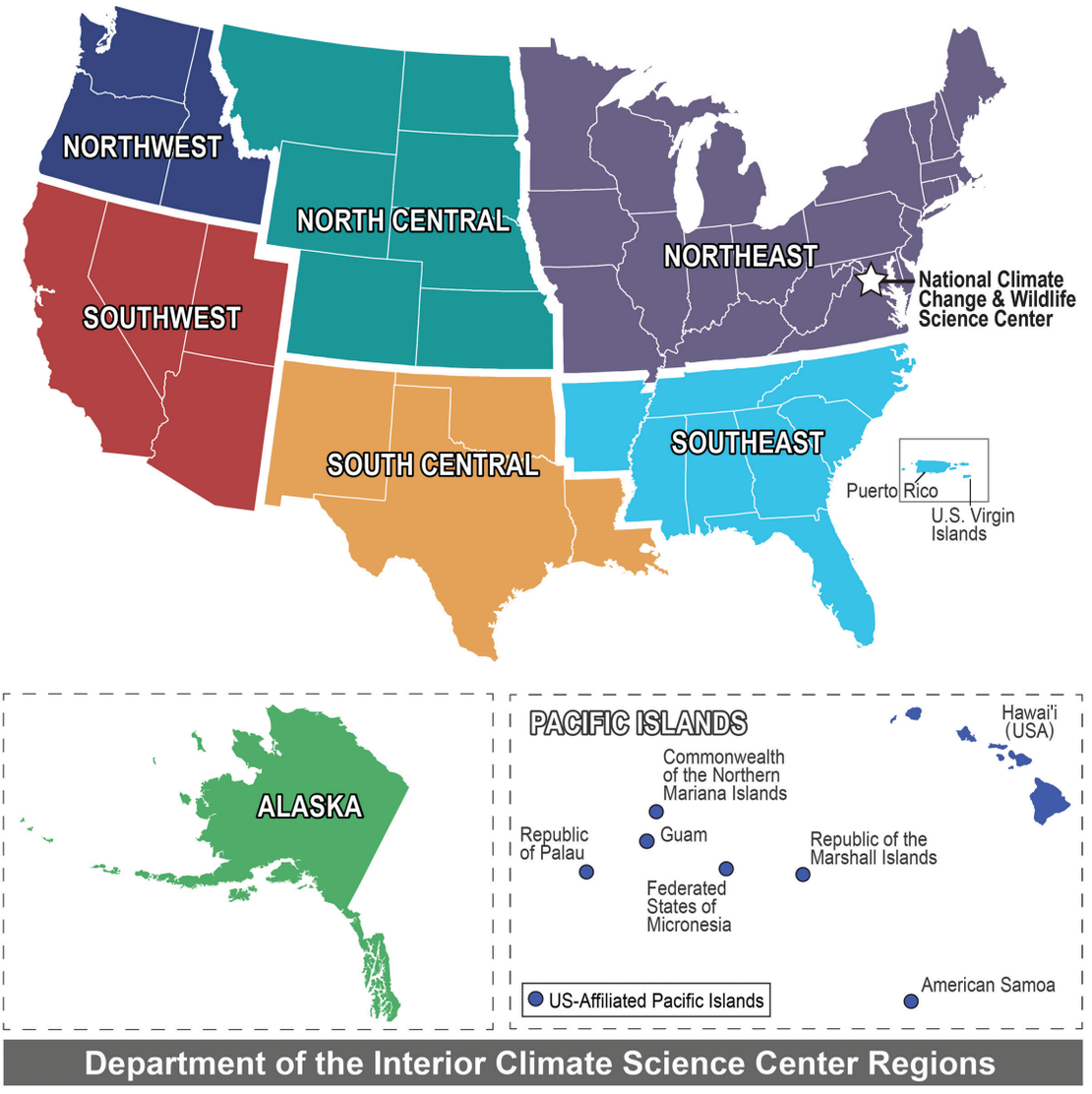
Five-Year External Reviews of the Eight Department of Interior Climate Science Centers

Southwest Climate Science Center



Department of the Interior Climate Science Center Regions

July 2017

American Fisheries Society
Cornell University Human Dimensions Research Unit

Suggested citation:

American Fisheries Society. 2017. Five-year external reviews of the eight Department of Interior Climate Science Centers: Southwest Climate Science Center. American Fisheries Society, Bethesda, Maryland.

Cover image: 2016 map of the Climate Science Center regions and consortia. U.S. Geological Survey, www.sciencebase.gov.

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

Southwest Climate Science Center

Science Review Team Members for the Northwest Climate Science Center*
James Leenhouts (Review Team Chair), U.S. Geological Survey Arizona Water Science Center
Gustavo A. Bisbal, Department of Interior Northwest Climate Science Center
Curtis Griffin, University of Massachusetts Amherst
Frances O'Donnell, Auburn University
Dave Rhode, Desert Research Institute
Jennifer Wilkening, U.S. Fish and Wildlife Service

Review Team Staff Resources
T. Bruce Lauber, Cornell University Human Dimensions Research Unit
Richard C. Stedman, Cornell University Human Dimensions Research Unit
Douglas Austen, American Fisheries Society
Andrew J. Loftus, American Fisheries Society

* After the Science Review Team chair, all Science Review Team members are listed in alphabetical order.

American Fisheries Society
425 Barlow Place, Suite 110
Bethesda, Maryland 20814

Contents

Acknowledgments

This review involved substantial effort and time commitments from numerous individuals, particularly members of the Science Review Team (SRT) who took time away from their jobs and professional commitments to prepare for the review, conduct a 3-day site visit, and assemble their findings into this report. Southwest Climate Science Center (SW CSC) staff devoted significant time to compile and provide necessary background material, hosted the week-long on-site review, answered follow-up questions, and provided substantive feedback to help improve the final report. In particular, we appreciate the contributions from Stephen Jackson, director of the SW CSC; Carolyn Enquist, deputy director of the SW CSC; Jonathan Overpeck, host-university director of the SW CSC/Institute of the Environment, University of Arizona; Christine Schirmer, University of Arizona; and Anita Govert, University of Arizona; as well as all of the SW 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 to share their experiences and opinions. Collectively, the information provided about the SW CSC throughout the review afforded a comprehensive overview of the center's first 5 years of operation. While the information provided to the SRT was extensive, we recognize the challenge of fully appreciating many years of accomplishments and challenges. We are, however, hopeful that the observations and recommendations of the SRT represented in this report are helpful to the SW CSC in continuing to realize its vision for collaborative climate science. 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. 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 Southwest CSC (SW CSC), established in 2011, is based in Tucson, Arizona, with the University of Arizona serving as host university, coordinating a consortium of five other academic/research entities spread throughout the region. The SW 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 complex, encompassing the states of Arizona, California, Nevada, and Utah, in addition to addressing issues in the upper Colorado River basin. Spanning 5 of the 22 Landscape Conservation Cooperatives (LCCs), two USGS regions, three U.S. Fish and Wildlife Service regions, four Bureau of Land Management regions, three Bureau of Reclamation regions, two National Park Service regions, three Bureau of Indian Affairs regions, and three U.S. Forest Service regions. Furthermore, the region includes more than 200 federally recognized tribes. The core funded staff include a USGS director, a deputy director, 0.1 full-time equivalent (FTE) of an administrative officer, and a 0.25 FTE postdoctorate position. The university staff was limited to 0.5 total FTE through fiscal year 2014 and, from 2015 to 2016, a partially funded director and 1.75 FTE for a communications officer and a grants administrator.

Like the CSC program as a whole, the SW CSC is an evolving enterprise, developing core strategies, concepts, and methods to evaluate successes as it builds a network of science producers and stakeholders/science users. Given this context of program growth and maturation, the SW CSC's scientific accomplishments are very strong. In the 5 years covered by this review, the SW CSC has brought together an internationally acclaimed group of climate scientists, successfully engaged numerous regional stakeholders to produce "Assessment of climate change in the Southwest United States" (Garfin et al. 2013; a comprehensive volume outlining stakeholder-relevant climate-impacts synthesis), and developed a solid working relationship between the university consortium partners. In 2015, the SW CSC engaged in two strategic planning workshops involving more than 60 individuals, but halted development of a full strategic plan pending completion of an overall NCCWSC plan. The review team recommends completing the development (and implementation) of this comprehensive regional strategic plan as a way to strengthen the integration of priorities of the key stakeholders into the SW CSC science agenda.

The SW CSC has incorporated knowledge coproduction into its strategic science agenda and has worked to foster this in the projects it has funded directly. The vast majority of the stakeholders surveyed by Cornell University as part of the review process agreed that the science produced through the SW CSC can contribute to policy or management. About three-quarters of the respondents felt that climate adaptation science in the Southwest region was available to decision makers, and many also believed that decision makers use the climate adaptation science to inform management. Nevertheless, many survey respondents believed that climate adaptation science did not influence management actions taken, although a majority also believed that the SW CSC had reduced the disconnect between scientists and decision

makers. 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. The survey found that factors most likely to limit science users' involvement in research projects were scientists not reaching out, different perspectives on what science is needed, and funders (not specifically CSC-funded research) not being supportive of collaboration between scientists and science users.

As required of all CSCs, the SW CSC has established a Stakeholder Advisory Committee (SAC) as a means to formalize stakeholder input into the science agenda. The SW CSC has clearly gathered the input of stakeholders from the SAC, and through a variety of other means at times when the SAC model did not work as successfully as planned. Emphasizing the purpose and role of the SAC, improving communications with all of the parties involved, and re-engaging SAC members (and member institutions) that have drifted away is likely to reinvigorate the SAC process as a structured means to incorporate stakeholder priorities as drivers of CSC research. Priorities obtained from the SAC can then be codified into an annual CSC work plan that drives both the research direction and other aspects of CSC work, such as plans for that year's outreach and communications. Strengthening the integration of stakeholder input into an annual work plan that drives the request-for-proposal process and university-directed research development process will make the subsequent research program more responsive to stakeholder needs.

