing the process of achieving their mission. This entailed numerous workshops, consultations, and formal and informal training activities. The net benefit of all of these likely exceeds that of site-specific and narrowly focused research activities. Such efforts are also likely to be the activities most readily expanded to additional communities, stakeholders, and research teams. Consequently, the funded research projects may be viewed as valuable contributions to understanding climate impacts and adaptation within a fairly narrow scope, but more broadly as models or case

The funded research projects may be viewed as valuable contributions to understanding climate impacts and adaptation within a fairly narrow scope, but more broadly as models or case studies that create a template that can be translated to other systems and specific concerns.

studies that create a template that can be translated to other systems and specific concerns. The potential impact of this benefit will be lost if it is not explicitly recognized and highlighted.

Stakeholder Community and Coproduction of Actionable Science

By definition, the term "coproduction" implies that the stakeholders are providing advice to the research team about their needs and how they would like to use the research output. The NC CSC has developed an ecological-climate-social system perspective to integrate climate science into decision making. This was done by engaging multidisciplinary groups of researchers (importantly engaging social scientists from the beginning of the projects) by

- Building knowledge of social-ecological climate vulnerabilities to inform planning.
- Creating scenarios and ecological models to facilitate decision making under uncertainty.
- Developing and prioritizing adaptive capacities and institutional arrangements.
- Documenting best practices for bringing climate science into decision making.

Some lessons that have been learned from this process include the following:

- Building a team takes time, especially when disciplines are varied and distances are great.
- It is quite helpful to have some investigators who bridge both studies areas, leading to increased continuity and cohesion.
- Bioclimatic models help managers and other stakeholders to visualize change.
- Uncertainty is really challenging for managers and leads to risk-averse, conservative decisions.
- There is a disconnect between the adaptation literature (focus on ecological targets—ecosystems, species) and the way agencies actually manage public lands (focus on specific activities—grazing, recreation, forestry, fire management, etc.).

The NC CSC should be cognizant of and address the frequent disconnect between the adaptation literature (focus on ecological targets) and the way that agencies actually manage public lands (focus on specific activities—grazing, recreation, forestry, fire management, etc.).

The NC CSC has done an excellent job of engaging students, postdocs, and other early-career scientists and managers at the host institution. It has capitalized on existing departmental structure and graduate student networks to expand its reach outside of the USGS and NC CSC proper at CSU.

Stakeholder Views on NC CSC Actionable Science

Across the NC CSC projects, there is a broad spectrum of success on actionable (and coproduction) of science. Some projects fully looped partners into whole process, but others have not. In the HDRU survey of NC CSC partners, respondents shared their perceptions both of climate adaptation science, *in general*, and of the climate adaptation science produced by the NC CSC. Table 3 provides a breakdown of the geographic distribution of respondents to this survey within the NC CSC region.[4]

With regard to climate adaptation science in general, nearly three-quarters of respondents (73%; n = 127) agreed or strongly agreed that climate adaptation science in the North Central region is available to decision makers (Figure 3), and nearly as many (71%; n = 112) thought that water managers used this science to inform management. Only about half, however, thought that fish and wildlife managers (55%;

[4] Refer to the full survey report in the Appendix D for a complete breakdown of respondents.

Table 3. States in which respondents work.

State	Percentage of respondents	*n*
Colorado	45%	93
Montana	32%	66
Wyoming	31%	63
South Dakota	23%	48
North Dakota	21%	42
Nebraska	19%	38
Kansas	14%	29

n = 88) and land managers (49%; *n* = 84) used climate adaptation science to inform management. Only about one-third (36%; *n* = 59) believed that policymakers used this science to inform policies. More than two-thirds (68%; *n* = 112) maintained that what is known about climate adaptation does not necessarily influence actions taken by decision makers in the region. Nearly as many (66%; *n* = 95), however, agreed that the CSC has helped to reduce the disconnect between what is known about climate adaptation and the actions taken by decision makers in the region.

In terms of the NC CSC science specifically, HDRU survey respondents (91%; *n* = 154) strongly or somewhat agreed that the NC CSC science can contribute to policy or management (Figure 4). Respondents were also positive about other characteristics of the NC CSC science, finding it high quality (85%;

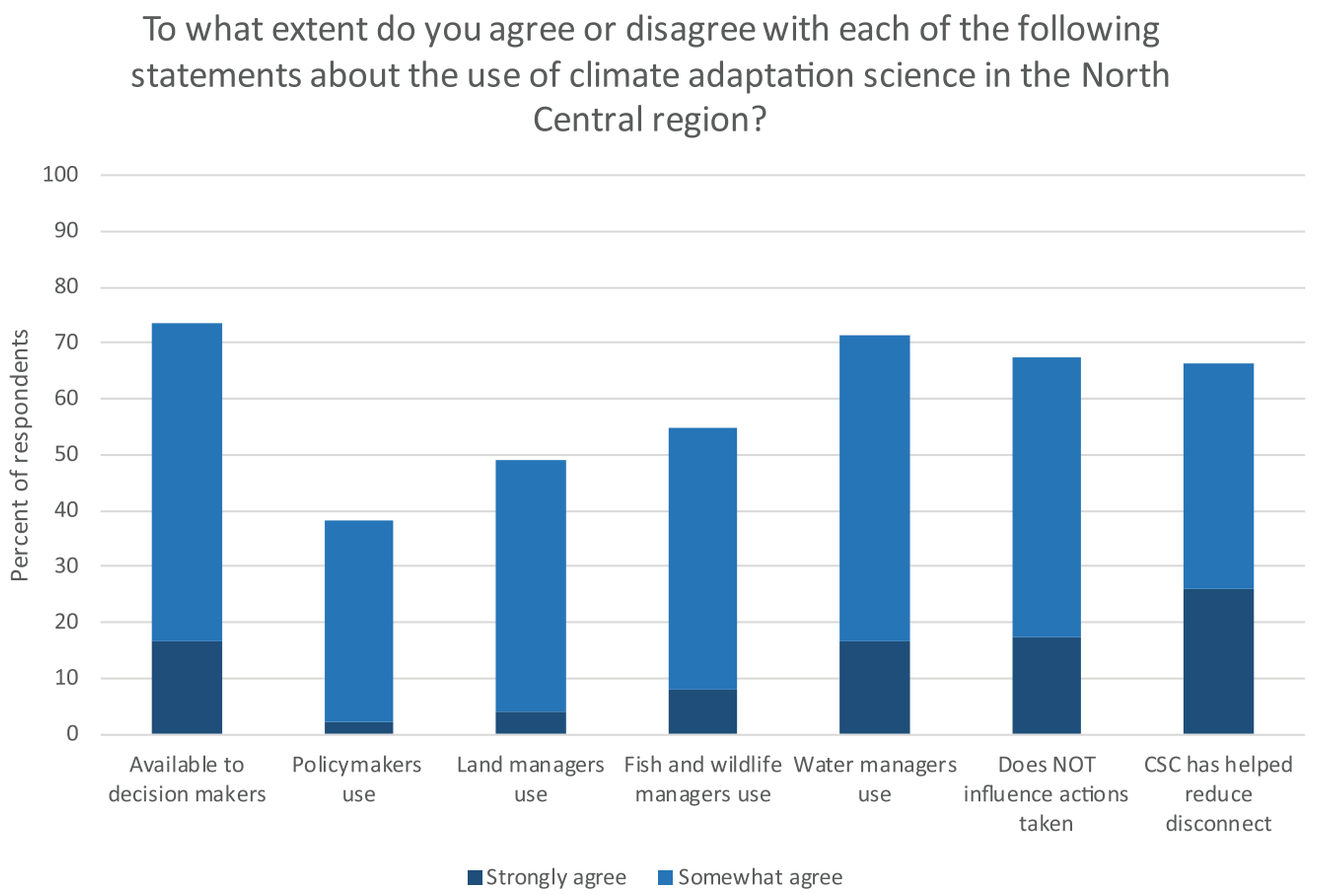

Figure 3. Perceptions on the use of climate adaptation science in general. Note: text in items shortened for presentation in graph.

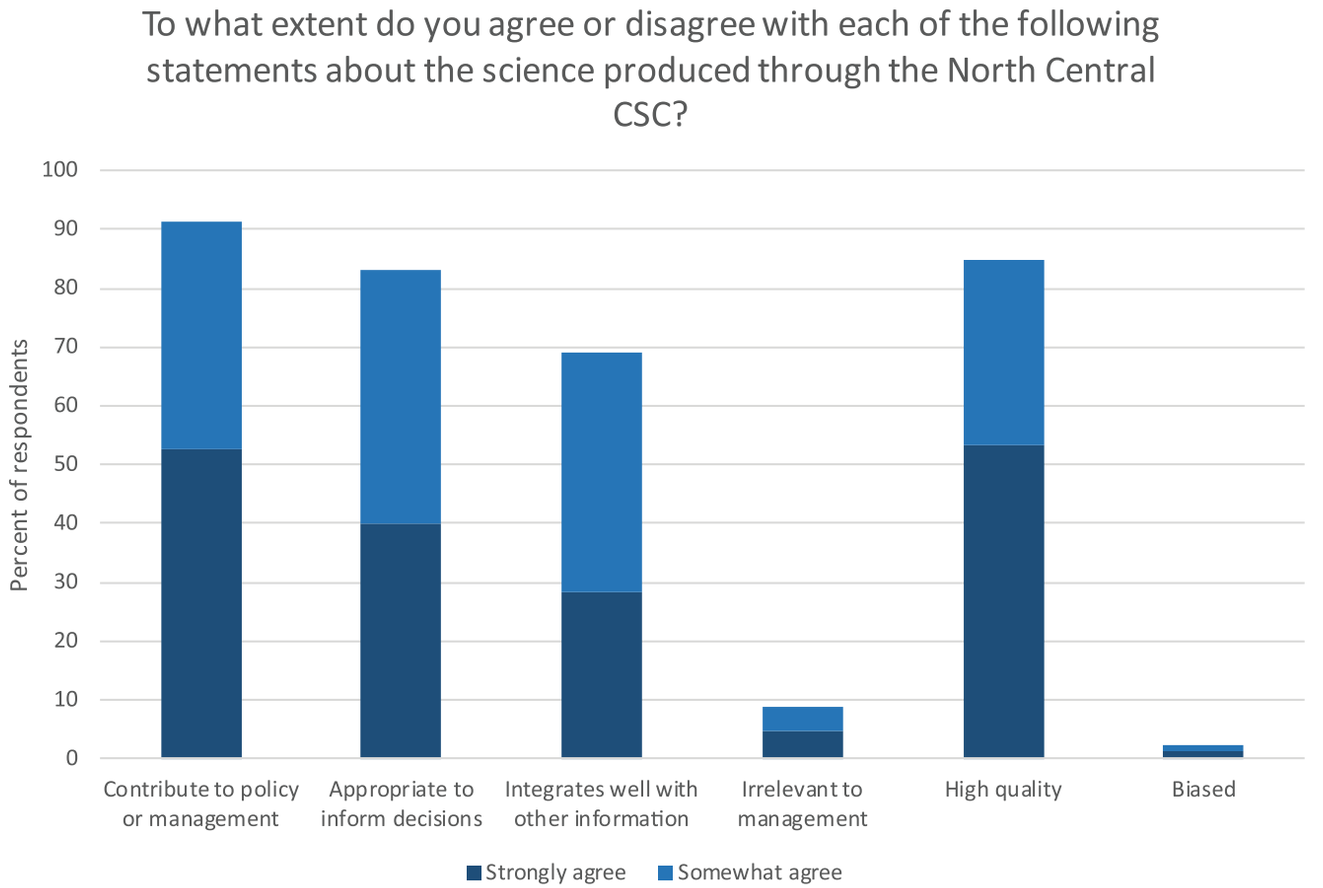

Figure 4. Perceptions on the use of science specifically generated by the North Central Climate Science Center. Note: text in items shortened for presentation in graph, and only "strongly agree" and "somewhat agree" responses are shown.

n = 140) and appropriate to inform the types of decisions being made (83%; *n* = 139). A majority also thought that it integrated well with other information (69%; *n* = 112). Fewer than 10% thought that the NC CSC's science was irrelevant to management (9%; *n* = 15) or biased (2%; *n* = 4).

While two-thirds of stakeholders responding to the HDRU survey believed that the NC CSC has helped reduce the disconnect between what is known about climate adaptation and the actions taken by decision makers in the region, as many also believe that that disconnect is so large that decision makers are not using the available knowledge.

Stakeholders overwhelmingly felt that NC CSC science is of high quality and can contribute to policy or management.

Science Users' and Producers' Use of Climate Adaptation Science

Among HDRU survey respondents who reported that they were science users, 66% (*n* = 31) reported that they or someone in their organization used climate adaptation science from sources affiliated with the NC CSC. Nearly all (91%; *n* = 50) reported that they or someone in their organization used climate adaptation science from sources not affiliated with the NC CSC.

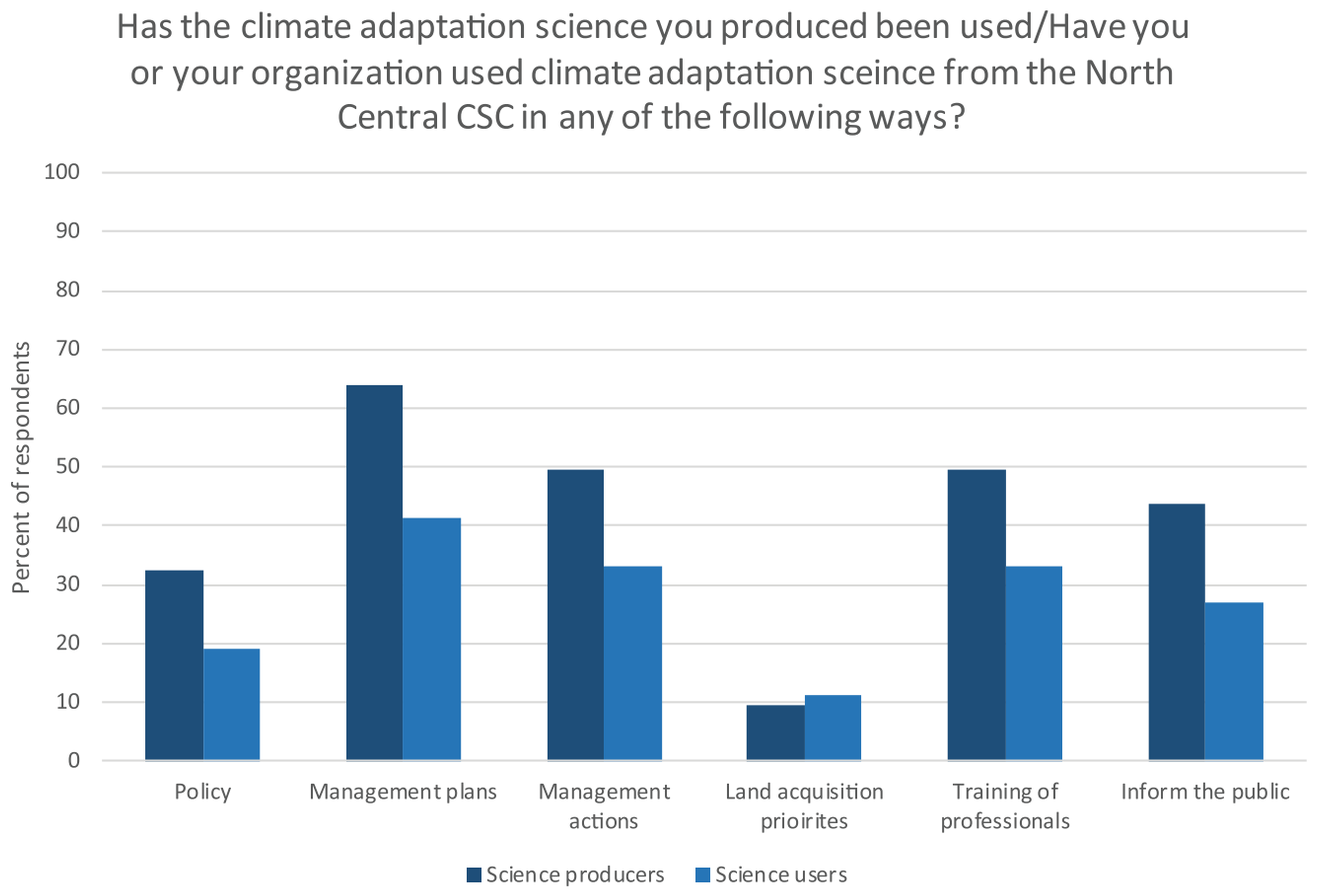

Figure 5. Partners' use of science generated by the North Central Climate Science Center. Note: text in items shortened for presentation in graph.

The most common way science users reported using the NC CSC science (Figure 5) was to inform management plans (41%; n = 26). One-third reported using it to inform management actions (33%; n = 21) or to inform the training of conservation professionals (33%; n = 21). About one-quarter (27%; n = 17) used it to inform the public about climate change and its impacts. It was less frequently used to inform policy (19%; n = 12) or inform land-acquisition priorities (11%; n = 7).

When science producers were asked a parallel set of questions about how the science they had produced had been used, the relative frequency of different types of reported uses was similar but the absolute frequency was greater. Nearly two-thirds (64%; n = 67) said that their science had been used to inform management plans, while about half said that their science had been used to inform management actions (50%; n = 52) and inform training of conservation professionals (50%; n = 52). The differences between science users' and science producers' responses could reflect differences in perceptions about how frequently NC CSC science is used. It could also reflect that the use of NC CSC science is concentrated in a subset of potential NC CSC science users.

The most common way that science users reported using the NC CSC science was to inform management plans.

In the focus groups, participants described a number of reasons why they thought that the NC CSC helped to meet decision makers' needs. First, they believed that the NC CSC made a concerted effort to tailor that science to the needs of managers. Part of this effort was directed toward helping scientists better understand science users' needs.

> The center really allowed us to understand how some of the main climate datasets that were being used for impact research were being used, and how a lot of the products out there did not meet … the needs of the users at all. And helped us figure out exactly what to focus on and really nail down in terms of developing the new products. [North Central Producer Focus Group (FG).]

In addition, the NC CSC made a concerted effort to make sure that they communicated regularly with key users.