The research projects supported by the SW CSC are impressive in scope and depth. Over the past 5 years, 31 distinct projects comprise the research portfolio spread across all but one of the research themes (SW CSC decided early on that it could not sustain long-term monitoring projects among its other program commitments). The review found that science productivity of the consortium was very strong, of high quality and relevance, with a concerted effort to translate the results into publications and presentations for both scientific and general audiences. The SW CSC is commended for pioneering social science research to promote and evaluate coproduction of actionable science.

The quality and credentials of the principal investigators (PIs) of research projects is highly acclaimed and effective. The review team recommends that the SW CSC and consortium leadership continue to increase diversity of institutional co-PIs, especially with respect to early career stage and other dimensions, and to find additional ways to enhance formal and diverse communication among consortium members at all levels to further grow the research community. Additionally, research projects would benefit from additional time and support to assist in the initial collaborative engagement between science users and producers to continue to maintain the actionable science objectives of the CSC network and foster the alignment of research with the management priorities of stakeholders. The completion and implementation of the aforementioned strategic plan may facilitate this engagement. The process of actionable science should be integrated into all aspects of the research enterprise and documented to show that the elements have been met, with continuous stakeholder engagement and communication and, where possible, technical assistance provided to apply the results.

The SW CSC has made significant contributions to increasing collaboration among scientists, awareness of available science, and interdisciplinary science. The review team commends the SW CSC for developing a robust Fellows Program within the past year; all institutional partners must invest and engage in this program to be successful. The coordination and oversight of postdoctoral researchers across the partner institutions is an important need to improve coordination and accountability of the postdocs across the consortium.

The SW CSC is to be commended on their active engagement with the Native American communities of the Southwest region. The programs supported by the SW CSC to strengthen Native American tribal involvement and planning offer great opportunities to better integrate their research and management priorities. A formal tribal engagement strategy, perhaps as part of a fully implemented strategic plan, that provides a better description of roles, responsibilities, and approach for tapping the resources available

(particularly the Climate Adaptation Science and Solutions, the Native Nations Climate Adaptation Program, and the Tribal Liaison) could further develop the effectiveness of this relationship.

While the SW CSC has demonstrated substantial engagement of LCCs, a need exists to clarify the complementary roles of LCCs and CSCs, as some confusion occurs with stakeholders. Tapping additionally into the inherent leverage that LCCs can provide will strengthen outreach with state and local agencies and other entities (nongovernmental organizations, other federal agencies, etc.) and will be a step towards improving an apparent weakness in the direct connection with management agencies. The USGS Cooperative Fish and Wildlife Research Units offer one conduit for state management agencies since, by the very nature of their mission, these units are tasked with working with state agencies on applied, cooperative research. Additional leveraging opportunities for reaching diverse stakeholder groups (in several aspects) will be found by engaging the full science and extension capacities within host institutions and across USGS CSCs.

In 2015, the SW CSC developed and implemented a strategic communications and outreach plan, which has established a solid footwork for communications moving forward. The review team recognizes the challenge of limited staff resources available for the crucial task of maintaining strong outreach efforts to a broad and diverse set of audiences, including decision makers. Implementation of this communications plan may be enhanced by leveraging and strengthening the connections with participating university consortium organizations and other professionals and networks who communicate science to diverse audiences beyond the reach of the SW CSC program. Additionally, the overall communications strategy may benefit by refocusing the annual report to directly targeting stakeholders, with messages connecting annual science plan objectives, realized outcomes, and stakeholder engagement. The SW CSC needs to be able to demonstrate that CSC funds support projects that are relevant to and applied by stakeholders.

In summary, the SW CSC was established with a proposal to bring to bear the capacities of major southwestern research institutions and the USGS to develop the science needed for climate-related resource management decisions using a stakeholder-driven process. In general, this review confirms that the SW CSC has established a mechanism and infrastructure that accomplished this goal. In doing so, the SW CSC has helped to generate a strong and diverse portfolio of climate science directly relevant to the varied environmental challenges of an extremely diverse region. The full review report provides details and many more observations about the first 5-year cycle of the SW CSC's program and recommendations to strengthen future planning and execution.

Abbreviations and Acronyms

ACCCNRS	Advisory Committee on Climate Change and Natural Resource Science
AFS	American Fisheries Society
BIA	Bureau of Indian Affairs
CCASS	Center for Climate Adaptation Science and Solutions
CFWRU	Cooperative Fish and Wildlife Research Unit
CLIMAS	Climate Assessment for the Southwest
CLU	Climate and Land Use Change
CNAP	California-Nevada Applications Program
CSC	Climate Science Center
CSC-Federal	Federal USGS-staffed component of the CSC
CSC-University	Host-university component of the CSC
DOI	U.S. Department of Interior
DRI	Desert Research Institute
ENR2	Environment and Natural Resources 2 building
F&A	facilities and administrative
FG	focus group
FY	fiscal year
HDRU	Cornell University Human Dimensions Research Unit
LCC	Landscape Conservation Cooperative
NCCWSC	National Climate Change and Wildlife Science Center
NGO	nongovernmental organization
NNCAP	Native Nations Climate Adaptation Program
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
PI	principal investigator
Q&A	questions and answers
RFP	request for proposal
RISA	Regional Integrated Sciences and Assessment
SAC	Stakeholder Advisory Committee
SINs	Scientific Information Needs
SIO	Scripps Institution of Oceanography
SRT	science review team
SSA	Strategic Science Agenda
SW	Southwest
SW CSC	Southwest Climate Science Center
TOR	Terms of Reference
UA	University of Arizona (host institution of SW CSC)
UCB	University of Colorado-Boulder
UCD	University of California-Davis
UCLA	University of California-Los Angeles
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service

List of Figures

List of Tables

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 the 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 Southwest Climate Science Center (SW 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 CSCs to ensure that established goals and obligations under the hosting agreements were being met, as well as to identify obstacles and areas of improvement for the CSC as a whole.

This report covers only the findings from the programmatic evaluation of the SW 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). The mission statements of the NCCWSC and the CSCs 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).

[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.

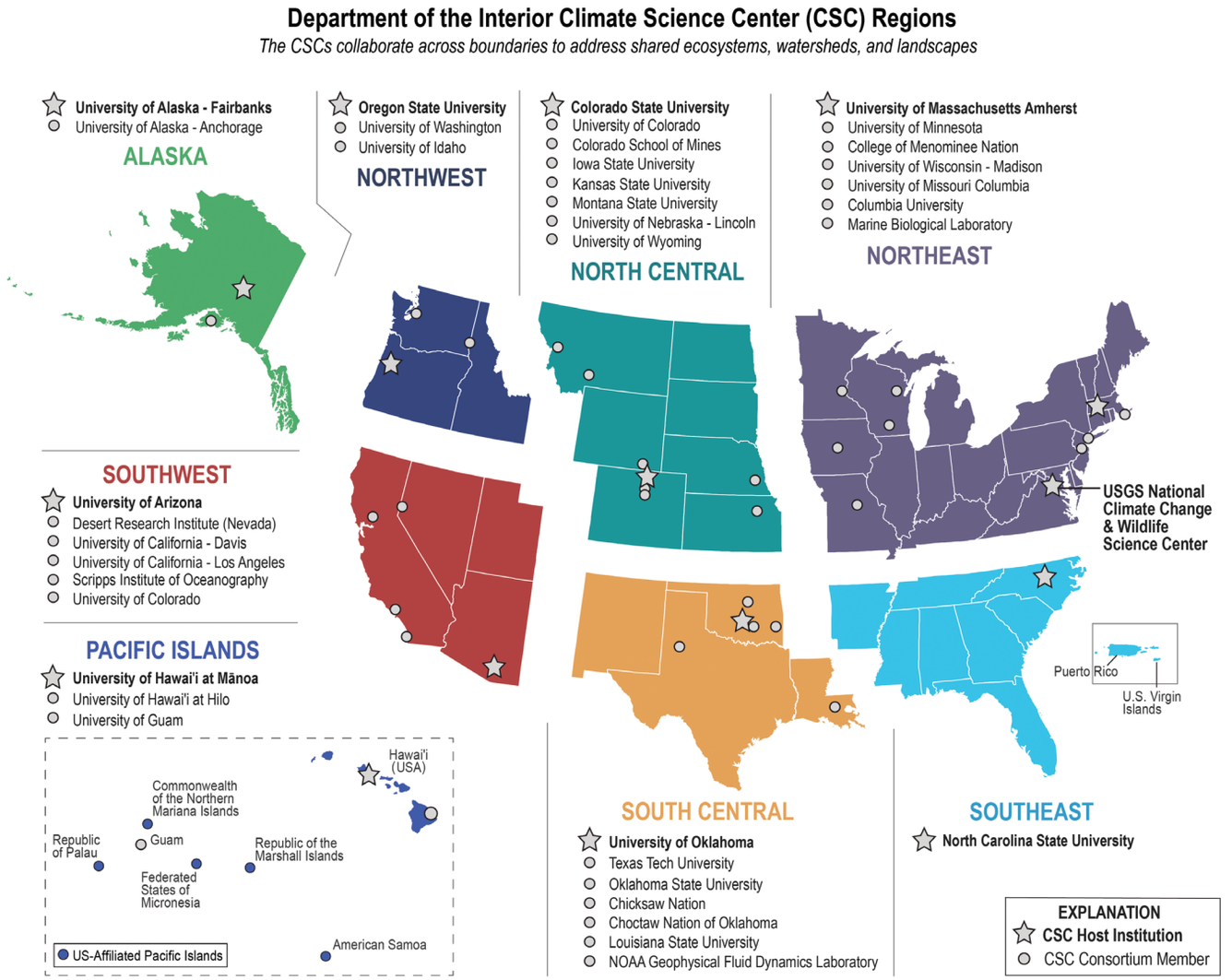


Figure 1. Map of the eight Climate Science Centers and consortia.

The NCCWSC-proposed 5-year strategy (2009–2014) was developed to guide the efforts of the NCCWSC–CSC network (USGS 2009). The plan states three basic goals:

- 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, regional, 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 NCCWSC proposed 5-year strategy 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 unprecedented collaboration across jurisdictional boundaries (Figure 2).

The process of identifying the CSCs began in fiscal year (FY) 2010 with the identification of the University of Alaska as the location of 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 FY2010 funds (NCCWSC 2011). Implementation of the Southwest and North Central CSCs was delayed by the late passage of appropriations legislation for FY2011, 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 is intended to provide a vehicle for building collaborative partnerships, identifying key regional science priorities, and communicating and coordinating results and objectives across regional stakeholder agencies and organizations. NCCWSC established a set of guidelines (CSC SAC Terms of Reference [TOR]) which defines membership, primary purpose, and other operating guidance (NCCWSC 2014). As outlined, the CSC federal director, with input and guidance from its SAC, is to develop 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 should be 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 single land-management agency unit.

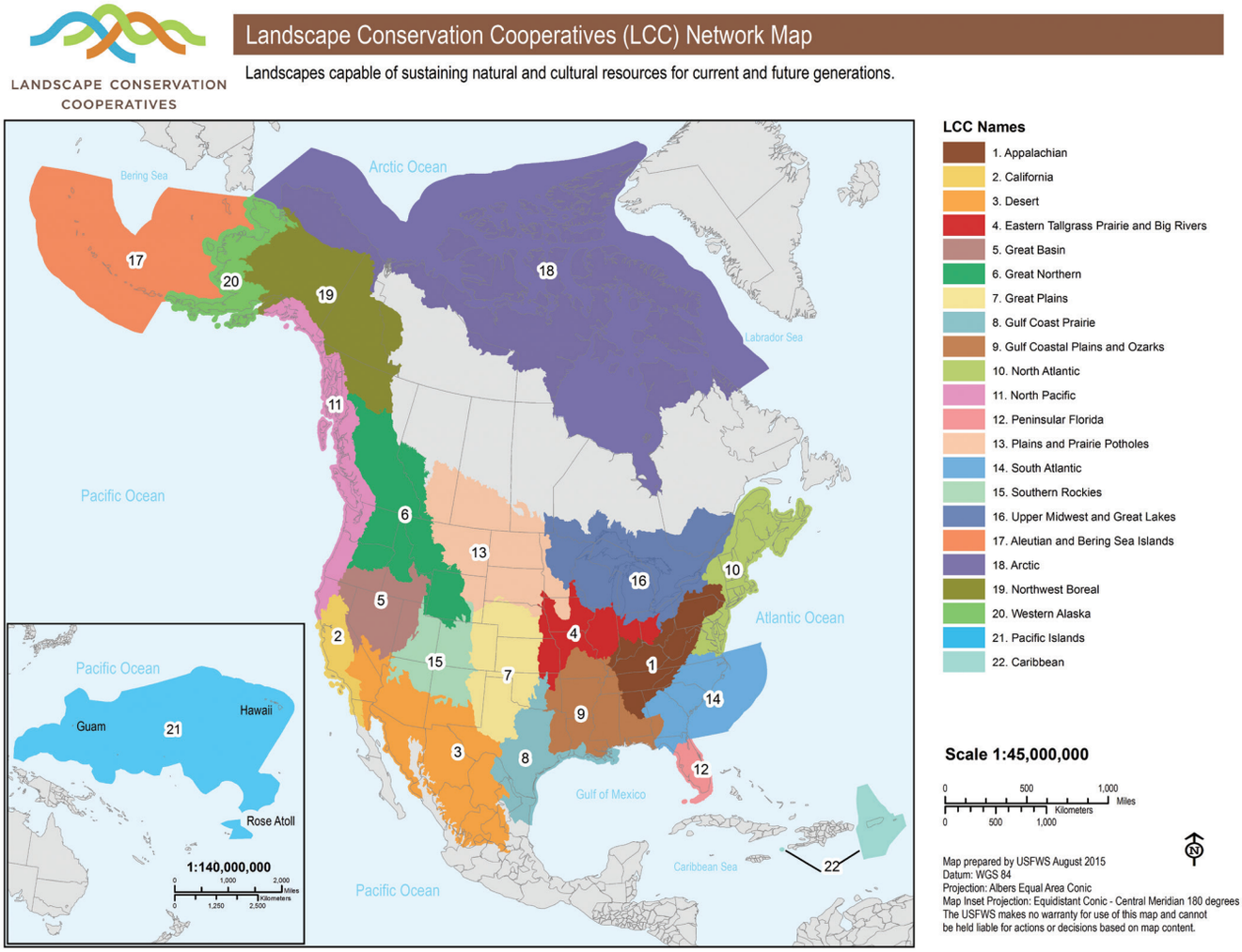


Figure 2. Map of the 22 Landscape Conservation Cooperatives.

Review Process

Roles of AFS, the HDRU, and NCCWSC

The CSC evaluation 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 host university, 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 all current and past CSC partners in each region to identify patterns of engagement with the CSCs, as well as barriers to engagement.

The SW CSC on-site review was conducted over a period of 3 days (February 14–16, 2017) in Tucson, Arizona, on the campus of the University of Arizona; Appendix B). The review process was designed to develop a full understanding of the SW 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 standard 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 in the review findings, the SW CSC developed a region-specific strategic science and operational plan and annual work plans. These 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).

In the "Report to the Secretary of the Interior, March 30, 2015" (ACCNRS 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.

While the ACCCNRS report was released several years after the formation of the CSCs and therefore cannot be applied as a definitive measure of effectiveness to the CSC's in retrospect, these general categories provide a useful framework under which to organize review findings and are applied in this report. Although the SW CSC initiation predates the ACCCNRS report, the original SW CSC project proposal highlights themes of partnerships and stakeholder-driven climate science, which are further developed but consistent with the ACCCNRS framework.

Survey and Focus Group Methodologies[2]

The partnership evaluation component of the CSC review, conducted under the lead of the HDRU, 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 SW 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 SW CSC. Two groups were included: science producers (or science partners) and science users (or conservation partners).

Participants were recruited by the SW CSC, with guidance from the HDRU, with the intent to include participants representing 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 SW CSC. Participants in the science users group included representatives of agencies intended to benefit from the science produced by the SW CSC, including the LCCs, federal natural resource agencies, state fish and wildlife agencies, tribal organizations, and NGOs. A total of 29 individuals participated in the two group interviews during the on-site visit, including 15 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 SW CSC and the factors that influenced the ability of the SW CSC to work with their partners. The specific topics of questions focused on how participants have worked with the SW CSC, reasons for becoming involved with the SW CSC, benefits of involvement with the SW CSC, challenges to involvement, and what the SW CSC could do to promote even more benefits from involvement.

Particular focus was placed on exploring how the SW 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 SW CSC in connecting them.

Web-based survey.—A standardized, Web-based survey of partners and potential partners of the CSCs was conducted (referred to herein as the 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. The HDRU survey of the Southwest region was sent to a total of 211 individuals, with 135 responding. The survey documented the ways in which partners were engaged with the SW 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

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

- 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 our 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 on February 7, 2017.

Institutional Development

The institutional development evaluation measures the overall health of the SW CSC as an institution, 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 and with other federal agencies) (ACCNRS 2015).

Overview of the SW CSC

The SW CSC is hosted by the University of Arizona (UA) in Tucson, Arizona and resides on campus in the recently constructed LEED Platinum-certified Environment and Natural Resources 2 building (ENR2) along with the Institute of the Environment, the School of Geography and Development, and the School of Natural Resources and the Environment. The University of Arizona serves as the Land Grant institution within the Arizona university system and, accordingly, has within its mission a focus on serving communities and addressing important societal concerns. Natural sciences at UA are globally recognized, and collectively, the organizations within and associated with the university enable substantial capacity for development of basic research and stakeholder-driven climate science. Within the UA system, many programs and resources exist that are highly complementary to the mission and principles of the CSC, including

- The Institute of the Environment
- Center for Climate Adaptation Science
- The Native Nations Climate Adaptation Program
- Climate Assessment for the Northwest (CLIMAS; National Oceanic and Atmospheric Administration [NOAA] Regional Integrated Sciences and Assessment [RISA])
- Tree Ring Laboratory

- Cooperative Extension
- The School of Natural Resources and the Environment
- Department of Geography
- Geosciences Department
- Department of Hydrology and Atmospheric Sciences
- Department of Ecology and Evolutionary Biology
- Department of Anthropology

In addition, several federal science agency offices are headquartered or have scientists in the ENR2 building, in the neighboring Environment and Natural Resources 1 building, or in close proximity to campus, including

- NOAA National Weather Service
- U.S. Department of Agriculture (USDA) Agricultural Research Service Southwest Watershed Research Center
- USGS Arizona Water Science Center
- USGS Southwest Biology Science Center
- USGS Western Geographic Science Center
- USGS Geology, Minerals, Energy, and Geophysics Center
- USGS Cooperative Fish And Wildlife Research Unit
- USFWS Desert LCC science coordinator

The SW CSC resides organizationally under the NCCWSC within the USGS Climate and Land Use (CLU) mission area. The SW CSC federal director reports directly to the office of the chief of NCCWSC. As a result of this organizational schema, the SW CSC's strategic and science goals must fit within the established science strategies of both CLU and NCCWSC. A guiding principle prominent in both CLU and NCCWSC strategy documents, consistent with the overall mission of the USGS, is that the science produced must inform the decision-making processes of natural and cultural resource managers and decision makers across the United States. This principle is consistent with the vision stated in the original SW CSC proposal to start with "a model of stakeholder-driven, linked work that seeks to empower the right science needed for resource management decision-making."