> Jeff (Morisette, CSC Federal Director) has done a really great job of involving us from the get-go. We've had a lot of face-to-face meetings and conference calls talking about the solicitations, the RFPs that would be announced and making sure that they were in line with LCC needs. [North Central User FG.]

> A lot of our interactions with them ended up being more ad hoc than systemized or institutionalized, and so Jeff basically decided that he was going to do something to systematize it more. So that was when he decided to have…at least one liaison at each of the LCCs in our region. [North Central Producer FG.]

The NC CSC makes an attempt to put its science products in a tangible form that can be used by decision makers.

> The very tangible products, that vulnerability assessment…We're also working on a publication…on the use of the visualization…. Those two parts are very tangible. But then it has also provided us with a tool to communicate a lot of climate science, climate change issues that we face and our mid-management partners seem to face as well…. Jeff…does a very good job at communicating…how the products that the state created for us through this process…how to use those. [North Central User FG.]

From the science users' perspective, the efforts by the NC CSC to help users develop adaptation strategies based on the NC CSC's science products were critically important.

> We're at the process of starting our adaptation…. They develop these vulnerability assessments, determine what's vulnerable, and then I think they just put them on the shelf. But you have to take that next step…. And I think that's where really…having the Climate Science Center be engaged with you can really make you do that next step. I mean you could do vulnerability assessments within your own organization…for these species or ecosystems or whatever, but what are you going to do with it? And I think that's where the Climate Science Center really comes in. [North Central User FG.]

Some of the NC CSC's decisions about how to use its resources helped in this regard. It hired not only scientific, but also technical staff because the technical staff played an important role in helping in the use of the science products. The university director also spent time working with potential users and helping them to understand how they could and could not use NC CSC science.

Nevertheless, NC CSC partners recognized factors that limited the use of NC CSC science. Science users and producers responding to the HDRU survey differed in their perceptions of what these factors were (Figure 6). In all cases, more science producers than science users perceived limits to the use (not necessarily their own use) of NC CSC science to a moderate, large, or very large extent. Two of the most common limitations cited were the same for science users and producers: scientists not working closely with decision makers (science users—34%; science producers—71%) and management issues not defined clearly enough (science users—40%; science producers—64%). Most science producers (73%) also felt that decision makers not being aware of the science was a limitation, while few science users (23%) agreed. The same pattern was found for decision makers lacking the skills to use the science (science users—15%; science producers—66%). Neither group considered a lack of quality of the science to be a problem (science users—4%; science producers—12%).

Focus group participants discussed these and other limitations to the use of the NC CSC's science. For some, the science did not address the particular management problems they faced. In such a large

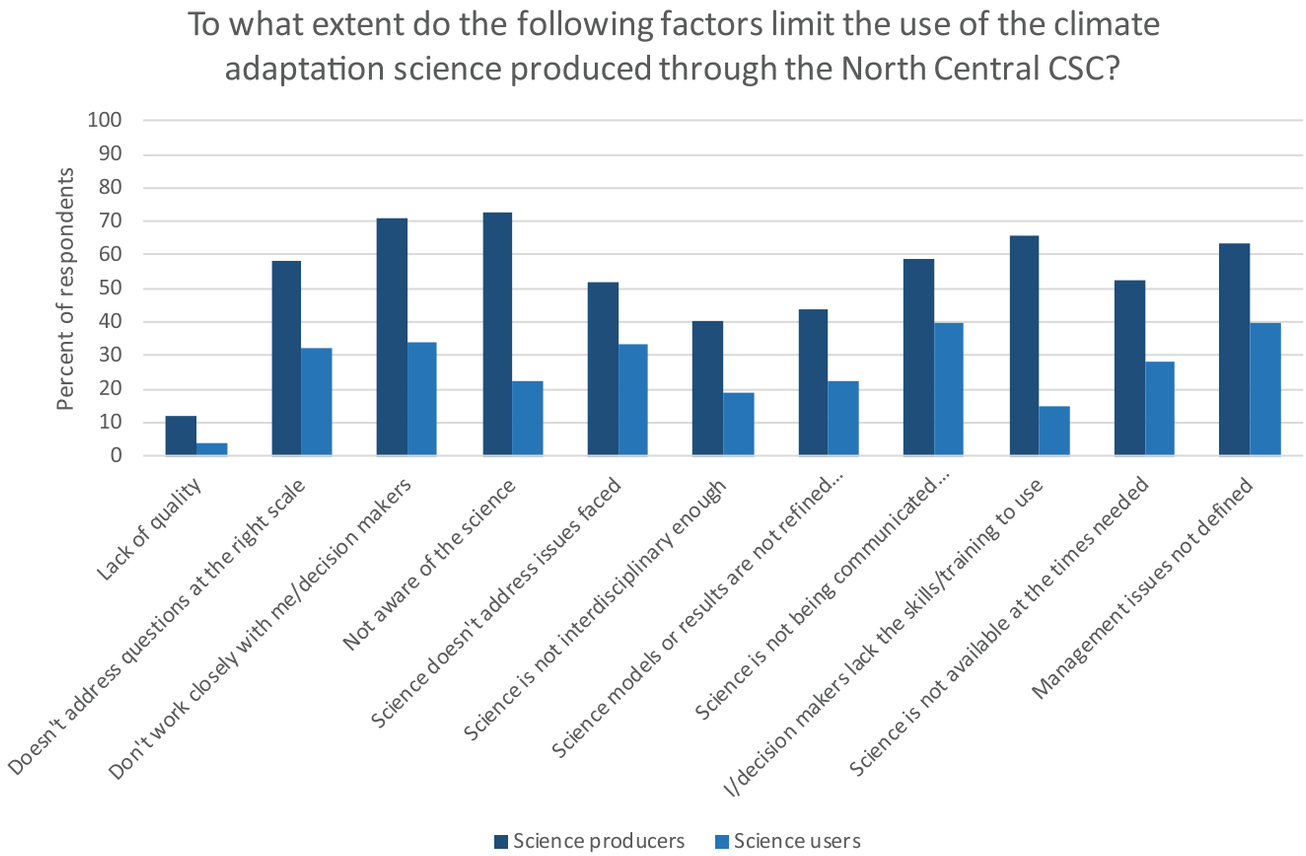

Figure 6. Limitations on the use of science. Note: Text varied slightly for science producers and users, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown..

region, work in the host universities was more likely to address problems in their vicinity but not in other parts of the region. In other cases, the science was relevant to their needs but it was difficult for science users to understand it adequately to apply it to management decisions in a meaningful way. For agencies with particular geographic areas of interest, like a statewide focus of state agencies, identifying the NC CSC science that addressed their interests at the right scale could be challenging. Decision makers faced constraints within their own organizations because sometimes the time windows during which scientific information could influence decision making were very narrow. In other cases, their time constraints were exacerbated because USGS's process of publishing results was a lengthy one, which could not always respond to immediate management needs. One focus group participant argued that for organizations like the CSCs to have a real impact on decision making, they had to "persist through lengthy amounts of time" so that they could effectively engage with decision-making processes. This issue is larger than simply the NC CSC but reflects institutional hurdles inherent in the agency overall.

Two of the most common limitations to the use of NC CSC science cited by both science users and producers were scientists not working closely with decision makers and science and management issues not being defined clearly enough.

Science Users' and Producers' Engagement in Coproduction of Knowledge

Science users and producers responding to the HDRU survey reported on their beliefs about coproduction of knowledge in general. An overwhelming proportion of both science users (90%; $n = 51$) and producers

(93%; *n* = 95) expressed support for coproduction, indicating that it was important or very important for climate adaptation scientists and natural resources decision makers to work together to produce science research.

Many science producers indicated experience in coproduction in various phases of research projects, much more so than did science users. For all phases of research projects except for "analyzing data," at least half of the science producers had experience collaborating with decision makers to a moderate, large,

An overwhelming proportion of both science users and producers expressed support for coproduction, but collaboration between scientists and decision makers was less common in designing research and collecting data than other phases of research.

or very large extent. (These results apply to all types of research, not just CSC-sponsored research.) In contrast, when science users were asked about their experience collaborating on research with CSC science, there were only three phases of research with which at least 30% of science users had experience: communicating results of a research project (37%), identifying research questions (31%), and applying research results (30%). Both science users and science producers perceived collaboration between scientists and decision makers to be less common in designing research methods (science users—19%; science producers—58%), collecting data (science users—19%, science producers—56%), and analyzing data (science users—23%; science producers—47%).

The factors that HDRU survey respondents thought were most likely to limit science users' involvement in research projects were scientists not reaching out to them (51% agreed or strongly agreed; *n* = 29), followed by different perspectives on what science is needed (33%; *n* = 19). Other factors were perceived to limit the involvement of smaller numbers of respondents: the science users not having enough time (26%; *n* = 15), funders not being supportive of collaboration between scientists and science users (25%; *n* = 14), different perspectives on how research projects should be conducted (19%; *n* = 11), and scientists not interested in listening to them (18%; *n* =10).

The factors most likely to limit science users' involvement in research projects were scientists not reaching out to them and different perspectives on what science is needed. Producers expressed that coproduction was inherently time-consuming and difficult to complete in relatively short-term projects.

During the science-producers focus group, in particular, participants engaged in a lengthy discussion of the factors that made coproduction challenging. To begin with, participants emphasized that coproduction was inherently a time-consuming process, which was difficult to complete in relatively short-term projects. The time required for coproduction is particularly challenging for young scientists who needed to maximize their publications to meet the expectations of their positions. Because so much time is needed to coproduce science, it is not uncommon for key players to change jobs, undermining the relationships that serve as the foundation for coproduction. Another challenge to coproduction is that scientists tend to be funded to work on projects over relatively short periods of 2–3 years. Science users will be making use of that research over much longer periods of time, however.

The NC CSC was viewed as doing a number of things that helped to address the challenges of coproduction. To begin with, the NC CSC makes an effort to understand users' needs and use that information in designing funding opportunities:

> They have always been responsive, both of them. But what speaks specifically about the North Central … to LCC's express needs: very often reaching out to try to understand what our needs are, being

> very responsive in terms of crafting funding opportunities for researchers that are directed towards the LCC's express needs. And those benefits have been consistent in ways that we've … not been able to achieve through other science delivery mechanisms. [North Central User FG.]

The NC CSC has also recognized and been supportive of the time required to do coproduction well.

The NC CSC was viewed as doing a number of things that helped to address the challenges of coproduction, including making efforts to understand users' needs, using that information in designing funding opportunities, and being supportive of the time required to do coproduction.

As summarized earlier, stakeholders acknowledge and appreciate the efforts of the NC CSC to ensure that their science activities are informed by, and inform, end user needs. However, even though science coproduction is a nascent field of research, it is clear that fuller integration of science into existing decision-making processes requires sustained, iterative interactions and translation activities that stretch far beyond the standard norms of science training. The NC CSC's efforts are well aimed and paying benefits, but full return on investment requires a larger cultural shift in career development and reward structures of science producing organizations, a shift beyond the power of the NC CSC alone, though they appear to be in the vanguard of the effort.

The SRT feels that one small step to enhance the implementation of science results could be requiring each PI, as part of the final project reporting, to work with NC CSC communication staff to develop informative flyers and other outreach products.

Geographic Domain of Science Projects

As noted in the earlier description of the NC CSC, the geographic domain of the NC CSC (Figure 7) encompasses a vast expanse of the interior continental United States. This large area covers dramatic gradients in elevation, hydrology, topography, precipitation, and temperature seasonality, as well as major differences in land ownership, management, and uses. Accordingly, it is inherently unreasonable to expect a monolithic view of climate impact, vulnerability, or options for adaptation. For comparison and perspective, the National Ecological Observatory Network (NEON) was designed to provide continental scale monitoring of ecological indictors, with a sampling design derived from multivariate analysis of major ecological gradients to define somewhat ecologically coherent domains (www.neonscience.org/science-design/spatiotemporal-design). This resulted in identification of 20 ecoclimatic domains, and the NC CSC overlaps at least six of these (although, it should be noted that most of the CSCs cover multiple ecoclimatic domains). In other words, the NC CSC encompasses an ecologically very heterogeneous region. That, in itself, is not a problem, and by vision and design, the NC CSC was never intended to be homogenous, but it does create a significant challenge in identifying common needs and values for climate research within the NC CSC's domain. The benefit to the ecological and jurisdictional overlap (both politically and relative to other federal agencies) is to facilitate integration across boundaries, which is a highly desirable goal, to the extent that information and solutions in one portion or jurisdiction impinge on other components, as they most certainly will. The example cited by the NC CSC staff is that of hydrological connections between precipitation and hydrology originating in the Rocky Mountains, and the ultimate outflow into the Missouri River system. The question remains: how can the NC CSC target efforts in a meaningful way that supports stakeholders across the entire domain? At this point, it appears that it does not.

As noted previously, during the initial phase of operation, the NC CSC had to make decisions about how to proceed with limited available effort and resources. Much of the funding and effort focused westward, with an emphasis on the high elevation system in the Northern Rockies and sagebrush and grazed

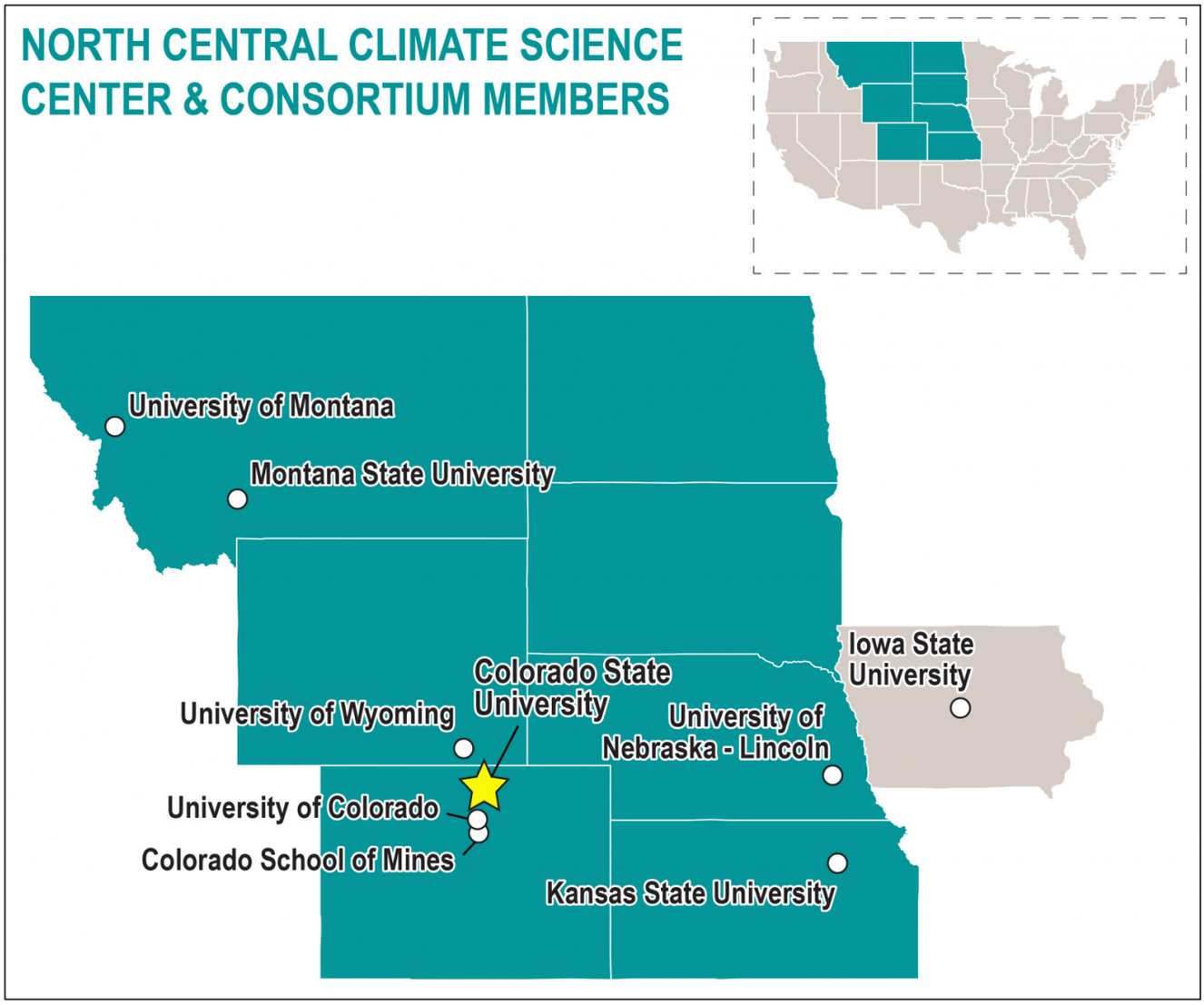

Figure 7. Geographic domain of the North Central Climate Science Center.

land in Wyoming and Colorado. Both areas are largely under federal or tribal jurisdiction. In light of limited resources, it would not have made sense to spread funding too thinly, but efforts in the eastern portion of the domain are much less evident. There was at least one funded project using a data-mining approach to assess vulnerability of species to climate change, and another project investigating the socioeconomic aspects of land conversion in the agricultural eastern portion of the Dakotas. Both of these projects appear to be valuable additions, but stand out as isolated contributions involving the NC CSC. These observations are consistent with the observation that although the NCUC is comprised of nine partner institutions from across the domain, most were not included in the funded efforts. Evidently, most did not continue to engage after initiation of the NC CSC and it is not clear what their degree of involvement or interest was at the outset.

> *Although the NC CSC indirectly engages nonfederal partners through the LCCs, additional effort should be placed on engaging nonfederal land managers where opportunities exist.*

One of the major challenges to integrative development of climate change planning is the jurisdictional or land-ownership landscape within the NC CSC domain. Because the eastern portion of the domain is largely agricultural and under private ownership, it would be worth exploring ways in which non-DOI

and nonfederal stakeholders (specifically USDA, states, and private landowners) might collaborate to a greater degree to create strategies for climate impact assessment and adaptation. The political interest will certainly vary across jurisdictions and among stakeholders, but to the extent that parallel efforts in one guise or another are underway or under consideration, USGS climate scientists and biologists should seek opportunities to engage and leverage current somewhat independent approaches and efforts. This was noted in a follow-up e-mail after one of the stakeholder/SAC discussion sessions that took place during the site visit.