The geographic area covered by the SW CSC formally comprises the states of Arizona, California, Nevada, and Utah. However, because the Southwest is heavily dependent on streamflow from the Colorado River basin, the SW CSC also addresses the upper Colorado River basin. The geopolitical domain of this region's geographic area is complex, spanning 5 of the 22 LCC regions, two USGS regions, three USFWS regions, four Bureau of Land Management (BLM) regions, three U.S. Bureau of Reclamation (USBR) regions, two National Park Service (NPS) regions, three Bureau of Indian Affairs (BIA) regions, and three U.S. Forest Service (USFS) regions, none of whose regional divisions map precisely onto any of the others. Furthermore, the region includes more than 200 federally recognized tribes.

Intrinsic to each CSC is a collaborative partnership with academic institutions selected through a competitive process subject to recompetition on a 5-year cycle. The SW CSC collaborative is hosted by the University of Arizona in Tucson and includes within its academic consortium the Desert Research Institute (DRI), University of California–Davis (UCD), University of California–Los Angeles (UCLA), Scripps Institution of Oceanography (SIO), and the University of Colorado–Boulder (UCB). Similar to the capacities that can be leveraged at UA, each of these other institutions brings additional capacities to the SW CSC enterprise that the SRT was unable to fully address.

Funding for the SW CSC consists of two sources: an annual allocation from USGS to support strategically important scientific activities that address regional science priorities at UA (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) 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.

The core funded staff of the SW CSC on both the federal and university sides are responsible for successful execution of the SW CSC's science mission, including management, administration, science planning, communications, agency coordination, and aspects of stakeholder interaction, among other tasks, The core funded staff on the federal side include a director, a deputy director, and 0.1 full-time equivalent (FTE) of an administrative officer and a 0.25 FTE postdoc. The university staff were limited to 0.5 total FTE through fiscal year 2014, after which the federal director reallocated research funding to support additional university support. Current SW CSC university staff support includes a partially funded director and 1.75 FTE for a communications officer and a grants administrator.

SW CSC Operational and Strategic Planning

Since its establishment in 2011, the SW CSC has operated under the guidance of a Strategic Science Agenda (SSA) and a series of tactical work plans. The CSC has also made significant efforts to establish a broader strategic plan to focus the center's efforts to achieve the most valuable outcome for science users.

Strategic science agenda.—The SSA, released in 2013, provides a 3-to-5-year outline of operational components such as the SW CSC's relationship to a SAC, establishes a climatic context of the Southwest, and, importantly, describes the vision, guiding principles, goals, and strategic research themes for the SW CSC. The vision and guiding principles described in the SSA clearly (and explicitly) articulate a focus on collaborating with stakeholders in the coproduction of knowledge that will effectively serve resource-management needs. The SRT commends the CSC for this prioritization of actionable science with stakeholder collaboration in its SSA.

The SSA defines five broad research themes that were developed following consideration of input from several sources. A key function of the SSA is to connect the management priorities and needs of resource managers to the science directions of the SW CSC. Prior to the release of the SSA, staff from the SW CSC compiled an extensive list of climate-driven management challenges and associated science needs from a total of 54 sources, including publications, workshop notes, Web sites, white papers, existing RFPs, and interviews. In total, 343 needs were identified. Those needs were then grouped into 10 categories that had been previously identified by the SW CSC SAC, plus an additional 15 categories. From this set of 25 needs categories, a set of eight stakeholder Scientific Information Needs (SINs) were developed and articulated in the SSA. These SINs were then cross-linked to the main SW CSC research themes, which are the main priorities for funding scientific support, as first presented in the 2013 SSA. Prioritization for funding specific research themes has shifted over the years, and the SINs were revised for the most recent (2017) RFP process based on SAC input. While the SW CSC has prioritized use-inspired science in addressing the stakeholder needs, both basic and user-driven research are supported within the themes.

The SW CSC has or will have available valuable assets for integrating actionable science and/or knowledge coproduction into its next SSA or strategic plan. Key among these are the investment that the SW CSC has made into social science research to assess several modes of climate science coproduction from its funded projects. The outcome of this research may offer an opportunity to directly include approaches for coproduction into the strategic planning and operational planning of the next SW CSC research agenda.

Science work plans and annual report.—On a more tactical basis, the SW CSC has produced several science work plans that draw from the themes of the 5-year SSA to define specific research goals for each fiscal year. They have produced these work plans for FY2013, FY2015, and FY2017 to inform that year's research focus. Generally, these work plans have been prepared prior to the release of an RFP. The science

work plans also describe operational aspects of the SW CSC, such as workforce planning and stakeholder engagement plans to help implement aspects of the SSA in a given fiscal year. The SRT noted that producing these documents as annual work plans consistently from year to year and early in the fiscal year would provide an early signal regarding the kinds of activities that the SW CSC intends to engage in and extend a timely opportunity for partners to collaborate and coordinate more effectively regardless of whether an RFP is planned. Such annual work plans (as opposed to science work plans) should broadly encompass the tasks planned by the SW CSC, including not only science themes but also outreach, communications, workshops, and so forth.

The SW CSC has produced four annual reports (FY2011–2012, FY2012–2013, FY2013–2014, and FY2014–2015) that document a variety of accomplishments in the reporting period, including milestones, awards, honors, presentations and outreach, and professional development. The annual reports also provide a summary and updates about the various ongoing research projects supported by the CSC and a bibliography of publications. The SRT found these reports to be informative, visually compelling, and a valuable means of documenting and communicating the annual accomplishments of the SW CSC. The SRT recommends coordinating the frequency, contents, and timing of the science work plans (prepare them annually) and annual reports such that each year's pair of documents facilitate a process of planning and reporting.

Strategic plan and communications and outreach plan.—When Director Stephen Jackson assumed his position in 2012, NCCWSC required the development of the SSA but not a strategic plan. Although not required, and in advance of any direction from NCCWSC, in 2015 the SW CSC engaged in two strategic planning workshops hosted (pro bono) by Anthros Consulting and involving more than 60 individuals. The participants represented the complex of communities with which the SW CSC was engaged, including

- Key stakeholders (LCCs, SAC members, regional executives, and unit managers),
- Key partners (LCCs, Regional Integrated Sciences and Assessment [RISAs], USDA hubs, etc.),
- University PIs (seven of the nine consortium PIs),
- Researchers (USGS and university) funded by the SW CSC,
- Other CSC directors and staff,
- NCCWSC senior leadership,
- USGS regional leaders (regional executives, CSC directors), and
- ACCCNRS members (including two chairs).

The purpose of these workshops was to gather stakeholder input into the most valuable roles that the SW CSC can fulfil to users of science-based climate adaptation information for use in framing the strategic plan. Five probable end states were developed describing a range of possible futures for the role of the SW CSC, in the coproduction of actionable science. The broad consensus from all of the participants in this process indicated that the SW CSC needed to play a role in all five of these end states, but should place greatest emphasis on three (knowledge coproduction, leadership in relevant science, and convening of diverse groups of stakeholders and researchers).

Complete development of a comprehensive strategic plan may strengthen the integration of priorities of the stakeholder advisory committee and key stakeholders into the SW CSC science agenda, more so than they already are.

In March 2016, the SW CSC received guidance from NCCWSC to suspend strategic plan development until completion of a NCCWSC network plan. Accordingly the SW CSC has as yet been unable to fully realize the value of its planning process as an implemented plan.

Operational and Strategic Planning Recommendations

- Use lessons learned in practice about effective knowledge coproduction during the SW CSC's first 5 years to develop specific strategies in the next SSA that institutionalize the link between priorities of resource managers and the SW CSC science capacities.
- Leverage both SW CSC-supported ongoing social science research regarding knowledge coproduction and the completed strategic planning workshops to inform the development of a strategic plan, timed as determined by NCCWSC, and the next SSA for the SW CSC.
- Build on the unique capacities afforded by the SW CSC's tribal liaison, UA's Center for Climate Adaptation Science and Solutions (CCASS), and the Native Nations Climate Adaptation Program (NNCAP) to link the capacities and information needs of Native nations into the CSC's strategic thinking and operations.
- During the next 5-year period, increase focus of science work plans and annual reports on the tactical realization of strategic approaches to coproduction of climate science and adaptation. Recognizing the limitations of staff resources, the production of annual work plans paired with the annual reports is strongly encouraged to connect planning and reporting of the many activities of the SW CSC—research, communication, education, coordination, data management, and so forth—within the scope of work of the university and federal components of the SW CSC.
- Annual work plans should be released as close as possible to the beginning of the federal fiscal year (October 1) to maximize activities prior to the generation of an annual report. Work plans should contain metrics within each activity category in order to facilitate performance evaluation by multiple interested parties.
- Further engage the university PIs in the development of science strategies to address management priorities identified by the SAC and other resource management interests.
- Include the capacities of both university consortium and USGS CSCs in the development of strategies to address critical resource management priorities.

The SW CSC should consider the production of an annual work plan and refocus the annual report to emphasize stakeholder engagement.

SW CSC Stakeholder Advisory Committee

The Stakeholder Advisory Committee is a construct that assembles diverse regional federal, state, and tribal natural and cultural resource management interests in each CSC across the nation. All SACs operate and respond according to generic TOR drafted by NCCWSC in 2014. The SAC for the SW CSC is chaired by the USGS Pacific regional director; membership includes representatives of five LCCs, relevant DOI agencies, the USFS, Environmental Protection Agency (EPA), Department of Defense (DoD), tribal representation, California Departments of Fish & Game and Water Resources, and the Nevada Division of Wildlife. The SAC assists the SW CSC by informing them about current and anticipated priorities of resource-management agencies within the geography of the SW CSC from the "30,000 foot" perspective. Meetings of the SAC are scheduled annually, with one conference call between meetings. In practice, the face-to-face meetings have occurred every 1.5 to 2 years. The SRT perceives that the SAC was more engaged at the initiation of the SW CSC, when it provided assistance in developing the SSA, but that engagement likely diminished for a time in part due to limited funding or perhaps changing priorities of members as the SW CSC was "spun up" in operation. The SW CSC has, however, accomplished additional outreach to stakeholders through other means.

Recently, the federal director and SW CSC staff have worked to increase SAC engagement and therefore the value of the SAC in a variety of ways, including strategic appointment of new members as op-

portunities arise. Additionally, the SW CSC took a different approach to the most recent SAC meeting by holding a 2-day facilitated workshop with the goal of identifying management priorities of member agencies as part of the coproduction process. Included in that process was an innovative "3 × 3" pre-meeting "homework" assignment to the SAC members to improve their engagement and readiness for the meeting. That effort appears to have yielded benefits and represents a positive development in the relationship with and value offered by the SAC.

The SRT appreciates the challenges inherent in engaging with and extracting feedback from a large, diverse advisory body such as the SAC and recognizes the efforts the CSC has put into the relationship. Nevertheless, the SRT believes that additional potential exists to use the membership of the SAC to inform and advance a stakeholder-driven agenda of actionable science. The SAC is unique in its potential to foster a collective regional dialog about resource management priorities for the entire geographic area of the SW CSC. Perhaps the most important input that the SAC could provide is information regarding regional resource-management priorities and an assessment of how effectively those priorities are actually addressed by the science themes. It did not appear to the SRT from information received during the review, however, that the SAC has consistently provided this type of input. Absent a formal closure of this process where identification, categorization, bundling, splitting, and permutation of resource-management priorities took place, it is not intuitive whether the final outcomes are truly reflective of the collective management interests represented at the SAC. The focus groups also supported this finding with a statement that "the challenges in generating products that decision makers would find useful is aggravated by an ineffective system for identifying stakeholder priorities." A comprehensive knowledge of the state of climate science as well as science opportunities is essential to identifying and articulating a strategic approach to developing science appropriate to addressing critical resource-management priorities.

SAC Recommendations

The SAC provides an important opportunity for the SW CSC to engage the stakeholder community in developing actionable science and knowledge coproduction from a broad perspective. The assessment of the SRT is that the SAC is currently an underutilized resource. Although the SAC represents only one vector of input from among several, it is unique in its ability to provide a broad, high-level agency perspective on critical resource management needs that can help shape the science agenda of the SW CSC. Specific recommendations include the following:

- Clarify the purpose and role of the SAC and better communicate to all of the parties involved. Even though this may have been done in the past, discussions with SAC members demonstrated uncertainty, lack of clarity, or lack of concurrency between the TOR and the expectation or the desires of the SAC members.
- Actively engage the entire SAC in an effort to clearly articulate concrete management priorities for the Southwest Region as they pertain to climate impacts and adaptation. These management priorities should, in turn, become the drivers of the science portfolio administered at the SW CSC.
- Continue ongoing efforts to actively engage members of the SAC, including participants from regional LCCs, federal, state, tribal. and local resource managers as a part of the strategy for knowledge coproduction.
- Continue, and enhance where possible, SAC engagement by increasing the overall level of communication, for example with webinars of ongoing project work and newsletter updates.
- Develop an atmosphere of collective participation and shared ownership by engaging the SAC annually in the development and review of the annual work plan and corresponding annual report. As appropriate, invite their review, comment, and discussion of new versions of the SW CSC's strategic plan, its SSA, and any other strategic documents central to determining the SW CSC's proposed directions and activities.

- Continue to strategically fill SAC positions with agency representatives known to be responsive and well connected to the resource management questions within their domain.
- The SRT commended the preparation of recent SAC meeting with specific "homework assignments" so that members arrive prepared to provide the feedback critical to informing the management priorities of relevance to the SW CSC and encourage the continuation to improve engagement and effectiveness of the SAC.

Funded projects would benefit from greater alignment with the research and management priorities of stakeholders and more effective inclusion/engagement of the stakeholder advisory committee and key stakeholders.

Other Advisory Committees

In addition to the SAC, the SW CSC has wisely, and by necessity, developed other approaches to stakeholder engagement. Although the SW CSC does not have additional formal advisory committees, it has actively developed close working relationships with other science and resource-management groups in its geographic scope. In particular, the SW CSC works closely with five LCCs represented on the SAC. The SW CSC federal director is an ex officio member of each of the LCC steering committees and a SW CSC representative actively participates in LCC meetings. In order to provide the LCCs with an opportunity to assist in the selection of funded projects, all five LCCs are offered representation on scientific and proposal reviews.

The SW CSC is colocated in the same building as the NOAA RISA CLIMAS. It was clear that relationships exist between the two entities, although the SRT had insufficient information to assess this relationship or make recommendations on how to capitalize on opportunities more effectively.

The SW CSC maintains an active relationship with the USDA Southwest Climate Hub and California sub-Hub. The Southwest Climate Hub is represented on the SAC and the SW CSC federal director is a member of the Southwest Climate Hub's Advisory Committee. In addition, Southwest Climate Hub staff members participate in the selection of research projects through proposal reviews. Other stakeholder engagement occurs informally through direct interactions with state and federal agency representatives, tribal members, various NGOs, and university consortium PIs, and through professional conferences.

The SW CSC has also hosted two large (120 and 250 participants) Southwest climate summits. These summits are scheduled to occur every 3 years and serve to bring together resource managers and scientists from various agencies, tribes, and NGOs, and from the private sector. The summits provide a forum to share resource management needs and science findings and capacities and to build networks among the climate adaptation network, and they appear to have been well attended and effective at achieving their purpose.

Other Advisory Committees' Recommendations

- Vertically integrated engagement with resource management agencies is essential to the effective assessment of management priorities; the SW CSC should continue to develop informal relationships with these organizations and others that would find value or contribute to the work of the SW CSC.
- The SW CSC has made commendable progress in effectively engaging the relevant LCCs outside of the SAC process. However, the roles and relationship of CSC and LCCs specific to needs within the Southwest region should be better defined to provide clarity for all stakeholders.
- To the degree that the SAC's effectiveness is limited in identifying regional management priorities and facilitating actionability, enhance investment in the relationships with LCCs and other stakeholder groups.

- Continue to capitalize on the significant investment that the LCCs make in bringing stakeholders and their management issues to the table
- Direct connections with resource managers by consortium members could be further developed.

The USGS has demonstrated good engagement of the LCCs, but the complementary roles of the LCC and the SW CSC should be better defined and articulated for the benefit of southwestern stakeholders.

Institutional Coordination

Climate-driven natural resource management issues in the Southwest reflect the great diversity and complexity of environments, ecosystems, land ownership, and land management objectives in the region, as well as vulnerability of sensitive systems to climate impacts. From its outset, the leaders of the effort to establish a SW CSC recognized that no one agency, organization, or institution possessed the capacity to develop actionable science outcomes at the scale and topical diversity demanded to address the region's complex issues. Accordingly, the proposal to establish the SW CSC included a consortium of six core host institutions from across the region, plus additional partner institutions, each bringing complementary capacities to the enterprise to work with USGS and the resource managers of the region to address climate issues. The University of Arizona serves as the primary academic host of the SW CSC and the physical location of the SW CSC offices for the directors, as well as administrative and support staff.

USGS and university host.—The colocation of the SW CSC with UA's Institute of the Environment and other groups has resulted in the federal and academic aspects of the SW CSC being effectively integrated together in the academic setting and has been provided excellent office and collaborative space. The SW CSC federal director holds adjunct positions in both the Geosciences Department and the School of Natural Resources and the Environment. The SW CSC university director holds regents' professor joint appointments in the Geoscience and Hydrology and Atmospheric Science Departments and serves as the director for the Institute of the Environment.

The University of Arizona is recognized widely for the strength of many of its programs in natural sciences and has a reputation for supporting the sort of collaborative, interdisciplinary research needed to successfully execute many climate-science projects. A number of departments and collaborative groups at UA share components of the SW CSC's goals and offer the potential for leveraged opportunities. Included in these are the Institute of the Environment, CLIMAS (NOAA RISA), the UA Center for Climate Adaptation Science and Solutions (CCASS), and the Native Nations Climate Adaptation Program (NNCAP). On the UA side, the SW CSC is integrated into the Institute of the Environment, which provides organizational support and serves as a pathway for accessing other climate science and adaptation-related capacities on campus. The SRT observed that the representative from CCASS expressed that the CSC helped build a nexus of collaboration with a mix of sources of funding but a broad common vision. The SRT commends this atmosphere of building on the collaborative opportunities intrinsic to the UA community.

The SRT observed a close and functional relationship between the federal and the UA SW CSC staff, who appeared to work together seamlessly. The relationship between Directors Jonathan Overpeck and Jackson is built on mutual respect, common goals, and effective communication. The university director's funding support from the SW CSC of approximately 1 month annually has the potential to be limiting, but the depth and degree of actual engagement appeared to exceed the funded time. Southwest Climate Science Center staff identified significant administrative and bureaucratic challenges particularly relating to execution of grants. The recent hiring of staff both on the USGS and UA sides of the SW CSC appear to have at least partially alleviated these challenges.