We noted elsewhere in this report that NC CSC activities could be extended to directly reach and benefit a broader group of regional stakeholders through regular workshops, training activities, and even ad hoc collaborations. This, of course, requires resources, particularly in the form of available staff effort. Potential beneficiaries might include additional federal agencies, state agencies, and private organizations. In the eastern portion of the NC CSC domain, this will include landowners and managers, many nonfederal, but experiencing many of the same climate impacts as those higher in the same watershed.

NC CSC Science Conveyance and Dispersion

The NC CSC is charged with conducting fundamental science and making this knowledge available to the public. Beyond this, the knowledge created needs to be actionable and used by constituencies to improve decision making. The NC CSC has used a wide variety of methods and venues for conveying their science to stakeholders. These include webinars, workshops, peer-reviewed papers, an open science conference, and newsletters. The NC CSC has been particularly successful at putting users and producers in touch with one another in some specific instances (described above). Participants in the users' roundtable emphasized that the NC CSC acts as a node among many disparate groups.

Additionally, researchers and staff serve as intermediaries between scientists and the public. They have been especially careful about communicating the uncertainty inherent in climate predictions and explicitly discussed how different models produce very different results. Users from the NPS, LCCs, and other agencies openly acknowledged that they often want climate scientists to "tell them what is going to happen," but they now have a deeper appreciation of what products and models are most appropriate for their particular problem. Ecologists no longer just grab the climate data and plug it into their habitat prediction model because they understand that they may be using a product in ways that it was not intended. At the same time, climatologists have a more nuanced appreciation for the kinds of temporal and spatial scales ecologists work on. Natural resource managers feel that the NC CSC scientists are committed to conducting research with the end user in mind and now know that their science is fundamentally an estimation of truth.

Extension services provided by NC CSC staff are not recognized in the traditional performance metrics of a research institution but should be.

In terms of disseminating information, users felt that they really valued the NC CSC's willingness to "come to them where they are." Staff and researchers travel to the field and have held workshops in regional offices. However, these extension-related services have not always been recognized in employee performance metrics, which tend to be heavily dominated by research-related metrics such as publications. To ensure that the successful foundation that has been established with partners continues, the NC CSC should investigate ways to recognize professional contributions of extension-related services. This has been particularly important in work with tribal partners. Similarly, the NC CSC has put a lot of effort into effective visualizations where they customize model output while working with managers. This allows users to incorporate these maps, charts, or graphs into presentations to supervisors or colleagues and enhance their credibility.

The NC CSC has done a good job connecting the climate scientists with the ecologists, biologists, and land-management community.

The RAM workspace at USGS FORT that enables sophisticated collaborations among scientists and users features a studio with a large table and a wall of monitors that can support up to 20 people working simultaneously together. Modelers are able to integrate remote sensing, climate model, geographic information systems, and other products seamlessly and project simulation runs or scenarios on the VisWall—a bank of 24 monitors mounted in a 6 × 4 array. Thus, stakeholders and scientists can easily view and discuss models together to enable robust data exploration.

Overall, the NC CSC has helped develop a community of science users and producers that remains in constant conversation with one another. People actively ask one another "does that make sense to you?" and there is a strong sense that everyone is coproducing knowledge. There is room for experimentation and collaboration because everyone is ultimately process-oriented with the eye toward getting stuff done.

Cultivating and maintaining these relationships is important but comes at some costs. North Central Climate Science Center researchers and staff receive numerous requests and cannot possibly address them all; declining requests, while necessary, affects relationships with partners and others. Additionally, time dedicated to outreach and support in the field means that there is less time for scholarly publication, which could be detrimental to junior researchers with a need to produce publications in support of tenure reviews.

The high demand for NC CSC services speaks to the strong reputation that has been established, but fulfilling all requests for assistance is limited by funding, personnel, and space.

General observations by the SRT include the following:

- Clearly, the NC CSC is doing an admirable job of producing scientific information that is being used to inform management decisions.
- These products are being shared through very effective workshops or trainings so that end users understand their caveats, limitations, and intended purposes.
- The NC CSC is committed to process and the coproduction of knowledge so that scientists and man agers work collaboratively and iteratively.
- This demands a great deal of trust, and the NC CSC is effectively stretched to the extreme limits in terms of service to its constituents.

The NC CSC is doing an admirable job of producing scientific information that is being used to inform management decisions, with products being shared through very effective workshops or trainings so that end users understand their caveats, limitations, and intended purposes.

Partnerships

The NC CSC largely came into being at a time when a broad recognition was developing that climate science work needed to move beyond the physical sciences and towards working on climate impacts and adaptation on the ground. There was an organic need for information at agencies that the NC CSC helped to fill. This has likely helped partnerships be successful for the group.

An emphasis on developing relationships and application of social science expertise has profoundly influenced the NC CSC's success in partnerships. This stood out as a great success of the CSC. For example, the NC CSC work with tribal stakeholders seems to be one of the more successful partnerships of this type nationally. Stakeholders repeatedly brought up the attention paid to process, the repeated engagement

of scientists and experts in meetings at the location of interest, and feedback as key to success. However, the SRT does have some concerns that these exemplary relationships rely on a few individuals and could be impacted by future staff changes.

Tribal engagement is a positive but hinges on a few individual staff and could be jeopardized by staff departures.

A formalized internship program with management agencies could help with the institutionalization of relationships. Currently, the NC CSC is producing high-quality information that could be used across a much larger management base. This information is being used but primarily due to personal initiative or connections on the part of managers. A formalized program would increase the number of managers aware of the information and provide them the tools to use it, which would broaden agency utilization of this resource. A formal internship program could increase awareness of the NC CSC's utility at all levels of agencies. Agencies are largely hierarchical in their reporting structures, and support from those higher up is necessary for on-the-ground managers to pursue innovative conservation work.

A formalized internship program with management agencies could help with the institutionalization of relationships with the NC CSC.

Another example, the Southwest Colorado project, has been a model in terms of bringing stakeholders together based on their interest in a place. The NC CSC brought three proposal groups together and facilitated collaboration even before the project got off the ground. Distilling climate science into pieces that fit into a sound learning framework was a focus of the project. They worked with social scientists to figure out the best way to clearly communicate uncertainty to stakeholders, which seemed to have a positive impact on stakeholder engagement. The project also purposefully incorporated information from stakeholders into its analysis, rather than discounting this knowledge since it did not come from traditional scientific sources.

Although the primary mission of the CSC is oriented to DOI lands and federal partners, the NC CSC has evolved to working with NGOs such as The Nature Conservancy and others to address their needs and support relevant projects. Much of what the NC CSC has accomplished goes beyond federal partners; for example, the NCTC training opportunities have been offered to a range of people involved with the NC CSC. Comments by other science users and producers highlighted the value of the influence on management decisions through NC CSC action, visiting agencies to learn their issues and problems, providing connections between physical climate scientists and end users/stakeholders (managers), providing climate expertise, providing presentations about climate and CSC products to stakeholders and users, providing travel support, supporting tribal actions on climate change (including support for Rising Voices), and providing drought assessments to Wyoming tribes on the Wind River Reservation. The SRT views these interactions between the NC CSC and a broad range of partners—including private lands and landowners, even though those are not their primary stakeholders—as a strong attribute.

The NC CSC is doing a good job of including private lands and landowners in certain locations, even though those are not their primary stakeholders.

The National Park Service has an exceptionally strong partnership with the NC CSC. The NPS identified that the NC CSC has been extremely helpful in providing information while the NPS has helped the scientists think about the ways to operationalization of products, such as the practical use of species distribution modeling. In this way, the two seem to be achieving the elusive goal of coproduction. The NC CSC has helped the NPS develop scenarios for dealing with uncertainty with risk-averse management community. There is an opportunity to take the successful collaboration achieved with the NPS to a larger pool of federal agencies.

For work with partners, the NC CSC seems good at distilling information into usable products. In general, the actual climate projections, and so forth, may not be the most useful to managers. Instead, information about trends, certainty of trends, thresholds crossed, and so forth might be most actionable. Providing products that can help produce this out-of-the-box content at appropriate scales for land managers is an opportunity to reduce barriers to utilization.

Benefits of Involvement

In the HDRU survey of NC CSC partners, the most frequently identified benefit attributed to participating with the NC CSC was "access to a broader network of people interested in climate adaptation science" (73% described as "important" or "very important"; $n = 114$). Participants in the focus groups described the importance of this network frequently. The networking opportunities that the NC CSC provided were associated with a whole variety of other benefits. The networks the NC CSC helped cultivate provided opportunities to connect with other agencies, organizations, or individuals who could contribute to partners' work. A second benefit attributed to the NC CSC almost as frequently was "access to climate adaptation science" (68%; $n = 106$; Figure 8). The access to high quality science or scientific products was discussed frequently by the science users in their focus group.

Limitations on Involvement

Most respondents to the HDRU survey (75%; $n = 154$) reported limits to their involve-ment with the NC CSC (Figure 9). The most common (41%; $n = 83$) limit was not having enough time, followed by not having enough funds (27%; $n = 56$). The focus group participants also recognized their available

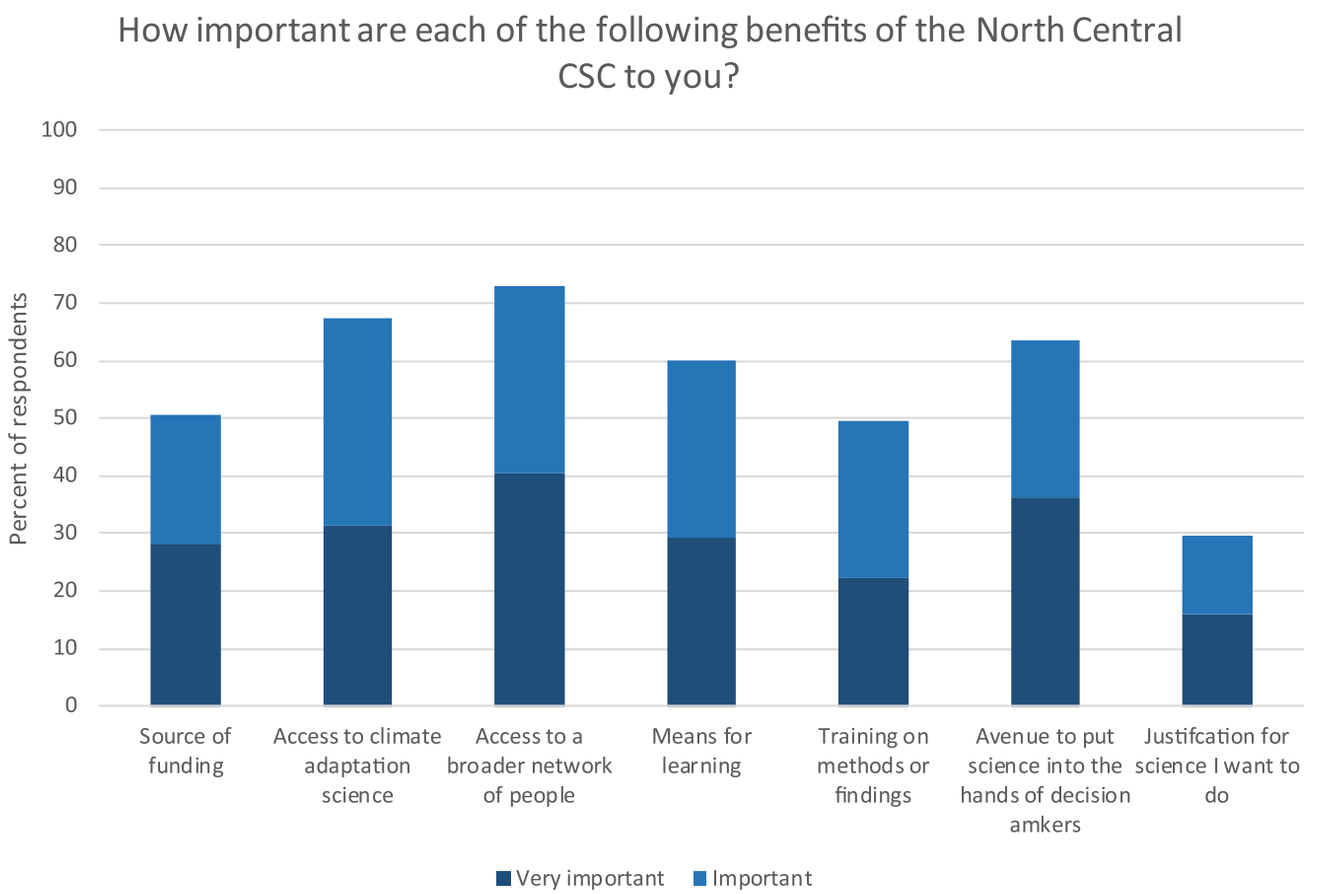

Figure 8. Partner benefits to involvement with the North Central Climate Science Center. Note: text in items shortened for presentation in graph, and only "important" or "very important" responses are shown.

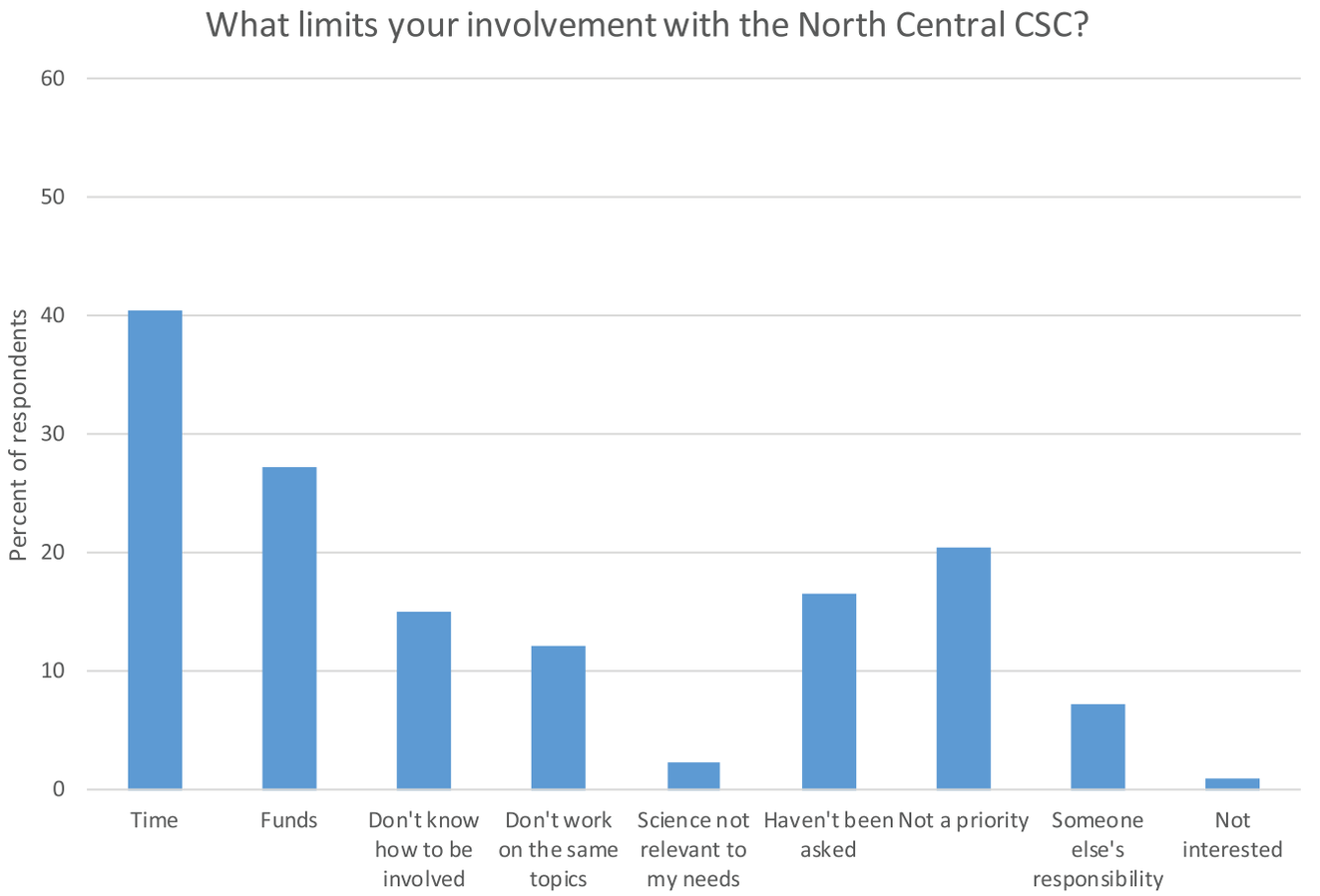

Figure 9. Limitations to involvement with the North Central Climate Science Center. Note: text in items shortened for presentation in graph.

time as limiting their involvement. Because of such constraints, focus group participants also recognized that it was easier for partners to be involved with the NC CSC if they worked at organizations that were located near to it.

Focus group participants pointed out that spending the time needed to develop products that were relevant to science users when working with the NC CSC was not always recognized as a valuable contribution by their organizations. A related topic that was discussed in the focus groups was that NC CSC staff were also constrained by the amount of time they had available to work with partners. This constraint placed limitations on the partners' engagement with them.

Not enough time and funding limit partner involvement with the NC CSC. Spending the time needed to develop products relevant to science users was not always recognized as a valuable contribution by their organizations and NC CSC staff were also constrained by the amount of time they had available to work with partners.

Partner Perceptions of the Role of the NC CSC

The NC CSC has helped facilitate various connections. The most common connections reported in the HDRU survey were with climate adaptation science (54%; $n = 93$) and climate adaptation scientists (52%; $n = 90$). Nearly half also reported getting connected with resources needed to conduct science (46%; $n =$

78) and professionals who might communicate science (45%; *n* = 77). Fewer reported help in connecting with decision makers who might use science (31%; *n* = 53).

More than half of HDRU survey respondents agreed that the NC CSC made a wide variety of contributions to the region. The contributions that were most widely perceived were awareness of available science (72%; *n* = 120), collaboration between scientists (71%; *n* = 119), communication between scientists and those who might use the science (71%; *n* = 117), and interdisciplinary science (70%; *n* = 116).

Partnership Recommendations

There are opportunities to build on the successes of the NC CSC to broaden the reach across other agencies. These include the following:

- The NC CSC has engaged with the BLM and USFS, though to a lesser extent than with the NPS. Considering that the BLM and USFS manage a larger portion of the country's public lands than the NPS, greater engagement with these managers will improve prospects for coproduction of actionable information and management options.
- The NC CSC directors identified the need to develop ways to improve working relationships with the CSU Extension programs. This positive idea will leverage existing trust relationships in rural communities.
- There is an opportunity to work more with other programs at the host institution, such as the Center for Environmental Management of Military Lands (CEMML). A larger link to water or fire management may also provide good links to other groups.
- The NC CSC has worked closely and effectively with the state climatologist and Colorado Natural Heritage Program. This seems to open opportunities to work in a similar fashion with other states as well.
- As noted under Geographic Domain, there are opportunities to leverage NC CSC expertise and approaches (the general template mentioned earlier) to benefit other state and federal agencies and private organizations or large landowners. At least, collaboration or sharing of approaches with other federal agencies (USDA, for example) in the eastern portion of the region) might create efficiencies and reduce redundant efforts.

Concluding Comments

The DOI CSCs are part of the ongoing mission to meet the challenges of climate change and its effects on wildlife and aquatic resources. The NC CSC has been addressing these challenges through its 5-year plan, based on three foundational science areas: climate drivers, ecological impacts, and adaptation. This is accomplished through partnerships between the university consortium, led by CSU, USGS, and the end user community. The review team worked with all three groups to determine the quality of the science, information, and tools produced and the relationships developed among these groups.

Overall, the review team found that the NC CSC has worked to meet the needs of the partnership by producing quality science, research, and tools. Areas where the NC CSC would benefit from improvements are generally associated with the lack of resources necessary to meet all of the needs of a large, diverse landscape and a multitude of end users. When the NC CSC researchers focused on a small part of the landscape with just a few end user partners that have developed strong relationships, they succeed with cutting-edge science and research. The researchers and the end users feel connected and accomplished. Moving forward, it will be important to the NC CSC, the consortium of universities, and the end user community to work together to set priorities for science and research and to continue to cultivate trust and cooperation.

The NC CSC is to be commended for advancing the integration of social science with the physical/biological science. The ReVAMP concept takes the implementation of science to another level by integrating

information into actionable tools to achieve adaptation strategies. The NC CSC has further enhanced the usability of the science through actions such as hiring technicians to aid land managers with implementation and providing extension services as a component of the NC CSC program. This actionable science can be improved through the development of metrics and processes to evaluate how the models and products are used in altering how decisions are made, what decisions are made, and how the process impacted relationships.

The science review team identified areas for improvement during the development of the next strategy. Addressing these areas will allow the NC CSC to continue to improve and meet the critical challenges that the DOI and partners are facing. Because one of criticisms related to demand for assistance, the review team recommends that the NC CSC attempt to identify and focus on priorities that would clearly define the direction and science needs. This may mean a single priority that could be landscape-wide or priorities that would allow the NC CSC to communicate clearly so that all partners would be aware and expectations could be moderated. This might also allow the NC CSC to work more closely with decision makers on defining the science and management issues, developing the strategy to assess those issues, and creating actionable science that connects to the decisions. The review team also recommends that the NC CSC consider assessing the number of universities in the consortium and the amount of funding available for research to determine the best cost–benefit for the NC CSC and the universities.

The review team recognized the challenges facing the NC CSC with limitations on staffing and resources for both USGS and the partners in the consortium universities. The NC CSC has added value to the knowledge of climate change impacts on the natural landscape, added to the tools available for use by the end user community working on the landscape, and added value by building relationships among the researchers, future researchers, federal and state agencies, and the DOI agencies. In this regard, the NC CSC has been successful during the first 5 years of effort. The recommendations contained within this report are designed to assist the NC CSC in identifying avenues to make the already strong program stronger in order to address the increasing challenges that land managers will face adapting to a changing climate in the future.

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Appendix A
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Appendix B
North Central Climate Science Center Schedule of Activities

Fort Collins, Colorado
January 30 to February 2, 2017

Monday, January 30, 2017

Approximate time frame	Preparatory or on-site activity	output	Desired person	Lead entity/ Participants
5:00–6:00 pm	Pre-meeting of review team members • Review schedule of meetings/ discussions • Overview of goals and expected products • Writing expectations • Identification of additional information needs		Austen, Shipp	Review Team and USGS-Reston
6:15 pm	Dinner gathering of review team members (only review team members and USGS-Reston staff) Follow-up discussion questions: • From the material that you've seen so far, what is missing? What do you want to see more of? • What new questions do you have for the CSC?		Austen	Review Team and USGS-Reston

Tuesday, January 31, 2017

Approximate time frame	Preparatory or on-site activity	Desired output	Lead entity/ person	Participants
	Location for all meetings (except otherwise noted) is Fort Collins Science Center 2150 Centre Avenue, Building C, Main conference room Fort Collins, Cololrado 80526			
8:00–8:30 am	Convene			Open to all participants
8:30–9:00 am	Welcome, introductions, and short background statements by review team members Review charge to the committee. Campus welcome and orientation.		Austen, Cushing, Morisette, Ojima	Open to all participants

Tuesday, January 31, 2017 (continued)

Approximate time frame	Preparatory or on-site activity	Desired output	Lead entity/ person	Participants
9:00–10:00 am	Brief review of main points from preparatory conference calls focusing on structure, funding, staffing, and related aspects of the Fort Collins component of the NC CSC. • Q&A and discussion of issues raised from the calls. • Identification of additional informations needs. *Note: Questions to be gathered by Austen/Loftus/SRT chair resulting from the calls and conveyed to NC CSC staff prior to site visits to allows for preparation of responses.*	Ensure that SRT has full understanding of the structure of the CSC, including core documents and key processes.	Austen, Shipp, Loftus	Open to all participants
10:00–10:15 am	Break			
10:15–11:15 am	Establishment of the climate change science and conservation context of the CSC. Selected presentations on significant climate change issues and conservation challenges that characterize the CSC operational area. • Jeff Morisetts—short overview of ReVamp, FSA, and three solicitations (5 minutes) 10 minutes each of the following: • Andrea Ray, NOAA, "NCPP Lessons Learned" • Brian Miller, NC CSC, "Simulating the Effects of Climate Change and Resource Management" • Nina Burkardt, USGS Fort Collins Science Center, "Building Social-Ecological Resilience in Southwestern Colorado" • John Gross, NPS "Collaboration between the NC CSC and NPS Climate Change Response Program"	Presentations and discussion should enable the SRT to recognize the linkage between these issues and the strategic plan and science agenda of the NC CSC.	CSC director and staff	Open to all participants
11:15 am–noon	University Consortium Discussion—review of partners, mechanisms for engagement, assessment of strengths,	Status of consortium coordination,	Partner university leads	Open to all participants

Tuesday, January 31, 2017 (continued)

Approximate time frame	Preparatory or on-site activity	Desired output	Lead entity/ person	Participants
	weaknesses, and opportunities of the consortium Dennis Ojima (CSU) Andy Hansen (MSU) Imtiaz Rangwala (NOAA) Kristen Avert (CU-Boulder) Lawrence Buja (NCAR) Other possible remote attendees: Reed Maxwell (CO School of Mines), Diana Debinski (ISU), Charles Rice (KSU), Cathy Whitlock (MSU), Steve Running (UM), Bob Oglesby (UNL), and Nanette Nelson (US)	involvement, management, adequacy of coverage, etc.		
noon–1:30 pm	CSC and host university research forum—research scientists and graduate student research updates, outreach, and engagement ***This time slot includes a working lunch—lunch planned for 20*** Shannon McNeeley – Wind River Indian Reservation Project Andy Hansen – Climate Change in Wildlands Tyler Beeton – NC CSC student experience Rick Miranda (CSU, Provost) Visit to RAM with Viswall showing SWAP maps; Colin Talbert to lead.	Understanding of the main drivers of science management needs that define the CSC and relevant other climate science providers. What is the context of the CSC with regard to the most significant conservation challenges?	CSC director and university PI to identify and select presentation with conferral of review team chair	Open to all partcipants
1:30–1:45 pm	Break			
1:45–3:45 pm	Partnership Dialogue #1 (Cornell Team— **NC CSC Science Producers Panel** **Remote participants can join from computer, tablet, or smartphone**		Bruce Lauber and Rich Stedman	Open only to invited focus group participants and the Review Team and USGS-Reston
3:45–4:00 pm	Break			

Tuesday, January 31, 2017 (continued)

Approximate time frame	Preparatory or on-site activity	Desired output	Lead entity/ person	Participants
4:00–5:00 pm	Review team only, closed session #1 1. Gather initial thoughts and questions. Quick gathering of initial observations (e.g., lightening round of 2–3 minutes for each team member to share thoughts), compilation of shared observations, gathering of questions, and information requests for day #2 2. Initial discussion of report authorship. This will have been addressed on pe-site visit conference calls but should be leading to team members accepting authorship responsibility.			Review Team only
6:00 pm	Group Dinner – all review participants are invited and encouraged to join us.			All are invited

Wednesday, February 1, 2017

Approximate time frame	Preparatory or on-site activity	Desired output	Lead entity/ person	Participants
8:00–8:15 am	Gather on campus at NC CSC research facility. Natural and Environmental Sciences Building Review day-1 notes and day-2 schedule of activities		Austen, Shipp, Loftus	Review Team, USGS-Reston, and CSC staff
8:15–8:45 am	Research lab tour and overtime (time can be modified as needed or even go direction into next session if appropriate)		Dennis Ojima	Review Team, USGS-Reston, and CSC staff
8:45–9:45	**CLOSED SESSION** CSU, Natural and Environmental Sciences Building, B215 Review team briefing and discussion with University/Host Institution PIs and relevant other university partners only Hank Garner (CSU, assistant VP for research) John Hayes (CSU, Dean of Warner College of Natural Resources) John Moore (CSU, Director of Natural Resource Ecology Lab)		Dennis Ojima, Jill Lackett, and other host-university representatives	Only Review Team, USGS-Reston, and NC CSC university designated participants.
9:45–10:15 am	Break and reconvene at regular meeting room			

Wednesday, February 1, 2017 (continued)

Approximate time frame	Preparatory or on-site activity	Desired output	Lead entity/ person	Participants
10:15–12:15 pm	Partnership Dialogue #2 (Cornell Team)— **NC CSC Science Users Panel** Remote participants can join from computer, tablet, or smartphone.		Bruce Lauber and Rich Stedman	Only open to invited focus group participants and the Review Team and USGS-Reston
Noon–1:15 pm	Lunch –off site			
1:15–2:45 pm	Role of Stakeholder Advisory Committees and other advisory bodies – Participants in Science Users focus group and members of SAC invited to continue discussions of the roles of advisory bodies. In-person participation Dannele E. Peck, Director, Northern Plains Climate Hub Theresa Boyle, APHIS Joining via GTM and conference call James Broska – USGWS Science Applications ARD **NC CSC Joint Stakeholder Advisory Committee Discussion** Remote participants can join from computer, tablet or smartphone.			Invited SAC members, Review Team, USGS-Reston
2:45–3:00 pm	Review Team only – preparation of notes for closed session with USGS			Review Team only
3:00–3:15 pm	Break			
3:15–4:30 pm	**CLOSED SESSION** Review panel briefing and Q&A with **USGS staff only**	Review responses to submitted questions and information requests, open discussion of CSC	Jeff Morisette and USGS NC CSC staff	Only Review Team, USGS-Reston, and NC CSC-federal designated participants
4:30–5:30 pm	Review team only closed session #2—compilation of notes from day 2			Review Team only
Evening	Working Dinner – For Review Team only			Review Team only

Wednesday, February 1, 2017 (continued)

Approximate time frame	Preparatory or on-site activity	Desired output	Lead entity/ person	Participants
Evening working session	Review Team session to further refine authorship, take time for drafting of material, identification of additional questions to CSC hosts. Initial identification of key findings and observations to be reported out on Thursday			Review Team only

Thursday, February 2, 2017

Approximate time frame	Preparatory or on-site activity	Desired output	Lead entity/ person	Participants
8:00–8:15 am	Gather. Review day-2 notes and day-3 schedule of activities			Open to all participants
8:15–9:45 am	Flex time available for additional discussion topics NC CSC Engagemnt Strategy and Examples • socioeconomic system framing • participatory methods and coproduced research • communications and engagement, including focus on tribal engagment • capacity building and training			Open to all participants
9:45–10:00 am	Break			
10:00–11:00 am	Review team closed session #3	Identify key initial observations. Discuss writing assignments.		Review Team only
11:00 am–12:30 pm	Report out of review team to CSC/ university hosts	• Open discussion and Q&A about initial observations • Develop list of follow-up items, responsibilites, and time lines		Open to all participants

Thursday, February 2, 2017 (continued)

Approximate time frame	Preparatory or on-site activity	Desired output	Lead entity/ person	Participants
		• Draft report development, review and finalization timeline		
12:30–1:30 pm	Lunch and release NC CSC staff and partners			Open to anyone to join the group
Afternoon	Working time for Review Team			Review Team only
5:00 pm	Complete working sessions of Review team			Review Team only
6:00 pm	Dinner or departure of Review Team members			

Appendix C
Partnership Effectiveness Focus Group and Survey Questions

Focus Group Questions

Science Producers

1. Why did you become involved with the Climate Science Center?
2. What are the benefits of your involvement with the Climate Science Center? (probe for benefits to them as individuals, to scientific knowledge, to people who are in need of scientific information, to professional development of others)
3. What are the challenges you face in your involvement with the Climate Science Center
4. To what degree have you worked with the intended "users" of your climate science produced with/for the Climate Science Center?
5. Tell us more about your efforts to work with these potential climate science users. Why and how have you worked with them?
6. What challenges have you faced in working with or reaching out to science users?
7. How have you overcome (or tried to overcome) barriers to working with or reaching out to climate science users? [or to ensuring that the science you produce is used]? (probe for whether and how the CSC staff has played a role in overcoming barriers)
8. Generally speaking, what could generate more benefits from your involvement with the CSC—whether to you individually, to scientific knowledge, to people who use currently or could use climate scientific information, etc.?

Science Users

1. Why did you become involved with the Climate Science Center?
2. What are the benefits of your involvement with the Climate Science Center? (probe for benefits to them as individuals, to scientific knowledge, to people who are in need of scientific information, to professional development)
3. What are the challenges you face in your involvement with the Climate Science Center?
4. To what degree have you worked with climate scientists or used the science produced in association with the Climate Science Center?
5. Tell us more about your impressions of this climate science. Has it been useful? How have you used it?
6. What challenges have you faced in using the science as part of the CSC? (probe for challenges in working with scientists in using science)
7. How have you overcome (or tried to overcome) barriers to using climate science? (probe for whether and how the CSC staff has played a role in overcoming barriers)
8. Generally speaking, what could generate more benefits from your involvement with the CSC—whether to you individually, to scientific knowledge, to people who use currently or could use climate scientific information, etc.?

Survey Questions

These questions represent the standardized content used in surveys for all CSC reviews. Some slight variation in wording may have been made for region-specific clarity.

1. To what extent does your work involve climate adaptation science, or management or policy related to climate change adaptation? (Select one option)
2. How serious of a threat do you believe that climate change is to natural resources, relative to other stressors? (Select one option)

3. How important do you believe it is that managers or policy makers take action now in the region to address climate change threats? (Select one option)
4. How important do you believe it is that climate adaptation science inform decisions about natural resource management in the region? (Select one option)
5. Which statement best characterizes your relationship with the Climate Science Center (CSC)? (Select one option)
6. In what ways have you been involved with the CSC in the last five years? (Select all that apply)
7. How long (in years) have you been involved with the CSC? (Fill in number of years, or zero, if none)
8. How frequently did you interact with following representatives of the CSC in your region in the last year? (Select one option per row)
9. How important are each of the following benefits of the CSC to you? (Select one option per row)
10. What limits your involvement with the CSC? (Select all that apply)
11. To what extent do you agree or disagree with each of the following statements about the use of climate adaptation science in the region? (Select one option per row)
12. To what extent do you agree or disagree with each of the following statements about the science produced through the CSC (their staff, university affiliates, those funded by the CSC)? (Select one option for each row)
13. Is making decisions about natural resource policy, management, or programs part of your job?
14. Have you or your organization used climate adaptation science produced by the following sources to inform decisions about natural resource policy, management, or programs? (Select one option per row)
15. How have you used the climate adaptation science produced by the CSC, if at all? (Select all that apply)
16. To what extent do the following factors limit your use of the climate adaptation science and tools pro duced through the CSC? (Select one option per row)
17. In your opinion as a natural resource decision maker, how important is it that climate adaptation scientists and natural resource decision makers work together to produce science? (Select one option)
18. Some climate adaptation scientists collaborate with the end-users of their science in various stages of the research process. We are interested in whether you, as a natural resource decision maker, have any experience collaborating with climate adaptation scientists. To what extent have you or someone in your organization been involved in the following stages of research in one or more CSC projects (led by others)? (Select one option per row)
19. To what extent do you, as a natural resource decision maker, agree or disagree that the following items limit your involvement in research projects? (Select one option per row)
20. Have you produced climate adaptation science through an affiliation with the CSC (e.g., as CSC staff; university faculty, staff or students funded by or affiliated with the CSC; others funded by the CSC) or otherwise? (Select one option) As a reminder, by "climate adaptation science," we mean "science that helps fish, wildlife, ecosystems, and the communities they support adapt to climate change."
21. Has the climate adaptation science you produced been used in any of the following ways? (Select all that apply)
22. In other settings, various factors have been found to limit decision makers' use of science. From your perspective as a scientist, to what extent do the following factors limit the use of the climate adaptation science produced (not specifically by you) through the CSC? (Select one option per row)
23. In your opinion as a scientist, how important is it that climate adaptation scientists and natural resource decision makers work together to produce science research? (Select one option)
24. Some climate adaptation scientists collaborate with the end-users of their science in various stages of the research process. To what extent have you, as a climate adaptation scientist, had any experience collaborating with natural resource decision makers in the following ways? (Select one option per row)

25. To what extent has the CSC helped connect you with each of the following? (Select one option per row)
26. Do you agree or disagree that the CSC contributes to the following in your region? (Select one option per row)
27. What state(s) do you work in? (Select all that apply)
28. What scale(s) do you address in your work? (Select all that apply)
29. What is your affiliation? (Select all that apply)
30. What type of position do you hold in your agency, university, or organization? (Select one option that best describes your type of work)

Appendix D
Report from the Cornell University Human Dimensions Research Unit

North Central Results

Excerpted from Lauber, T. B., R. C. Stedman, and A. A. Dayer. 2017. Quality and extent of partnership involvement in Climate Science Centers in the North Central and Southwest regions. Cornell University, Human Dimensions Research Unit, Ithaca, New York.