University consortium.—The broader university consortium brings to the SW CSC enterprise research expertise representing a wide range of southwestern climate-related issues. The consortium of DRI, UCD, UCLA, SIO, and UCB include three land-grant universities, the Western Regional Climate Center, and all three of the RISA programs in the Southwest. Collectively, the co-PIs at these institutions possess the capacities and connections to conduct and implement actionable climate science to address a variety of resource manager priorities.

The SRT interaction with representatives of the universities in the SW CSC consortium suggested that the overall team enjoys active, collegial collaboration, and communication built on relationships that far predate the SW CSC. Such communication occurs at several levels, including on a project-to-project basis, through informal interactions and through monthly calls that include the PIs, postdoctoral associates, and graduate students. All PIs at the SW CSC are also widely respected scientifically and well connected to the climate-science community. The SW CSC program of research has provided opportunities and opened doors for early-career scientists, and the SRT strongly encourages the SW CSC PIs to continue to expand the engagement of early-career scientists into the broader consortium coordination to strengthen future collaborative climate science.

An important example of successful collaboration on the part of the consortium PIs is the preparation and release of the Assessment of Climate Change in the Southwest United States. This document fed into the National Climate Assessment and represents a comprehensive compilation of climate-science information and interpretation crossing disciplines from across the Southwest region, intended to assist resource managers in making informed decisions. The effort also helped build effective partnerships across the consortium and engaged both senior researchers and early-career scientists.

The SW CSC planning documents indicate that, in addition to the core university consortium, several partner institutions play a role, including Arizona State University; Northern Arizona University; University of California–Merced; University of Nevada–Las Vegas; NASA Ames Research Center; and the U.S. Institute for Environmental Conflict Resolution. Collectively, these institutions, together with the consortium institutions, represent both a large capacity to conduct climate science and a large number of organizations to coordinate. The SRT recognizes the challenges of collaborating beyond the funded core group of universities but did not see much evidence of significant participation by these other partner institutions. As the SW CSC matures and moves into its next phase, the SRT recommends exploring the collaborative opportunities and capacities at these additional institutions. Representation in the consortium by one or more institutions from Utah is also desirable.

The university consortium partners have developed a good working relationship with each other under the umbrella of the SW CSC.

SW CSC with federal, state, local, and tribal partners.—Each of the consortium universities is engaged in numerous science and research programs predating or unrelated to the SW CSC with various DOI agencies, including the USBR, BIA, BLM, NPS, and USFWS, as well as non-DOI agencies such as the USFS. In addition, consortium members have pre-existing partnerships with multiple state and local resource-management agencies and organizations. The University of Arizona has particularly strong tribal nations programs. The SRT had limited opportunity during the review to assess how these pre-existing relationships are leveraged into successful actionable climate science implementations. Proposals funded through the RFP process, however, do include a number of agencies as partners. Perhaps the most institutionalized engagement with other partners is through the participation of CW CSC staff with the five LCCs represented on the SAC.

The SW CSC would benefit from stronger relationship with the USGS Cooperative Fish and Wildlife Research Units.

The SRT observed that the connection between the SW CSC and the USGS Cooperative Fish and Wildlife Research Units (CFWRU) was not well developed. Such CFWRU are established in multiple SW CSC states (including the Arizona unit located in the same building at the SW CSC). Given the specific role of the CFWRU in providing fish and wildlife science to state resource management agencies, additional effort to collaborate with that program may be beneficial.

Recommendations for SW CSC Institutional Coordination

- Continue to build on the collaborative climate science opportunities afforded by groups on the UA campus, such as CCASS and NNCAP, as well as with the campus research community.
- Enhance engagement of early-career scientists into the broader consortium to strengthen future collaborative climate science.
- Increase participation of researchers in additional departments and groups across the consortium universities through communication and collaboration .
- As resources allow, explore opportunities at the partner institutions identified in the planning documents beyond the direct university consortium.
- Coordinate more closely with the USGS Cooperative Fish and Wildlife Research Unit colocated in the ENR2 building.

Actionable Science

Overview of Actionable Science Objectives

The core of the SW CSC's mission is the production of climate science that is useful to natural resource managers and policy developers. The overall CSC network was formed expressly to foster collaborative linkages among climate scientists, resource managers, and policymakers to create science products usable by the managers and policymakers. According to the NCCWSC, the key aspect of actionable science is knowledge meeting stakeholder needs, with several key characteristics:

- It is relevant to management policy (but not prescriptive).
- It directly reflects expressed needs of constituents.
- It is understandable to managers and science users.
- It is accessible to users at the times and places they need it.
- Users and producers work together from the start.
- Its usefulness to managers and to society is subject to evaluation.

Actionable science production can be accomplished in various processes, but effective processes generally contain four main elements: (1) identification of management priorities and needs, (2) support for scientific research directed toward those priorities, (3) communication and implementation of the science to meet those priorities, and (4) evaluation of the success of the process. In all of these elements, close collaboration among stakeholders may be essential for full success. The SRT emphasizes that a broadscale communications strategy, which the SW CSC has developed (discussed later), is essential to highlighting successes, challenges, and near-term expectations of the actionable science production enterprise.

The research projects supported by the SW CSC represent direct collaboration between science users and science producers or meet identified scientific or management priorities. For RFP-funded research, the SW CSC process requires applicants to articulate engagement with stakeholders or decision makers as part of both the statement of interest and invited proposals. In the FY2015 call, for example, 30% of the evaluation criteria was weighted on "engagement of stakeholders, decision makers, LCCs, or other SW CSC partners" (USGS 2014). The background information for that same RFP states that "proposals developed in response to the RFP should focus on developing knowledge that can be directly applied to specific management challenges, either locally or broadly across the landscape" (USGS 2014). In addition,

Director Jackson communicates with each funded project PI to underscore the SW CSC's expectations of stakeholder engagement. The SRT commends the SW CSC for this proactive approach to funding science with good potential for actionability (and hopefully to be put into action).

The research projects supported by the Southwest Climate Science Center are impressive in scope and depth, demonstrating good progress toward embracing the principles of actionable science. These principles should be integrated into all aspects of the research enterprise and documented to show that the elements have been met.

Research Project Support

Funding for science projects falling within the research themes is allocated in several ways (Tables 1 and 2). The host institution (University of Arizona) receives support to cover partial salary for the university director, salary support for postdoctoral and graduate researchers at various partner institutions, and other research expenses; in FY2016, this support to the host amounted to approximately US$595,000. The primary research funding from the SW CSC (~$1 million in FY2016) supports research projects selected in two ways. The first is through a competitive call for proposals submitted by researchers from partner institutions (the RFP process) and other USGS research centers. This call for research proposals is run approximately annually, depending on availability of funding and prior commitments. The second way that research projects are supported is through direct support to specific projects that SW CSC determines are necessary to meet program goals or to fill recognized gaps in the funding provided through the RFP process. Funds are, at times, allocated to USGS scientists to collaborate with researchers supported through this second mechanism. The SW CSC allocated approximately $130,000 in FY2016 to support science coordination, travel, operations, information technology, and so forth.

The research projects supported by the SW CSC are impressive in scope and depth. According to the 5-year summary report, 31 distinct projects make up the research portfolio from FY2011 to FY2015 (Schirmer et al. 2016). These projects are spread across all research themes (Table 1), with the exception of theme D (designing monitoring strategies). The SW CSC decided early on that it could not sustain long-term monitoring commitments, so stand-alone monitoring-intensive programs are not funded, although several research projects do contain monitoring components. An additional six projects focus on topical initiatives, particularly Native American tribal engagement and scenario planning. From these research projects, a total of 78 publications were produced as documented in the 5-year summary report (Schirmer et al. 2016), with many others in preparation. The SW CSC Web site (www.swcsc.arizona.edu, accessed March 2017) currently lists 131 publications.

The SRT found that science productivity of the consortium was very strong, of high quality and relevance, with a concerted effort to translate the results into publications and presentations for both scientific and general audiences. In general, consortium team members work together well and are committed to

Table 1. Number of projects supported in each Southwest Climate Science Center research theme (fiscal years 2011–2015).

Research theme	Number of projects
Climate science and forecasting	6
Hydroclimate and water availability	8
Ecological responses and vulnerabilities	12
Designing monitoring strategies	(0 projects, but elements of many)
Establishing best practices for researcher–stakeholder engagement	5

Table 2. Total Southwest Climate Science Center (SW CSC) funding through the annual allocation to the federal component and the university consortium through the hosting agreement with the University of Arizona (UA). Note: The third column, "USGS non-CSC science centers," refers to funds directed outside of the SW CSC to other USGS science centers. The SW CSC travel budget is primarily devoted to staff travel related to science projects and for coproduction-related convening (e.g. Landscape Conservation Cooperative meetings) and related activities.

	Annual allocation		SW CSC federal staff			
Fiscal year	UA	USGS non-CSC science centers	Hosting agreement Payroll	Total expenditures Travel	Hosting agreement	Total expenditures
2011	250,000.00	Unknown	192,195.12	20,761.33	833,130.00	1,296,086.45
2012	833,492.00	737,353.00	265,391.85	44,177.80	552,919.00	2,433,333.65
2013	1,299,718.00	137,777.00	110,693.15	5700.54	566,564.00	2,115,322.69
2014	890,404.19	239,309.00	333,078.28	25,038.24	580,562.00	2,068,391.71
2015	912,450.78	334,007.00	275,491.25	45,400.32	595,265.00	2,162,614.35
2016	589,144.40	183,576.00	356,573.35	44,407.34	680,180.00	1,853,881.09
Total	4,775,209.37	1,632,022.00	1,533,423.00	185,485.57	3,808,620.00	11,929,629.94

the CSC framework of providing novel climate science research to the real-world applications of managers and decision makers. Human Dimensions Research Unit survey results bear out this observation (see below).