Respondents

We sought to survey both partners and potential partners of the North Central CSC (as we did with other CSCs). Specifically, we attempted to include people who were working to address climate change either as "science producers" (those who produce climate adaptation science) or "science users" (those who make decisions about natural resource policy, management, or programs). Doing so is somewhat complicated because this population is not well defined. As described in the Methods section, we compiled our sample from three sources, but this approach may have yielded different numbers and types of partners from region to region. Consequently, we characterize our respondents in this section.

Thirty-four percent (n = 63) of the respondents reported that they make decisions about natural resource policy, management, or programs as part of their jobs. We refer to these individuals as science users. Thirty-four percent (n = 63) reported that they have produced climate adaptation science through an affiliation with the North Central CSC, while 22% (n = 42) have produced climate adaptation science but never with such an affiliation. We refer to both of these groups as science producers (56%; n = 105). Thirty of the respondents (16%) were both science users and producers.

Fifty respondents (27%) were neither users nor producers. These individuals were similar to other respondents in many ways, including the types of involvement they had with the North Central CSC. They were less engaged, however, in work involving "climate adaptation science" or "management or policy related to climate change adaptation." They also interacted less frequently with representatives and affiliates of the CSC.

All of our respondents did work that involved climate adaptation science, management, or policy to at least some extent. Almost half of our respondents (44%, n = 92) were involved to a large or very large extent (Table NC-1). About one-quarter (24%, n = 50) were involved only to a small extent. Producers were more involved than users. Sixty-six percent (n = 62) of producers were involved to a large

Table NC-1. Respondents' extent of involvement with climate adaptation science or management or policy related to climate change adaptation.

Extent of involvement	User	Producer	Both user and producer	Neither user nor producer	Total
To a small extent	39%	11%	10%	40%	24%
To a moderate extent	42%	21%	30%	38%	31%
To a large extent	6%	39%	30%	14%	24%
To a very large extent	12%	29%	30%	8%	21%

or very large extent. Sixty-two percent (n = 39) of users were only involved to a small or moderate extent.

Most respondents (85%; n = 164) reported that they have had at least some interest in or involvement with the North Central CSC (Table NC-2). Just 10% (n = 20) reported that they had no involvement but someone else in their agency or organization did, and another 5% (n = 10) had no interest or involvement at all. Those respondents who were users (but not also producers) were least likely to be interested or involved with the CSC. Fewer than half of them (46%; n = 15) had at least some interest or involvement with the CSC. Nearly one-quarter (24%; n = 8) had heard of the CSC, but had no interest or involvement.

Respondents worked in states throughout the North Central region, but particularly in Colorado, Montana, and Wyoming (Table NC-3). More than one-third (35%; n = 71) also worked in states or regions outside of the North Central region.

A majority of respondents worked at the regional/multi-state scale (62%; n = 127) and the state scale (57%; n = 116) for some or all of their work. Smaller percentages worked at the watershed (42%; n = 86), local (41%; n = 83), or national scale (38%; n = 77). Only about one-quarter (24%; n = 50) worked at the international scale.

Table NC-2. Respondents' relationships with the North Central CSC.

Extent of involvement	User	Producer	Both user and producer	Neither user nor producer	Total
Heard of the North Central CSC, but no interest or involvement	24%	0%	7%	0%	5%
No involvement with the North Central CSC, but someone else in my organization involved	30%	7%	3%	8%	10%
At least some interest or involvement with the North Central CSC	46%	93%	90%	92%	85%

Table NC-3. States in which respondents work.

State	Percentage of respondents	n
Colorado	45%	93
Montana	32%	66
Wyoming	31%	63
South Dakota	23%	48
North Dakota	21%	42
Nebraska	19%	38
Kansas	14%	29

Table NC-4. Respondents' affiliations.

Affiliation	Percentage of respondents	*n*
Federal agency	38%	77
University	33%	68
Non-profit organization	13%	27
State agency	10%	21
Private industry	2%	4
Tribal government	2%	3
Local government	1%	2

The majority of respondents were affiliated with either federal agencies or universities (Table NC-4). Fewer were affiliated with non-profit organizations or state agencies. Very few were affiliated with private industry, tribal governments, or local governments.

Most respondents held research positions (53%; $n = 108$). One-quarter (25%; $n = 52$) were in leadership/administration. Only a few were in operations (8%; $n = 17$) or policy (6%; $n = 13$).

Extent of Involvement with the CSC

On average respondents have been involved with the North Central CSC for 3.1 years. Respondents reported a variety of types of involvement (Table NC-5). Most common was as a participant in a CSC training, webinar, workshop, or conference (53%; $n = 87$). More than one-quarter (29%; $n = 47$) were CSC grant recipients, applicants, or partners on a grant. Relatively few (10%; $n = 17$) were resource managers or decision makers who had used the science produced by the CSC.

The respondents reported on their frequency of interaction with five types of CSC representatives and affiliates (Figure NC-1). For three of the types (US Geological Survey CSC staff; University leads/PIs for the CSC; and CSC-affiliated researchers) the modal response was "up to a few times a year." Respondents interacted most frequently with the USGS CSC staff. For their interactions with CSC graduate or

Table NC-5. Types of involvement with North Central CSC in the last five years.

Affiliation	Percentage of respondents	*n*
Participant in a CSC training, webinar, workshop, or conference	53%	87
CSC grant recipient, applicant, or partner on a grant	29%	47
University member affiliated with the CSC	20%	32
CSC-funded graduate student or postdoctoral fellow	14%	23
CSC Stakeholder Advisory Committee member	11%	18
Resource managers or decision maker who has used the science produced by the CSC	10%	17
LCC steering committee member	10%	16
CSC USGS staff	7%	12
LCC staff member	7%	12

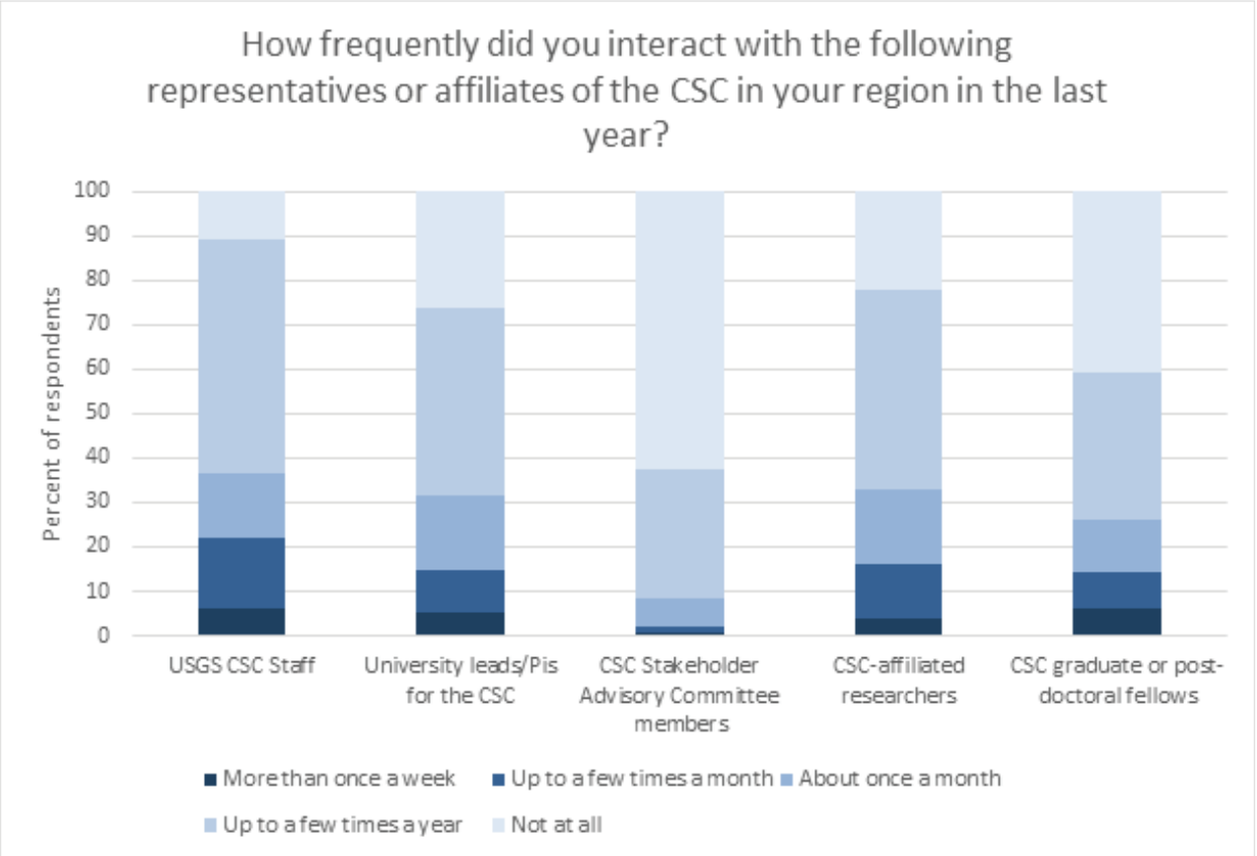

Figure NC-1. Based on survey question 8.

post-doctoral fellows and CSC Stakeholder Advisory Committee members, the modal level of interaction was "not at all," although 59% interacted with CSC graduate or post-doctoral fellows and 37% interact with Stakeholder Advisory Committee members at least some of the time.

Benefits of Involvement

The most frequently identified benefit attributed to the CSC (Figure NC-2) was "access to a broader network of people interested in climate adaptation science" (73% described as "important" or "very important"; $n = 114$). Participants in the focus groups described the importance of this network frequently. The networking opportunities that the CSC provided were associated with a whole variety of other benefits. The networks the CSC helped cultivate provided opportunities to connect with other agencies, organizations, or individuals who could contribute to partners' work:

> The Northern Plains Climate Hub is really charged with focusing on some kind of private land management, agricultural producers, private forests. And so we don't have a direct charge to work on public lands, and yet we know that a lot of our agricultural producers in this region rely heavily on public land for grazing and other uses. And so the Climate Science Center is our bridge to BLM and U.S. Fish and Wildlife Service, EPA, BIA whose activities and decisions directly impact our agricultural producers. (NC User focus group [FG])

These connections provided the opportunity for sharing information and developing a more complete understanding of climate-related work going on in the region:

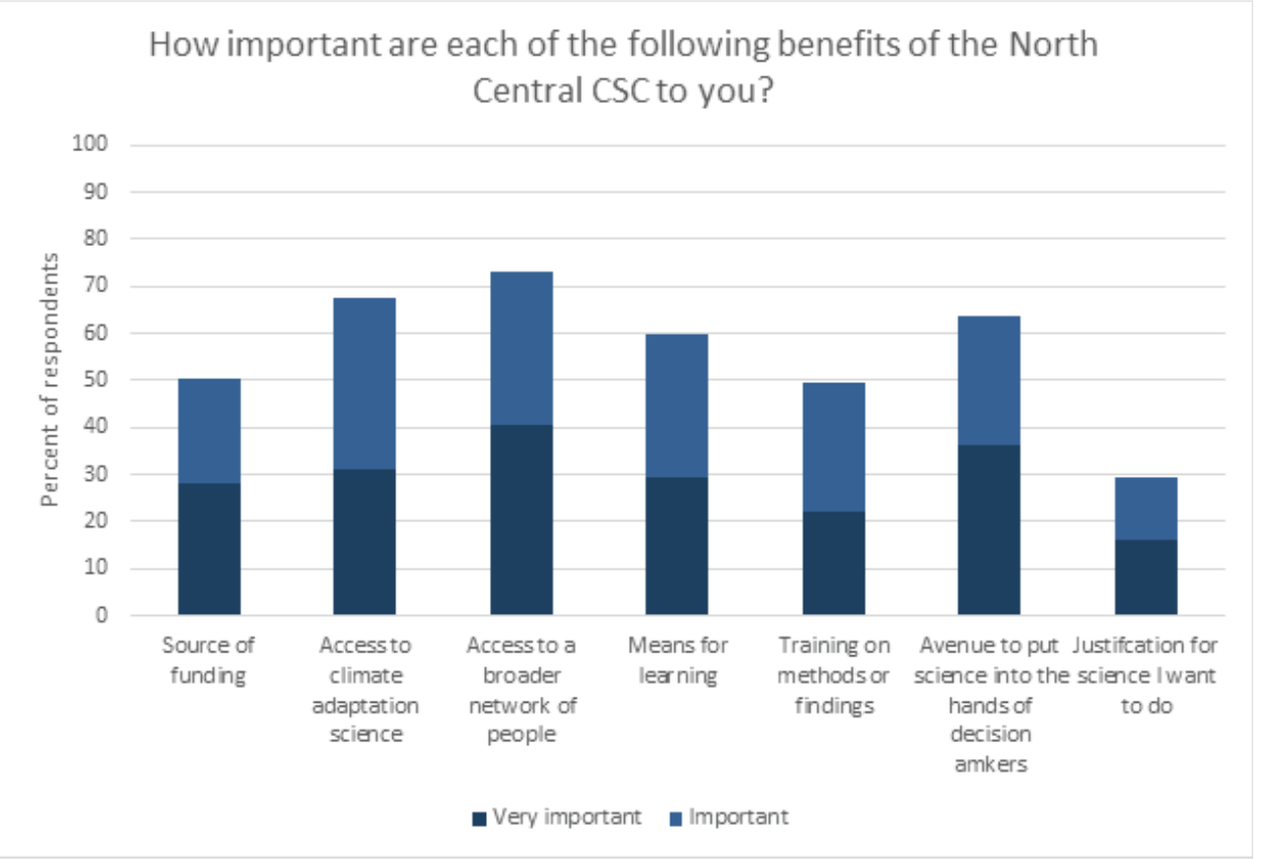

Figure NC-2. Based on survey question 9. Text in items shortened for presentation in graph, and only "important" or "very important" responses are shown.

> One of the really wonderful things, the benefits of being funded by the Climate Science Center was being on some of these conference calls with other funded projects and learn what they're doing say up in Montana … So that was a huge benefit. (NC User FG)

This type of interaction could lead to co-learning in which people learned from other people with different specialties:

> Some of the … work with social scientists that were on our team through the marriage that we were forced into by the Climate Science Center, which was an absolutely wonderful thing … That really expanded our horizon. (NC User FG)

The relationships that were established also laid the foundation for future work together:

> I think what's outstanding from that project is our connections were strengthened to the University of Nebraska Lincoln and the National Drought Mitigation Center and the High Plains Regional Science Center.… We didn't have that strong ties before that project.… [It] has really helped elevate that relationship so that now we have that working relationship that we can go from there to continue to develop other projects. (NC Producer FG)

Ultimately, many partners believed these working relationships led to better science and better management options:

> We are partnering with … a whole bunch of other investigators…. There were actually originally several proposals that were combined, and it was an interesting experience. But it's turned out to be fantastic because we've been able to work with academia and natural resource managers and, and the Heritage Program and just a real group of diverse set of stakeholders to develop a better understanding of the social vulnerabilities to climate change.… This funding really enabled quite a diverse group of people to start working together to figure out how to develop practical adaptation strategies for natural resource managers who as you know really struggle in how to, how to plan for climate change and how to integrate it into their natural resource work. (NC User FG)

A second benefit attributed to the CSC almost as frequently was "access to climate adaptation science" (68%; n = 106) (Figure NC-2). The access to high quality science or scientific products was discussed frequently by the science users in their focus group:

> The science that we're connected to through people [affiliated with the CSC] and their project partners has been critical for our program. (NC User FG)

> Before the formation of the, of all the Climate Science Centers, we were starting to realize that climate change was really at the center of almost everything our program is doing… There's nothing we do that doesn't touch on climate change. And when the center formed we were super excited about this as a really critical resource, and they have been that ever since they formed. It's been a really valuable partnership…. They've been able to be able to connect us with the science we needed to get the work done. (NC User FG)

> Now we have regular drought maps developed just for Wind River, specific to Wind River. (NC User FG)

> He just did a terrific job of building these climate scenarios and then continuing to help bring in more information (NC User FG)

Nearly two-thirds of the survey respondents also thought that an important benefit of the CSC was as an "avenue to put climate adaptation science into the hands of decision makers" (64%; n = 100). Participants in the science users focus group referred to this benefit on several occasions:

> The CSC provided a platform like no other because it's part of our mandate to support … tribes, and there's not a lot of other opportunities out there to bring this type of work specifically to tribes. And so that link is something that wouldn't have happened for me … in the way that it has, but with CSC. (NC Producer FG)

> From a climate products developer standpoint, the center was really important in developing linkages for us to the end users of the products we were developing … in really understanding their requirements and … how they were using the data.(NC Producer FG)

A majority of survey respondents also believed that that an important or very important benefit of the CSC was as a "means for learning about climate adaptation" (60%; n = 94).

> We're learning from each other. The climate change scientists are learning more about drought and drought indicators and [other] folks are learning more about the projections. (NC Producer FG)

> The CSCs and LCCs to some regard have filled … a hole where many of us on the … atmospheric side or … non-biological side have no idea what we're talking about. So it's good to have … federal relatives … that we can turn to with that expertise when necessary. (NC User FG)

About half of the partners we surveyed thought that serving as a "source of funding for climate adaptation science" (51%; *n* = 79) and "training on climate adaptation science methods or findings" (50%; *n* = 78) were important benefits. Funding was mentioned occasionally during the focus groups. People considered the funding important, but discussed it much less frequently than some of the other benefits of being involved with the CSC.

> The funding from … the NC CSC has been super important. It's really the only way we've had to sort of leverage all these different things that we're doing. It's been tremendously effective use of resources to receive that funding … which is ramified into benefits that have transferred … to all the other climate science projects that we're doing and will do … in the future. It has been an extremely effective use of funding for that. And really, it's at the center of the growth of our whole program into this new realization of what we can do. And without the Climate Science Center we would not have been able to grow into the roles that we have now. (NC User FG)

One respondent to the survey also wrote in comments about the importance of CSC funding, despite the fact that that funding was limited:

> The amount of science funding is negligible … but important as seed funds for collaborative research and partnerships. The real value of the CSC is providing a forum and collaboration space to share ideas, data, analytical techniques and researcher-practitioner integration. (NC CSC Survey)

Relatively few respondents considered "justification for science I want to do" as an important benefit of the CSC (30%; *n* = 46).