The science productivity of the consortium was very strong, of high quality and relevance, with a concerted effort to translate the results into publications. Consortium members work together well and are committed to providing novel climate science research to the real-world applications of managers and decision makers.

Two improvements to the RFP process are suggested. First, better avenues for collaboration among science producers at different partner institutions within the consortium were sought. The SRT recognizes that interinstitutional research partnerships are very productive scientifically and should be encouraged. On reviewing the SW CSC's support for such collaborations, the SRT found that 63% of total funding is already awarded to interinstitutional partnerships, rather than single institution projects (Table 3). The SRT finds that interinstitutional partnerships are a valuable outcome of the CSC network and that the SW CSC is doing an excellent service in fostering such partnerships. Additional avenues for interinstitutional communications may lead to further partnership opportunities. In particular, the SRT recommends that the SW CSC and university consortium leadership continue to strive for increased diversity of institutional co-PIs, especially with respect to early-career stage and other dimensions, and to find additional ways to enhance formal and diverse communication among consortium members at all levels (PIs, postdoctoral associates, graduate students, etc.) to further grow the research community.

The SRT finds that interinstitutional partnerships are a valuable outcome of the CSC network, and the SW CSC is doing an excellent service in fostering such partnerships.

The SW CSC and consortium leadership should strive for increased diversity of institutional co-PIs, especially with respect to early-career stage and other dimensions.

Table 3. Project funding by institution.

Institution	Number of projects	US$ (in thousands)
University of Arizona (UA)—host	1	3,809
UA	9	893
UA/Desert Research Institute (DRI)	2	797
UA/U.S. Geological Survey (USGS)	2	138
Ill/UA	1	181
USGS	1	98
USGS/UA	2	204
USGS/University of California–Davis (UCD)	1	133
USGS/University of California–Los Angeles (UCLA)	2	233
USGS/Point Blue Conservation Science	1	45
UCD	3	627
UCD/Scripps Institution of Oceanography	1	1,369
UCD/USGS	1	401
U.S. Forest Service (USFS)/UCD	1	133
Scripps	2	208
Scripps/University of California–San Diego	1	210
UCLA	1	100
DRI	1	141
Boise State University	1	20
Udall Foundation	1	59
USFS	1	12
National Park Service	1	250
Desert Landscape CC	1	33

Second, and perhaps most important, the need for more time and support to assist in the initial collaborative engagement between science users and producers was singled out as important by both groups, in keeping with the actionable science objectives outlined above. Finding ways to further foster stronger research linkages between the science users and science producers at early stages of science production was viewed as the most valuable means to enhance the scientific output and relevance of the SW CSC

The Southwest Climate Science Center should foster stronger research linkages between the science users and science producers at early stages of science production, including

- actively engaging the entire stakeholder advisory committee (SAC) to clearly articulate concrete management priorities;
- assessing how effectively resource-management priorities are actually addressed by the Strategic Science Agenda;
- engaging members of the SAC, including participants from regional Landscape Conservation Cooperatives, and federal, state, tribal, and local resource managers as a part of each project's strategy for knowledge coproduction;
- increasing the level of communication with the SAC;
- strategically filling SAC positions with agency representatives responsive and well connected to the resource management questions.

program as a whole. Suggested steps toward fostering early-stage collaborations between science users and producers have been given in previous sections, most notably recommendations for more effective utilization of the SAC.

Climate Science Implementation

The SW CSC has implemented climate science through several channels: collaboration with the LCCs, stakeholder interactions within funded projects, the SCENIC Web data platform (www.wrcc.dri.edu/csc/scenic), and the publication of important results, including landmark synthetic reports such as the Assessment of Climate Change in the Southwest United States.

The LCCs in the region have acted as a bridge between SW CSC scientists and the management community. The California LCC led this effort through activities such as a project to provide managers with site-level predictions of sea-level rise based on science produced by the SW CSC and workshops to translate climate science to managers. These projects have resulted in the successful implementation of climate science produced by the SW CSC, but generally represented a one-way transfer of information from the science producer to the science user. More recent programs underway through the Desert and Great Basin LCCs have exemplified implementation of SW CSC climate science through two-way interaction, which is ideal for actionable science coproduction. Deputy Director Carolyn Enquist is working with managers through the Desert LCC to coproduce climate scenarios and adaptation strategies for landscape conservation design using SW CSC climate science. Additionally, university co-PI Tamara Wall is leading climate forums through the Great Basin LCC to conduct scenario planning with stakeholders. Both of these projects seem to be successfully integrating science users, including those at the state and municipal level who can be hard to reach, into the production and implementation of SW CSC science. Yet, the SW CSC needs to expand their leverage with all of the regional LCCs to implement climate science. The SRT found that the complementary roles of the CSC and LCCs were not clear to many science users, which could pose a barrier to information access.

Climate science funded by the SW CSC has also been implemented by stakeholders involved with projects funded through RFPs or direct funding. Successful implementation often occurred through a collaboration between scientists and resource managers who make on-the-ground decisions. Several stakeholders identified a need for stronger connections between activities at this level and the SAC and PI level decision making that defines the directions of the SW CSC. Conversations with science users provided evidence of successful implementation of funded science. However, the documentation of the projects by the SW CSC in the annual and 5-year reports relied on traditional science metrics such as papers published and students trained, making it difficult to assess the degree to which science from the projects had been implemented. Development of nontraditional metrics to track implementation would aid in demonstrating successes. As noted in the previous section, the limitation of support for RFP-funded projects to 1–2 years presents a challenge to effective implementation as this process often happens on longer time scales; this limitation, however, is not unique to the SW CSC but is a product of the overall CSC operating structure.

The SW CSC recently launched the Web interface SCENIC, a project led by DRI, to allow science producers and users to access and analyze environmental data. Britta Daudert, an early-career scientist funded by the SW CSC, and Nina Oakley, at DRI, conducted and published a usability study to inform the development of SCENIC. A comprehensive implementation strategy will be key to ensuring that SCENIC is integrated into science-implementation projects conducted by the LCCs, that it is utilized in science funded by the SW CSC, and that decision support tools are developed to help stakeholders apply the science for developing their climate adaptation strategies.

Evaluation of Actionable Science Success

The SRT recognizes the challenges of successfully implementing actionable science into management actions (or the potential for management actions), particularly within constraints of funding and person-

nel resources. Actionable science is not a singular process. The SW CSC has, however, taken several steps to facilitate actionable science. As examples, the SW CSC has identified its research priorities (SINs) on the basis of SAC and other stakeholder feedback during the initiation of the SW CSC and has successfully embedded stakeholder engagement into its RFP process. During the review the SRT did observe some instances of science projects in which the a priori identification of management priorities (and the complementary engagement of stakeholders who need research results) seemed not to be the model driving particular projects (i.e., no management application defined at the beginning of the project, and unclear indication of how the results were going to be used in a management context).

The SW CSC's investment into the social-science research of Meadow and Wall to evaluate CSC-funded research projects relative to their actionability demonstrates the SW CSC's commitment to actionable science and knowledge coproduction. The SRT anticipates that future application of the results of the Wall et al. (2017) research efforts will substantially enhance the CSC's process of implementation.

As noted above, the implementation step currently appears to occur in a variety of ways depending on the project. For some projects, the communication of scientific findings and tools to managers relies on the ability and interest of individual researchers who have received project funds to conduct stakeholder interactions (as required by the RFP process). The SRT observed that in those cases, the effectiveness of interacting with managers and of conveying science results to resource managers relies on the abilities of individual researchers to communicate their work. A potential issue arises when a researcher is late to engage with resource managers, which may impact successful actionability. For other projects, the SW CSC uses relationships with LCCs and other stakeholder groups in the process of actionable science; in these cases, the process provides a more consistent path to implementation. While each approach has shown that it can be successful, a deliberate approach to document and coordinate climate science implementation would help assess best practices and facilitate consistent success.

Based on traditional metrics, the SW CSC has been very successful in funding and conducting high-quality climate science. Both direct-funded and RFP-funded projects produced a strong publication record. Most projects have produced at least two to three peer-reviewed publications, and the publication portfolio includes articles in prestigious journals such as Science and Proceedings of the National Academy of Sciences of the United States of America. Publication success is clearly documented in the annual reports and 5-year report. The SRT notes that a highlight of successful actionable science implementation is represented in the coastal marsh initiative work of consortium-affiliated researchers such as MacDonald, Ambrose, Takakawa, Thorne, and others in partnership with USFWS California coastal wildlife refuges.

Southwest Climate Science Center affiliates and other scientists working on funded research have been active in presenting research results at professional meetings. As documented in the annual reports, these science producers have also attended and presented at a broad range of management-focused conferences, workshops, panels, webinars, and working groups. The advancements made in engaging stakeholders in the production of science, discussion of project progress, participation in planning exercises, and consultative group exercises from the early years of the SW CSC to the more recent years are clearly evident. This commitment to outreach is commendable.

The SW CSC is conducting excellent science with highly acclaimed scientific community. The advancements made in engaging stakeholders in the production of science, discussion of project progress, participation in planning exercises and consultative group exercises, from the early years of the SW CSC's existence to the more recent years are clearly evident.

The SW CSC has also been successful in training the next generation of scientists in actionable science. By providing consistent funding to early-career scientists, including Britta Daudert, Alison Meadows, Ta-

mara Wall, and Christine Albano, the SW CSC has helped to develop individuals with expertise in stakeholder interaction and actionable science who are ready to move into senior positions. One benefit of the current hosting agreement is that UA has a substantial number of Native American students, providing the opportunity for the SW CSC to facilitate the development of the next generation of tribal scientists and managers.