Limitations on Involvement

Most survey respondents (75%; n = 154) reported limits to their involvement with the CSC (Figure NC-3). The most common (41%; *n* = 83) limit was not having enough time, followed by not having enough funds (27%; *n* = 56). The focus group participants also recognized their available time as limiting their involvement:

> We have two big challenges working with the CSC and one of them is internal in that we just don't have enough time to come over and participate in the activities. (NC User FG)

Because of such constraints, focus group participants also recognized that it was easier for partners to be involved with the CSC if they worked at organizations that were located near to it.

> Geographical co-location really, really helps things out. (NC User FG)

About one in five survey respondents said that working with the CSC was not as high of a priority as other work (21%; *n* = 42). Their work priorities were affected to some degree by the policies of their own organizations. One survey respondent wrote in comments arguing that the policies and perspectives of his or her organization made it challenging to spend time engaging with the CSC.

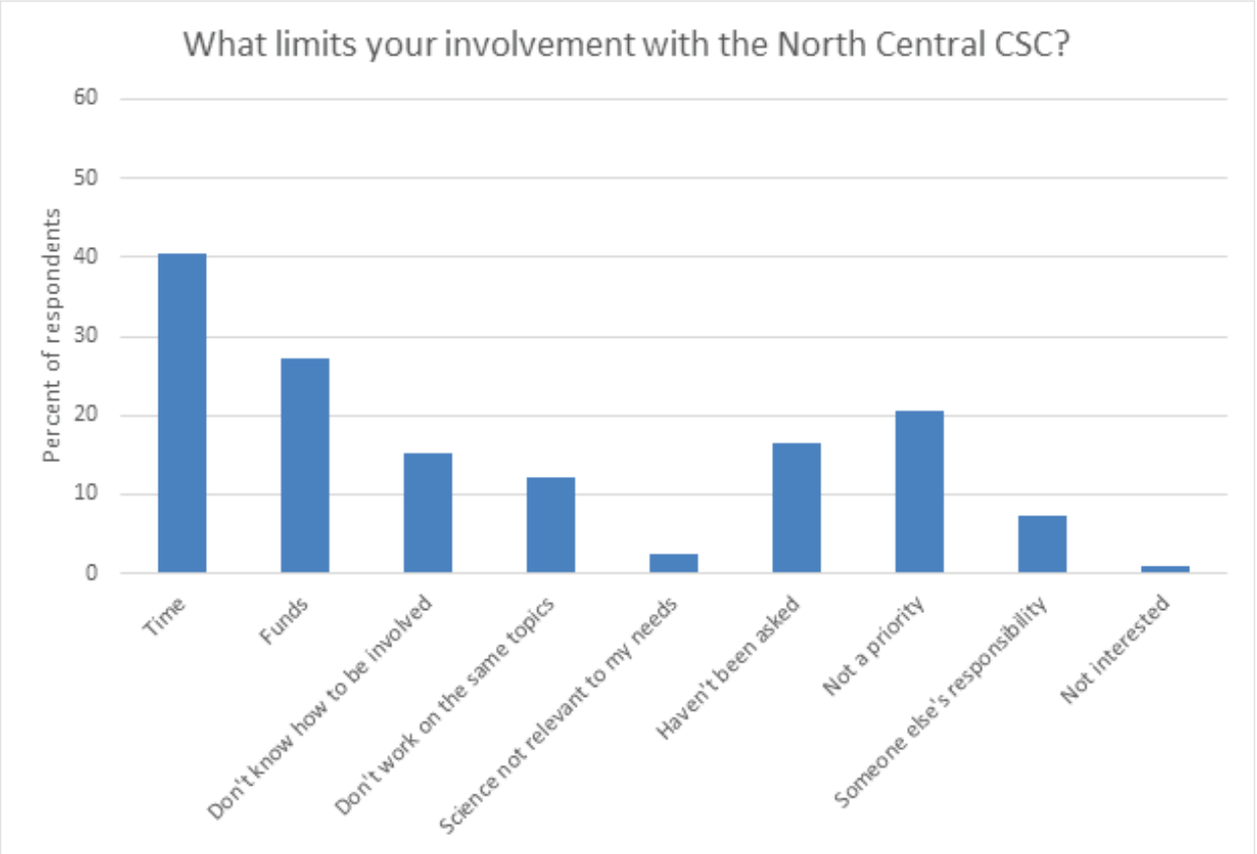

Figure NC-3. Based on survey question 10. Text in items shortened for presentation in graph.

> Institutional barriers… In my case, I have to work hard within my institution to make a case of my continued involvement with NC CSC and the relevant research and outreach I perform for it. Applied, inter- and trans-disciplinary are not easily supported. (NC CSC Survey)

Focus group participants pointed out that spending the time needed to develop products that were relevant to science users when working with the CSC was not always recognized as a valuable contribution by their organizations.

> All the extra work you do in terms of developing user relevant products that are not research papers and that kind of level of participation, just presenting and interacting and teaching with respect to climate adaptation work, I think that puts a real challenge to publishing papers. But also convincing your peers that we are doing this extra work that prevents us from any publishing of the same amount of papers. (NC Producer FG)

A related topic that was discussed in the focus groups was that CSC staff were also constrained by the amount of time they had available to work with partners. This constraint placed limitations on the partners' engagement with them:

> They don't have the capacity. We've … done our best to exploit the CSC (chuckle) to the maximum amount that we can. And unfortunately they work with all these other groups and so there have been times when we've gone and asked them for stuff…. They have a lot of things to offer us… And Jeff goes, "That's really nice but our whole staff is actually out of town this week meeting with [another

> partner]"…. They've been extremely accessible to us. They've been very receptive to our requests, but they do have a capacity issue. (NC User FG)

This point was echoed by some of the staff themselves:

> The time that it takes to do this type of work … it can't be understated…. I didn't publish pretty much all last year because I was managing projects, setting up projects, designing projects, implementing projects and responding to all the ad hoc requests all at the same time. So that is a real, real challenge for staff, staff scientists…. The ad hoc stuff, we just simply don't have the staff. We get so many requests…. I have to tell people, "no," all the time. And I hate it, but … it is what it is…. The need far outweighs our capacity to serve all of the requests that we get. (NC Producers FG)

Fewer than one-fifth of survey respondents reported limits on their involvement of not being invited or asked to be involved (17%; $n = 34$) or not knowing how to be involved (15%; $n = 31$). Not knowing how to be involved was discussed in the focus groups.

> I'm learning today just how groups have used the Climate Science Centers… Really, our fundamental challenge is using them to the full capacity, finding out how the Climate Science Center really can benefit the state wildlife agency… understanding of the true opportunities that are there that we have to take full advantage of. (NC User FG)

Two LCC representatives, one a focus group participant and the other a survey respondent, described some of their unique challenges in knowing how to be involved with the CSC.

> The earliest framers of the LCC and CSC relationship thought the CSC would inform LCC work and vice versa but this doesn't seem to be happening. Since this would be my main avenue for interaction, it ends up being not much of an opportunity. (NC CSC Survey)

> The LCC that I'm involved with … we engage with three different Climate Science Centers. And sometimes that does get to be rather a challenge… We have issues that transcend our entire geography and sometimes we're not quite sure which Climate Science Center to bring that issue to. So I wouldn't say that it's been a problem, but it is a challenge. (NC User FG)

Other limits on involvement noted by survey respondents included not working on the same topics as the CSC (12%; $n = 25$) or the CSC's science being perceived as irrelevant to their needs (2%; $n = 5$). Only two respondents reported not being interested in the CSC's work. Although these types of limits were not mentioned by many survey respondents, several took the time to write in additional comments about them. Two of these individuals maintained that the leaders of the CSC were not interested in their work.

> I have reached out to the leaders of the NC CSC, have met with them, and have even participated in a short work-shop where I presented some of my work (both research and outreach to land managers). There seems to be some interest, and it is clear to me the contributions my work and the work of some of my partners could make to the NC CSC and vise-versa, but the leadership of the CSC don't seem that interested, and don't follow up with opportunities. I have decided there isn't enough interest on their part to warrant continued effort on my part, even though we are logical partners. (NC CSC Survey)

> It's been some time since NC CSC showed interest in talking with me. (NC CSC Survey)

Is Climate Adaptation Science Actionable?

Respondents shared their perceptions both of climate adaptation science, in general, and of the climate adaptation science produced by the CSC. With regard to climate adaptation science in general, nearly three-quarters of respondents (73%; *n* = 127) agreed or strongly agreed that climate adaptation science in the North Central region is available to decision makers (Figure NC-4), and nearly as many (71%; *n* = 112) thought that water managers used this science to inform management. Only about half, however, thought that fish and wildlife managers (55%; *n* = 88) and land managers (49%; *n* = 84) used climate adaptation science to inform management. Only about one-third (36%; *n* = 59) believed that policy makers used this science to inform policies. More than two-thirds (68%; *n* = 112) maintained that what is known about climate adaptation does not necessarily influence actions taken by decision makers in the region. Nearly as many (66%; *n* = 95), however, agreed that the CSC has helped to reduce the disconnect between what is known about climate adaptation and the actions taken by decision makers in the region.

In terms of the North Central CSC science specifically, respondents (91%; *n* = 154) strongly or somewhat agreed the CSC science can contribute to policy or management (Figure NC-5). Respondents were also positive about other characteristics of the CSC science, finding it high quality (85%; *n* = 140) and appropriate to inform the types of decisions being made (83%; *n* = 139). A majority also thought that it integrated well with other information (69%; *n* = 112). Fewer than 10% thought that the North Central CSC's science was irrelevant to management (9%; *n* = 15) or biased (2%; *n* = 4).

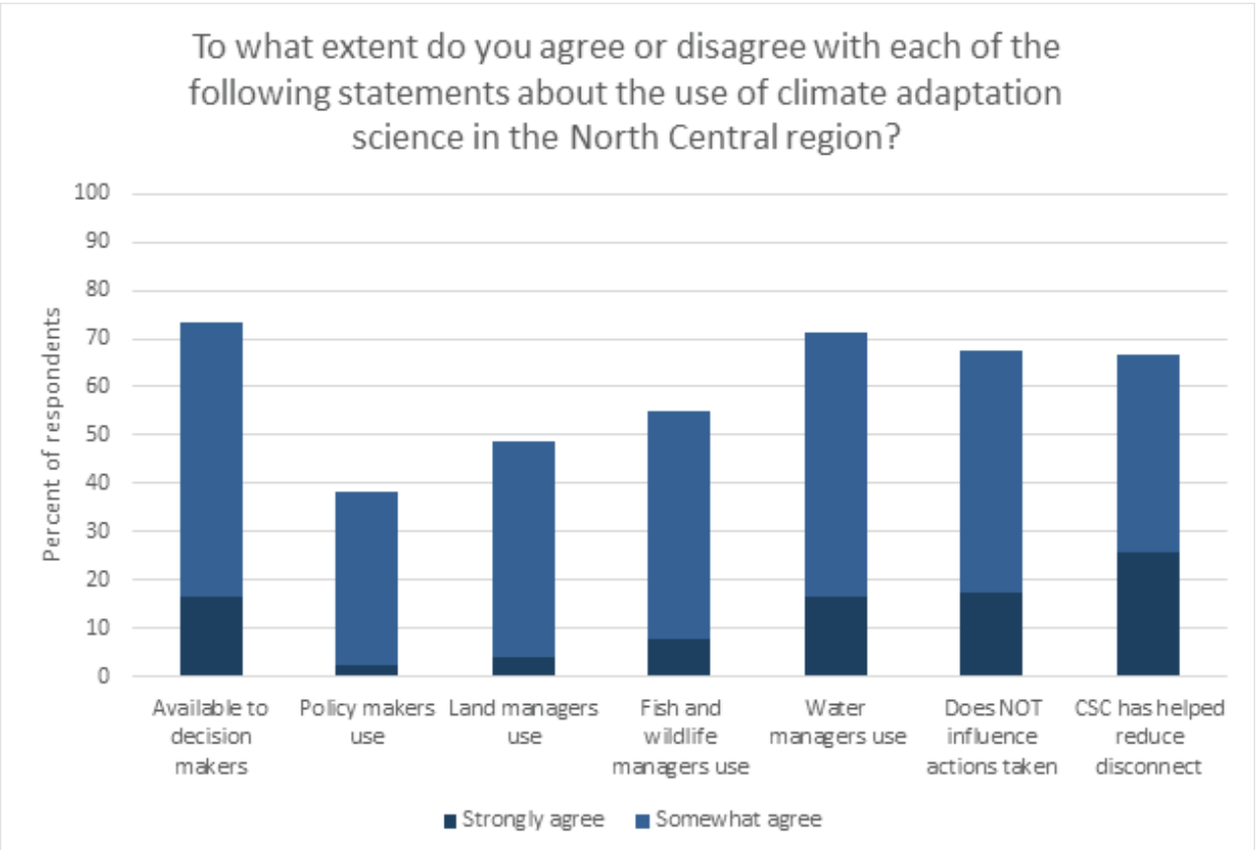

Figure NC-4. Based on survey question 11. Text in items shortened for presentation in graph.

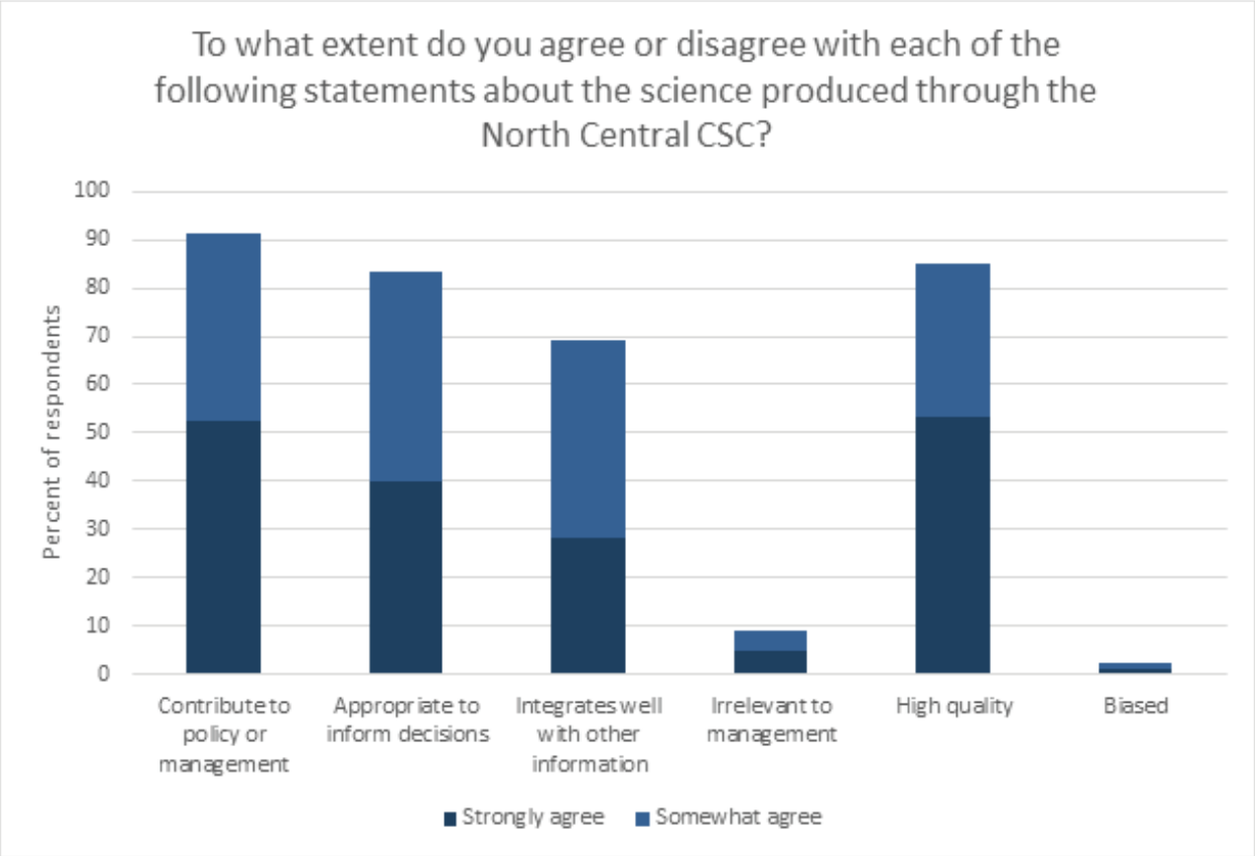

Figure NC-5. Based on survey question 12. Text in items shortened for presentation in graph, and only "strongly agree" and "somewhat agree" responses are shown.

Science Users' and Producers' Use of Climate Adaptation Science

Among respondents who reported that they were science users, 66% (n = 31) reported that they or someone in their organization used climate adaptation science from sources affiliated with the North Central CSC. Nearly all (91%; n = 50) reported that they or someone in their organization used climate adaptation science from sources not affiliated with the CSC.

The most common way science users reported using the North Central CSC science (Figure NC-6) was to inform management plans (41%; n = 26). One-third reported using it to inform management actions (33%; n = 21) or inform training of conservation professionals (33%; n = 21). About one-quarter (27%; n = 17) used it to inform the public about climate change and its impacts. It was less frequently used to inform policy (19%; n = 12) or inform land acquisition priorities (11%; n = 7).

When science producers were asked a parallel set of questions about how the science they had produced had been used, the relative frequency of different types of reported uses was similar, but the absolute frequency was greater. Nearly two-thirds (64%; n = 67) said their science had been used to inform management plans, while about half said their science had been used to inform management actions (50%; n = 52) and inform training of conservational professionals (50%; n = 52). The differences between science users' and science producers' responses could reflect differences in perceptions about how frequently CSC science is used. It could also reflect that the use of CSC science is concentrated in a subset of potential CSC science users.

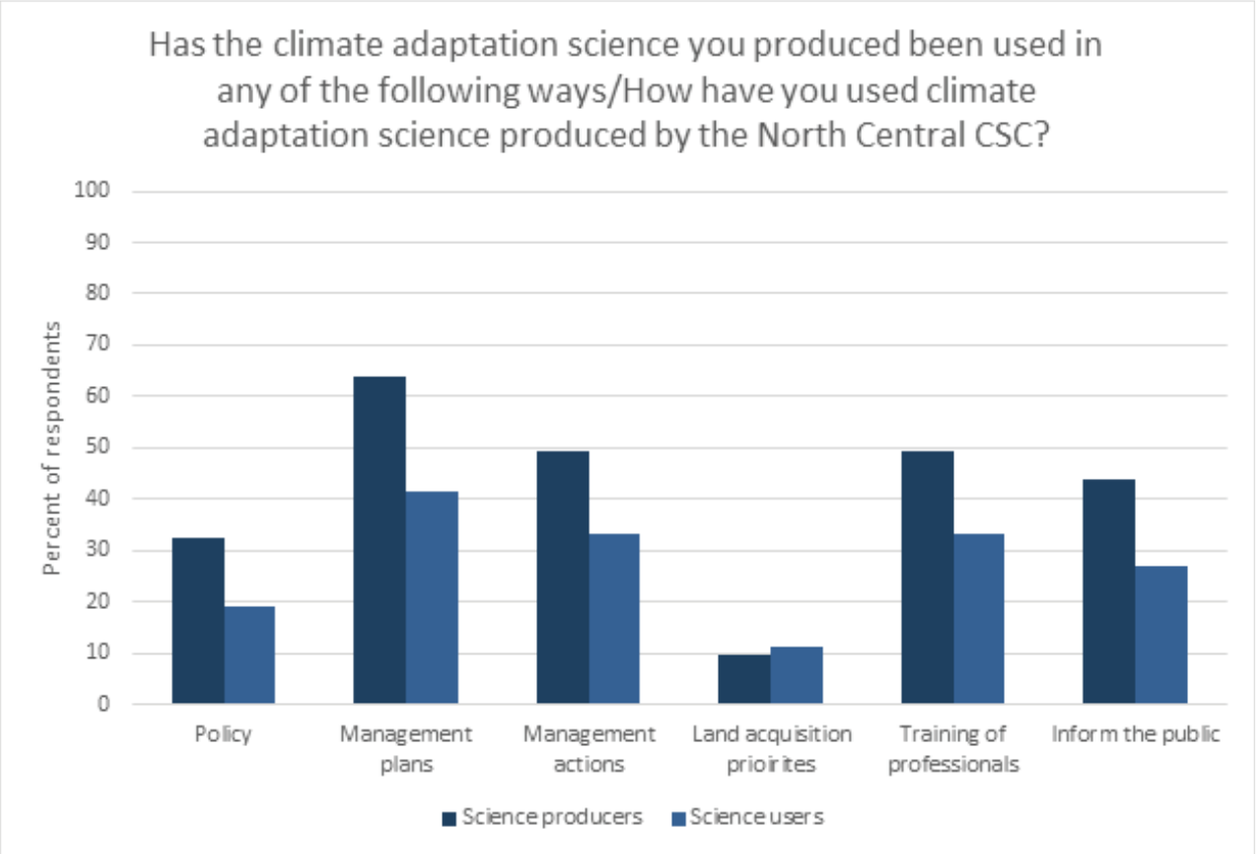

Figure NC-6. Based on survey questions 15 and 21. Text in items shortened for presentation in graph, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown. Also, text varied slightly for science producers and users.

In the focus groups, participants describe a number of reasons why they thought North Central CSC helped to meet decision makers' needs. First, they believed that the CSC made a concerted effort to tailor that science to the needs of managers. Part of this effort was directed toward helping scientists better understand science users' needs.

> The center really allowed us to understand how some of the main climate datasets that were being used for impact research were being used, and how a lot of the products out there did not meet … the needs of the users at all. And helped us figure out exactly what to focus on and really nail down in terms of developing the new products. (NC Producer FG)

In addition, the CSC made a concerted effort to make sure that they communicated regularly with key users.

> Jeff has done a really great job of involving us from the get-go. We've had a lot of face-to-face meetings and conference calls talking about the solicitations, the RFPs that would be announced and making sure that they were in line with LCC needs. (NC User FG)

> A lot of our interactions with them ended up being more ad hoc than systemized or institutionalized, and so Jeff basically decided that he was going to do something to systematize it more. So that was when he decided to have … at least one liaison at each of the LCCs in our region. (NC Producer FG)

The CSC makes an attempt to put its science products in a tangible form that can be used by decision makers.

> The very tangible products, that vulnerability assessment … We're also working on a publication … on the use of the visualization…. Those two parts are very tangible. But then it has also provided us with a tool to communicate a lot of climate science, climate change issues that we face and our mid-management partners seem to face as well…. Jeff … does a very good job at communicating … how the products that the state created for us through this process … how to use those. (NC User FG)

> One of the biggest impediments to acting on mitigation or adaptation is really just … not knowing … the realm of possibilities … being able to contextualize what that might look like. And then, especially with respect to adaptation, coming up with strategies which is sometimes what we're already doing, right? We've seen this with Parks and Wildlife. A lot of the adaptation strategies are things that we already do. It's just doing them slightly differently or on an enhanced timeline…. That kind of contextualization for policymakers and decision makers is really critical because it conveys the message that this is not this obtuse thing that we can't do anything about now…. You really need the science to be able to get at least a picture of what that range might be. (NC User FG)

From the science users' perspective, the efforts by the CSC to help users develop adaptation strategies based on the CSC's science products were critically important.

> We're at the process of starting our adaptation…. They develop these vulnerability assessments, determine what's vulnerable, and then I think they just put them on the shelf. But you have to take that next step…. And I think that's where really … having the Climate Science Center be engaged with you can really make you do that next step. I mean you could do vulnerability assessments within your own organization … for these species or ecosystems or whatever, but what are you going to do with it? And I think that's where the Climate Science Center really comes in. (NC User FG)

> Going to that next step after the vulnerability assessments to the adaptation, that really is the cutting edge of where we are in land management right now. (NC User FG)

Some of the CSC's decisions about how to use its resources helped in this regard. It hired not only scientific, but also technical, staff because the technical staff played an important role in helping in the use of the science products.

> Rather than hiring, in some cases, hiring scientific staff … he's hired technical staff. And that's turned out to be really critical. So a number of the things that I've talked about today and yesterday also rely on the ability of having programmers and GIS people and technicians that can support a variety of products…. We have access in many cases to a rich set of scientists through the CSC… and oftentimes what you need is the technical kind of project management stuff that helps make the connections between projects, and that's not always … a job that's for a tenured faculty member. You know it's the Master's level programmer or the post-doc or whatever that helps glue everything together. (NC User FG)

The university director also spent time working with potential users and helping them to understand how they could and could not use CSC science.

> We have a technical climate change advisory group that essentially serves as our advisory committee on all the studies that we do to make sure we're utilizing sound science in our decision making. Dennis sits on that committee… It really is an opportunity … to not only bring the science and information to the table but also to directly influence, like, "Yes you can use this to answer this question, but no you

> can't use that science to use to answer that question because that's a bit of a stretch." And we, we've had that sort of thing happen this discussion so that's, you know I think a big opportunity to go forward where they really, where you know the folks on that committee really do have direct influence and access to how information is used. (NC User FG)

Nevertheless, CSC partners recognized factors that limited the use of CSC science. Science users and producers differed in their perceptions of what these factors were (Figure NC-7). In all cases, more science producers than science users perceived limits to the use (not necessarily their own use) of CSC science to a moderate, large, or very large extent. Two of the most common limitations cited were the same for science users and producers: scientists not working closely with decision makers (science users – 34%; science producers – 71%) and management issues not defined clearly enough (science users – 40%; science producers – 64%). Most science producers (73%) also felt that decision makers not being aware of the science was a limitation, while few science users (23%) agreed. The same pattern was found for decision makers lacking the skills to use the science (science users – 15%; science producers – 66%). Neither group considered a lack of quality of the science to be a problem (science users – 4%; science producers – 12%).

Focus group participants discussed these and other limitations to the use of the Climate Science Center's science. For some, the science did not address the particular management problems they faced. In such a large region, work in the host universities was more likely to address problems in their vicinity, but not other parts of the region:

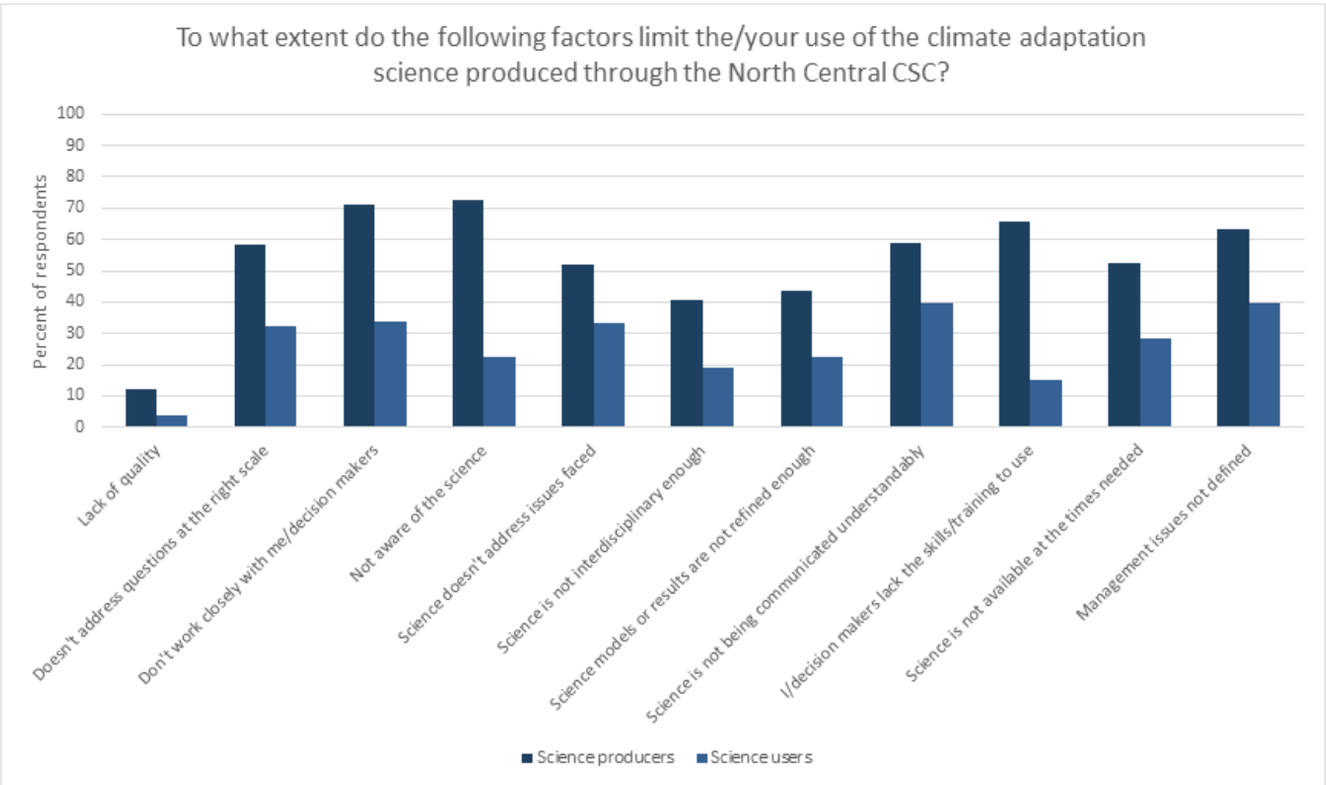

Figure NC-7. Based on survey questions 16 and 22. Text in items shortened for presentation in graph, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown. Also, text varied slightly for science producers and users.

> Where the Great Plains LCC I think has not benefitted … is even though we've been involved in the stakeholder advisory committee and putting input into those RFPs, what we have seen is that these funding opportunities have not come back with a lot of folks in the consortium that have brought proposals related to the Great Plains LCC…. The challenge for us has been, in my opinion, that researchers in the consortium haven't really put forth proposals and work related to the Great Plains LCC…. It seems like the Plains and Prairie Potholes, Great Northern … every time we've had proposal or funding opportunities there's been a lot of folks wanting to work up there. I think that's related to where those universities are obviously. So again that's been our challenge is getting … those folks to sort of look a little bit more southward towards our LCC. (NC User FG)

In other cases, the science was relevant to their needs, but it was difficult for science users to get "their heads around." Consequently, it was difficult for them to apply it to management decisions in a meaningful way.

> They gave us … lots and lots of information. And the ecological response in all the five models told us a lot of things about the systems….And we had to sort of pare it down to something that people could get their hands on and their heads around. And so I think when we came up with adaptation strategies for those things, they wound up being on a pretty small scale. And maybe they didn't seem momentous enough for people to even want to argue about it. (NC Producer FG)

For agencies with particular geographic areas of interest, like a statewide focus of state agencies, identifying the CSC science that addressed their interests at the right scale could be challenging.

> I … work across state agencies…. Jeff has been very open any time we have approached him with ideas or resources as to how he could help. But … there are so many different projects going on it's about kind of finding the best place for us to engage. And what is both concrete enough that it provides useable actionable science for us, but at the same time it's not so narrow and specific that it wouldn't be applicable statewide or wouldn't be informative statewide. Or at the same time like maybe it's too broad, it's more of a regional effort and, and not necessarily something that can be downscaled to just specifically Colorado. (NC User FG)

Decisions makers faced constraints within their own organizations because sometimes the time windows during which scientific information could influence decision making were very narrow.

> Our plans are very rigid and it's trying to find that window of when you incorporate the science into those plans…. We're doing a land use plan revision for our office…. They're just starting to develop their alternatives, and … we've been told … with the climate adaptation part, it's too late in the process already to incorporate that science. And it's like it's really frustrating when you know we haven't even released a draft plan. A draft plan won't come out for another 1½ years or so. Well, why can't we incorporate you know some of this climate information scenario planning … and eventually getting to adaptation type work in a land use plan? … I've been told that you need to do that well out in advance of a planning process. So it's like, "Well, tell me a plan that we're going to start two years from now. I'll get you the data that you can incorporate into it."(NC User FG)

In other cases, their time constraints were exacerbated because USGS's process of publishing results was a lengthy one, which could not always respond to immediate management needs.

> The USGS publication process … sometimes don't fit so well with management agencies and the need to get stuff done quickly. And so we once or twice, actually several times, … we really need something.

> It would be nice to have like an official report or something and it gets tied up in the USGS publication process. And so that I don't think that's necessarily a CSC, but given the speed of management decisions and that we have deadlines … we're often working on a very tight schedule and anything that ties that up is going to be a problem. Again … I don't know that it's CSC-specific but we have run into that a couple times. (NC User FG)

One focus group participant argued that for organizations like the CSCs to have a real impact on decision making, they had to "persist through lengthy amounts of time" so that they could effectively engage with decision making processes.

> Programs like the Climate Science Centers … need to persist through lengthy amounts of time that can sort of … be cognizant and patient about integrating with those land management cycles in appropriate ways. … How do you integrate novel information like climate science to those kinds of decision processes? … The BLM is figuring out how as an agency how they incorporate science at the landscape conservation planning and delivery. And the Climate Science Centers were there to help that and so it's not going to happen fast. And the barrier is just sort of you know institutional speed if you will and, and we all have to sort of recognize that and be willing to be patient just so that we can overcome those barriers with a little persistence and a little patience. (NC User FG)

Science Users' and Producers' Engagement in Co-production of Knowledge

Respondents reported on their beliefs about co-production of knowledge in general. An overwhelming proportion of both science users (90%; $n = 51$) and producers (93%; $n = 95$) expressed support for co-production, indicating it was important or very important for climate adaptation scientists and natural resources decision makers to work together to produce science research.

Many science producers indicated experience in co-production in various phases of research projects, much more so than did science users (Figure NC-8). For all phases of research projects except for "analyzing data," at least half of the science producers had experience collaborating with decision makers to a moderate, large, or very large extent. (These results apply to all types of research, not just CSC-sponsored research.) In contrast, when science users were asked about their experience collaborating on research with CSC science, there were only 3 phases of research with which at least 30% of science users had experience: communicating results of a research project (37%), identifying research questions (31%), and applying research results (30%). Both science users and science producers perceived collaboration between scientists and decision makers to be less common in designing research methods (science users – 19%; science producers – 58%), collecting data (science users – 19%, science producers – 56%), and analyzing data (science users – 23%; science producers – 47%).

The factors that survey respondents thought were most likely to limit science users' involvement in research projects were scientists not reaching out to them (51% agreed or strongly agreed; $n = 29$), followed by different perspectives on what science is needed (33%; $n = 19$). Other factors were perceived to limit the involvement of smaller numbers of respondents: the science users not having enough time (26%; $n = 15$); funders not supportive of collaboration between scientists and science users (25%; $n = 14$), different perspectives on how research projects should be conducted (19%; $n = 11$), and scientists not interested in listening to them (18%; $n = 10$).

During the science producers focus group, in particular, participants engaged in a lengthy discussion of the factors that made coproduction challenging. To begin with, participants emphasized that coproduction was inherently a time-consuming process, which was difficult to complete in relatively short-term projects.

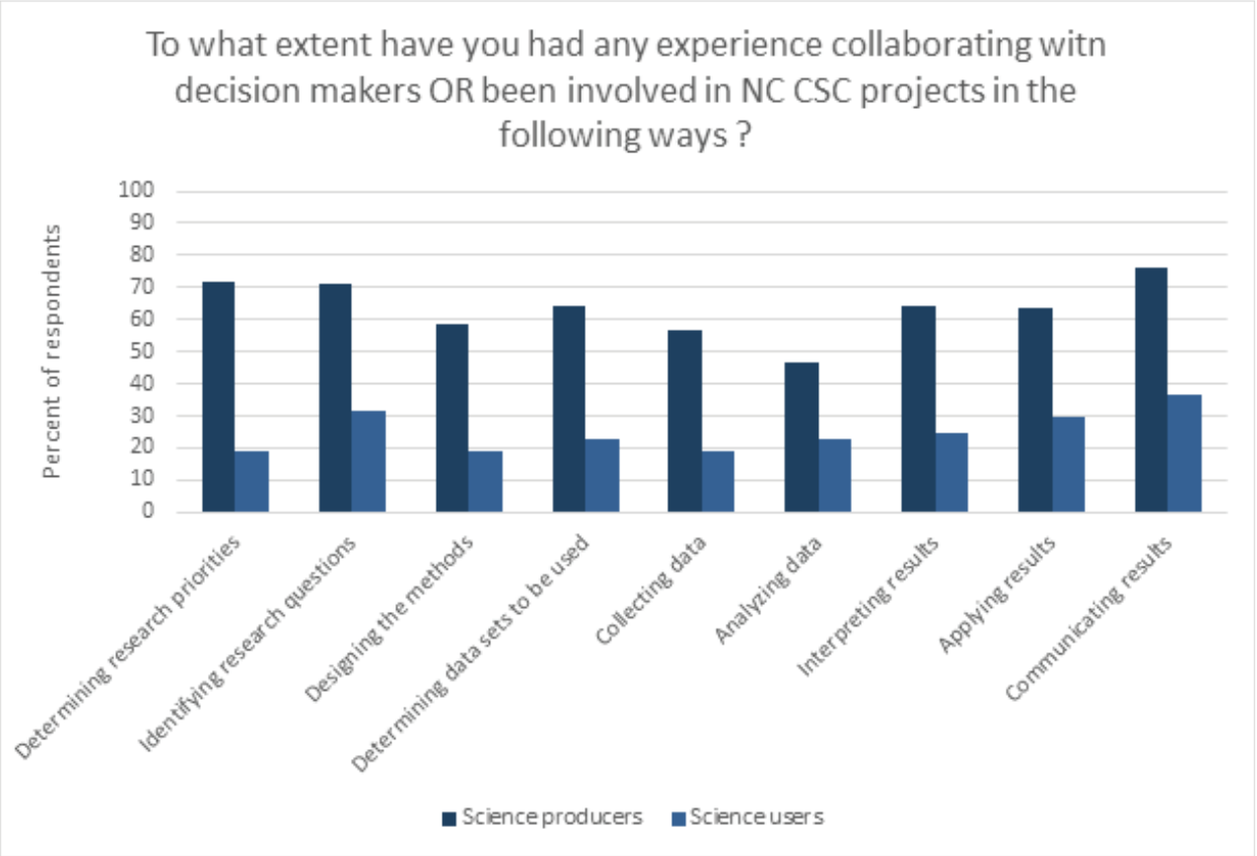

Figure NC-8. Based on survey questions 18 and 24. Text in items shortened for presentation in graph, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown. Additionally, the text of the question varied slightly for science producers and users (e.g., the users' version referencing "you or someone in your organization" and specifying a North Central CSC project).

> The additional goal of not only producing the science but then to coproduce this with your managers and help them figure out how to apply it. It's like all of that really is hard to do in a three-year period. (NC Producer FG)

> These are really long-term endeavors of these coproduction processes. And the scaling that has to happen, the relationship building that has to happen, and all of that. (NC Producer FG)

The time required for coproduction is particularly challenging for young scientists who needed to maximize their publications to meet the expectations of their positions.

> Coproduction, that takes a lot longer. Especially the young scientists … they need to be publishing papers, and that takes longer and if you're a research grade scientist in USGS or you're a young faculty or research scientist at the university. (NC Producer FG)

> At the university level … and I've been at the USGS level. Our … evaluations are based solely on our publications… Working with post docs and grad students, the pressure for them is they have to publish or they'll never get a job. And so I think the challenge is getting into cutting edge research that can get in high level journals but also doing it that's really appropriate for managers and applications…. I think the CSC … does a great job of helping us balance that…. It really is a balancing act. And I think

> for especially the young scientists that need to maintain a publication record, it's really a very hard challenge to do everything. (NC Producer FG)

Because so much time is needed to coproduce science, it is not uncommon for key players to change jobs, undermining the relationships that serve as the foundation for coproduction:

> There's staff turnover and so some of the people that are the most involved in what you're doing and giving you input upfront will end up moving from Bismarck to the regional office. And all of a sudden there's maybe no one to take that position for a while. And … they only have a certain amount of their time that they can really focus on this. So … the huge staff turnover. (NC Producer FG)

Another challenge to coproduction is that scientists tend to be funded to work on projects over relatively short periods of two to three years. Science users will be making use of that research over much longer periods of time, however. Some support for their uses is needed.

> There are several projects that are getting towards the end that we need to keep going and want to keep going. And aren't sure … how they're going to sustain themselves. So I think … being able to sustain the types of activities is really challenging and of course that's not unique to the CSC, but it is one that I've observed. (NC Producer FG)

> You have the initial product development, and you develop the product, and then you put it out there…. But then come how do you maintain the product going forward? How do you operationalize it, how do you improve it, how do you co-produce improvements with end users? That's a challenge we haven't overcome yet is how to keep the product going for the center? Does the center take it? Do I … keep it going somehow in my spare time? … But one challenge is … figure out how to keep things going in terms of maintaining the products going forward. (NC Producer FG)

Focus group participants also described the challenges posed by the different scales at which scientists and managers tended to work. This applied to the geographic scope of projects:

> Just the challenge of scale… Anybody who has been doing climate work for a long time knows that this is always the case. But just trying to find that balance at the center between how do we service the region while at the same time servicing the managers – that are … inherently local scale, the types of things that they're dealing with. That's an ongoing struggle … It's really challenging. (NC Producer FG)

Making time scales mesh is also difficult.

> We are trying to figure out how to support ongoing planning process or upcoming planning processes…. We had a conference call with one of the managers there … A lot of our conversation had to do with the timing … the planning process that they go through and at what point does it make sense for us to jump into that process and when is it too late because the horses are already out of the stable…. So we had a big discussion about … when did it make sense and how do you catch these planning processes at the right time so that you can actually help them in developing their adaptation strategies. And that's not easy to do. (NC Producer FG)

Scientists find it difficult to coproduce science when there are multiple types of stakeholders they are trying to serve.

> When you're getting to the point of trying to work with these agencies … and you're trying to get them to think about adaptation strategies. Because they have different mandates, different missions, different pressures. How do you really come up with adaptation strategies that work in the landscapes here?.... How do you really work that out so the Forest Service and the Fish and Wildlife Service and the Park Service and the county commissioners, and everybody can agree, "Yeah, this is really great. This is robust over various scenarios in this landscape." So I think that's kind of an ongoing question. (NC Producer FG)

Working with tribes poses unique challenges.

> In climate work, working with tribes is a whole other instance again…. They have their own … different sets of problems…. The Wind River Reservation Project, one of our biggest challenges is the fact that the two tribes are in a lawsuit because they're having a governance conflict that was imposed by the BIA many, many decades ago. (NC Producer FG)

The North Central CSC was viewed as doing a number of things that helped to address the challenges of coproduction. To begin with, the CSC makes an effort to understand users' needs and use that information in designing funding opportunities:

> They have always been responsive, both of them. But what speaks specifically about the North Central … to LCC's express needs: very often reaching out to try to understand what our needs are, being very responsive in terms of crafting funding opportunities for researchers that are directed towards the LCC's express needs. And those benefits have been consistent in ways that we've … not been able to achieve through other science delivery mechanisms. (NC User FG)

The CSC has also recognized and been supportive of the time required to do coproduction well.

> We were able to get an extension … Every piece is so big. I think we have done a really good job of marching through it and getting done what we can, and they've been extremely supportive the whole way. (NC Producer FG)

> You have to have patience. And to toot Jeff and Dennis's horn again … they're so good at being flexible and being supportive for us about that stuff. And understanding that this is what happens. And you just got to be flexible and work around it and figure out a strategy to keep going and not burn bridges. (NC Producer FG)

Perceptions of the Role of the CSC

The North Central CSC has helped facilitate various connections (Figure NC-9). The most common connections reported were with climate adaptation science (54%; n = 93) and climate adaptation scientists (52%; n = 90). Nearly half also reported getting connected with resources needed to conduct science (46%; n = 78) and professionals who might communicate science (45%; n = 77). Fewer reported help in connecting with decision makers who might use science (31%; n = 53).

Most than half of respondents agreed that the North Central CSC made a wide variety of contributions to the region (Figure NC-10). The contributions that were most widely perceived were awareness of available science (72%; n = 120), collaboration between scientists (71%; n = 119), communication between scientists and those who might use the science (71%; n = 117), and interdisciplinary science (70%; n = 116).

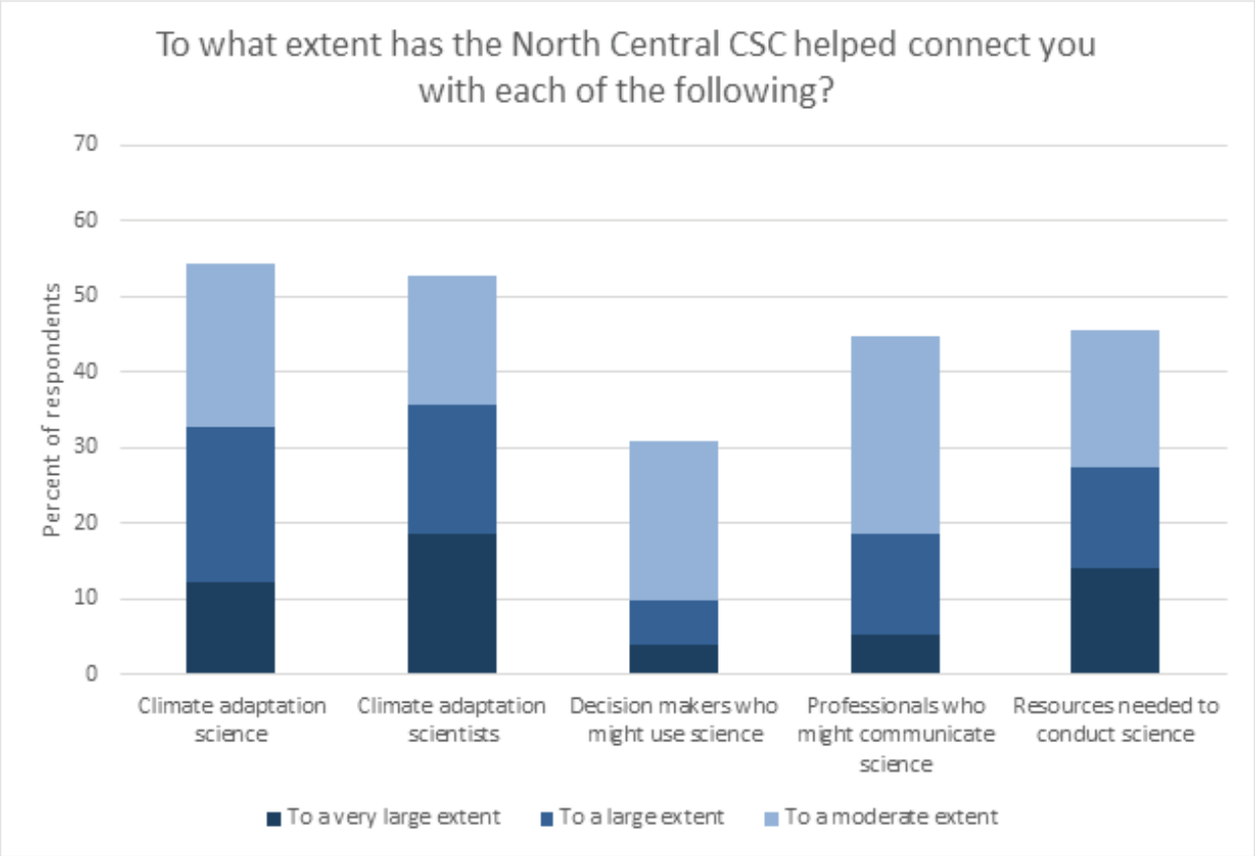

Figure NC-9. Text in items shortened for presentation in graph, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown.

Summary of North Central Results

Survey respondents were comprised of one-third science users, slightly more than half science producers, and some individuals who fell into neither group. All were involved with climate work to some extent, but producers were more involved than users. All were aware of the North Central CSC, but more than half of the users (those who were not also producers) had no involvement with it themselves. Respondents included employees of a variety of types of organizations and agencies, but federal agencies and universities were most prominent.

Survey respondents were involved with the North Central CSC in a variety of ways, but the most common was as participants in CSC trainings, webinars, workshops, or conferences. Nearly one-third were CSC grant recipients, applicants, or partners on a grant. Only 10% were resource managers or decision makers who had used the science produced by the CSC. Partners interacted most frequently with USGS staff, and CSC-affiliated researchers.

The CSC provided many important benefits to partners with the top ones identified by survey participants being providing access to a network of people interested in climate adaptation science and providing access to the science itself. Focus group participants spoke at length about the value of the networks to which the CSC gave them access. Survey respondents reported they were limited in their involvement with the CSC by a variety of factors with the most common ones being time, funds, and other priorities.

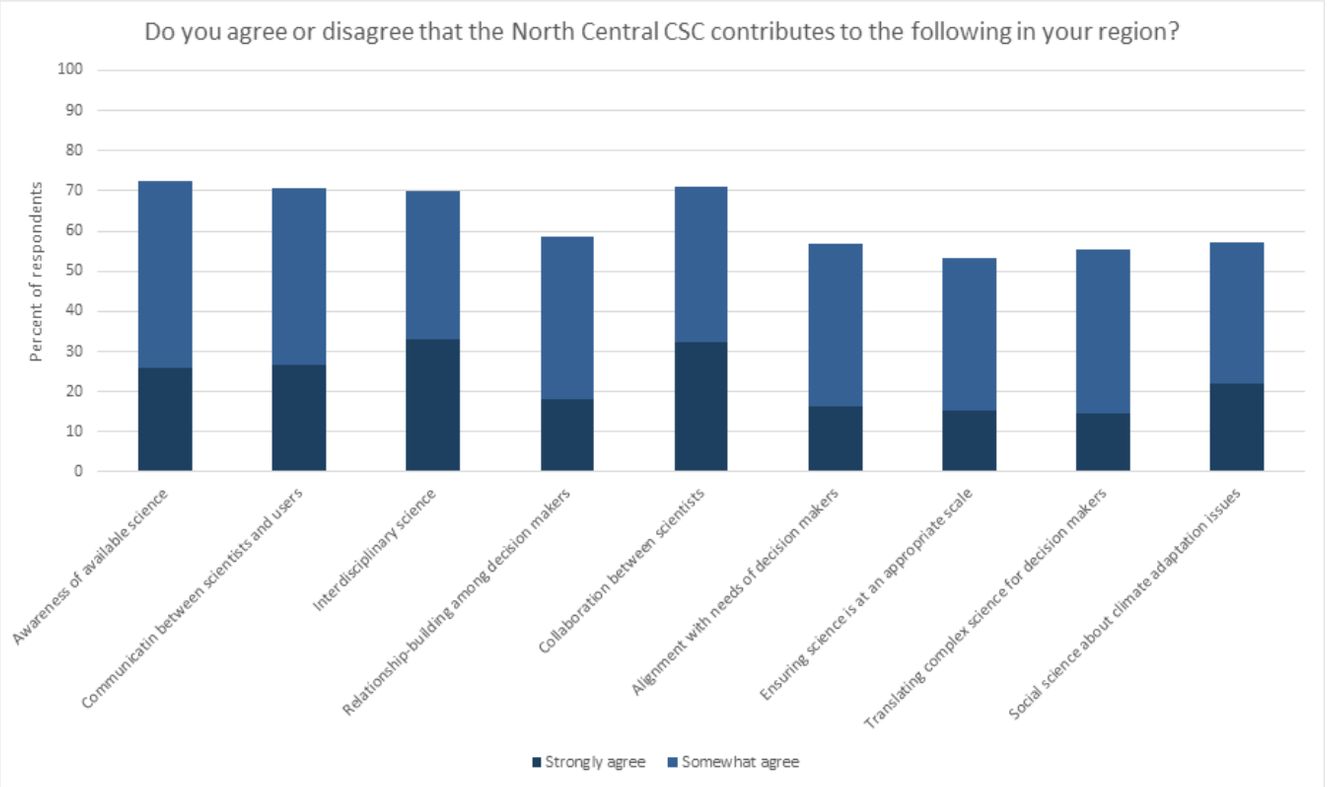

Figure NC-10. Text in items shortened for presentation in graph, and only "strongly agree" or "somewhat agree" responses are shown.

About three-quarters of the survey respondents felt that climate adaptation science in the North Central region[1] was available to decision makers, and many also believed that decision makers, particularly water managers, use the climate adaptation science to inform policies and management. Nevertheless, many believed that climate adaptation science did not *necessarily* influence management actions taken, although a majority also believed that the North Central CSC had reduced the disconnect between scientists and decision makers. When asked specifically about the science produced through the North Central CSC, the vast majority of the survey respondents agreed it can contribute to policy or management. Respondents were also generally positive about other characteristics of the CSC science, and the majority found it appropriate, high quality, and able to integrate well with other information.

The most common ways science users and producers reported that the North Central CSC science was used were to inform management plans, inform management actions, and contribute to the training of professionals. Focus participants elaborated on a number of reasons they thought the CSC science was used. These included efforts by the CSC to help scientists understand user needs, regular communication between the CSC and science users, efforts to produce tangible products from CSC science, providing assistance to science users in developing adaptation strategies, and hiring of technical staff who could provide assistance to users.

Science users and producers differed in their perceptions of what limits the use of CSC science. Science producers perceived issues to be more limiting, than science users found them to be. Focus group discus-

[1] All climate adaptation science in the region, not solely the science produced by the CSC.

sions centered on limitations in capacity: both the capacity of the CSC to work with all interested users and the capacity of scientists and decision makers to work with each other. Focus group participants also spoke at length at how the geographic scales and time frames over which scientists and decision makers worked were often difficult, making it more challenging for them to work together. They also noted that the CSC's science focused on only some parts of the North Central region, making it less useful to those outside of those areas.

An overwhelming proportion of both science users and producers expressed support for coproduction of knowledge. While many of the science producers indicated experience in coproduction in various phases of research projects, many fewer science users reported first-hand experience. Coproduction was more common in the early stages (setting priorities and identifying research questions) and late stages (interpreting and communicating results) of research than the middle stages. Science users who responded to the survey reported that their involvement in co-produced research projects is most limited by scientists not reaching out to them to collaborate and having different perspectives from scientists on what science is needed. In the focus groups, discussions of the limitations on coproduction centered on the amount of time required to coproduce science, the lack of rewards for scientists to spend the time needed on coproduction, and turnover in the people who are involved in coproduction (either as scientists or decision makers).