The training and development of postdoctoral associates and graduate students was largely the responsibility of individual PIs and varied with project and university. In some cases, it was clear that working on a SW CSC project was a unique and valuable experience. For example, UCLA students contributing to a project on sea level rise and coastal marsh habitat interacted extensively with USGS and USFWS managers. In other cases, it was recognized that students and postdoctoral associates had been too focused on basic research to receive effective training in actionable science.

Stakeholder Perceptions on Actionable Science

(see Appendix D for complete results of the HDRU survey and focus group process)

Respondents to the HDRU survey shared their perceptions both of climate adaptation science, in general, and of the climate adaptation science produced by the SW CSC.

Climate science in general.—With regard to climate adaptation science in general, nearly three-quarters of respondents (73%; $n = 87$) agreed or strongly agreed that climate adaptation science in the Southwest region is available to decision makers. A majority also believed that it was used to inform management decisions by water managers (85%; $n = 93$), fish and wildlife managers (70%; $n = 78$), and land managers (59%; $n = 66$). Only about one-third (36%; $n = 40$), however, believed that policymakers used this science to inform policies. More than half (60%; $n = 69$) maintained that what is known about climate adaptation does not necessarily influence actions taken by decision makers in the region. Nearly as many (59%; $n = 57$), however, agreed that the SW CSC has helped to reduce disconnect between what is known about climate adaptation and the actions taken by decision makers in the region.

About three-quarters of the respondents to the HDRU survey felt that climate adaptation science in the Southwest region was available to decision makers, and many also believed that decision makers use the climate adaptation science to inform management. Nevertheless, many believed that climate adaptation science did not influence management actions taken, although a majority also believed that the SW CSC had reduced the disconnect between scientists and decision makers

SW CSC climate science.—In terms of the SW CSC science specifically, respondents (90%; $n = 102$) strongly or somewhat agreed that the SW CSC science can contribute to policy or management. Respondents were also positive about other characteristics of the SW CSC science, finding it to be of high quality (90%; $n = 98$) and appropriate to inform the types of decisions being made (80%; $n = 90$). A majority also thought that it integrated well with other information (71%; $n = 77$). Few thought that the SW CSC's science was irrelevant to management (13%; $n = 14$) or biased (2%; $n = 2$).

The vast majority of the HDRUsurvey respondents agreed that the science produced through the SW CSC can contribute to policy or management.

Stakeholder's Use of Actionable Science

(see Appendix D for complete results of the HDRU survey and focus group process)

Among respondents to the HDRU survey who reported that they were science users, 74% ($n = 25$) reported that they or someone in their organization used climate adaptation science from sources affiliated

with the SW CSC. Slightly more (86%; *n* = 36), reported that they or someone in their organization used climate adaptation science from sources not affiliated with the SW CSC.

The most common way that science users reported using the SW CSC science were to inform management plans (55%; *n* = 27). Forty-three percent reported using it to inform management actions (*n* = 21), and nearly as many used it to inform training of conservation professionals (41%; *n* = 20). Slightly more than one-third (37%; *n* = 18) used it to inform the public about climate change and its impacts. It was less frequently used to inform policy (18%; *n* = 9), and no one reported using it to inform land acquisition priorities.

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 (although not identical), but the absolute frequency was greater. More than four-fifths (82%; *n* = 65) said that their science had been used to inform management plans. Nearly two-thirds (65%; *n* = 51) had work that had been used to inform the public. More than half said that their work had informed management actions (61%; *n* = 48) or had contributed to the training of professionals (57%; *n* = 45). Nearly half (49%; *n* = 39) reported that their work had informed policy, which was relatively much more frequent than the science users had reported. The differences between science users' and science producers' responses could reflect differences in perceptions about how frequently SW CSC science is used. It could also reflect that the use of SW CSC science is concentrated in a subset of potential SW CSC science users.

Comments from stakeholders in the focus group discussions indicated that stakeholder engagement was key to ensuring that the science was used.

Some of the focus-group discussions explored the conditions under which SW CSC science could be useful to decision makers. Comments from participants indicated that stakeholder engagement was a key to ensuring that the science was used.

Stakeholder Perceptions on Limitations on Use of Science

(see Appendix D for complete results of the HDRU survey and focus group process)

Science users and producers responding to the HDRU survey differed in their perceptions of what limits the use of SW CSC science (Figure 3). In virtually all cases, more science producers than science users perceived limits to the use (not necessarily their own use) of SW CSC science to a moderate, large, or very large extent. At least 64% of the producers believed that the use of the SW CSC's science was limited by all of the factors listed, except for three factors having to do with the nature of the science itself: the science not being interdisciplinary enough (51%; *n* = 38), the science models or results not being refined enough (47%; *n* = 35), and a lack of quality of the science (10%; *n* = 7). Producers believed that the top barriers were a lack of awareness of the science (77%; *n* = 58), scientists not working closely enough with decision makers (76%; *n* = 57), and science not being communicated understandably (74%; *n* = 55). The most frequently cited barriers for science users also included scientists not working closely enough with decision makers (50%; *n* = 22), science not being communicated understandably (40%; *n* = 17), and decision makers not being aware of the science (38%; *n* = 17). The science users were much less likely to consider a lack of skills and training among decision makers to be a barrier (16%; *n* = 7) than science producers did (71%; *n* = 53). Focus groups participants discussed these and other limitations to the use

Focus groups participants noted that applying climate science in decision making is a complex process that takes time. Both science producers and science users felt that major limitations to the use of science produced by the SW CSC included scientists not working closely enough with decision makers and science not being communicated understandably. Issues related to the lack of awareness of the science by decision makers and others was also a limiting factor according to both groups.

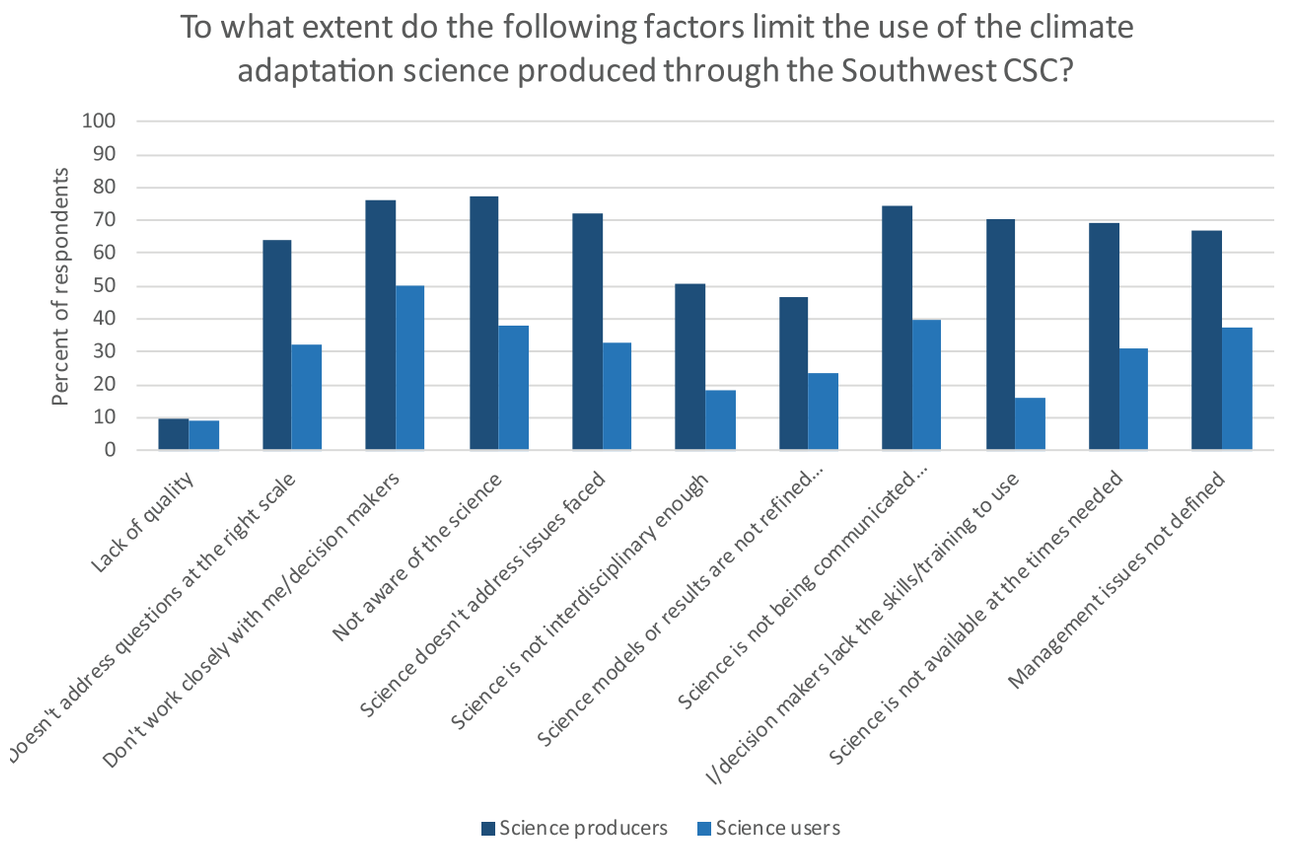


Figure 3. Factors limiting use of climate adaptation science. Note: text in items shortened for presentation in graph, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown. Additionally, text varied slightly for science producers and users. Full results and text in tables in Appendix D.

of the SW CSC's science products. To begin with, they argued that applying climate science in decision making is a complex process that takes time.

Actionable Science Recommendations

- Implement a deliberate approach to assess and document successful climate-science actionable products to facilitate future successes.
- Actionable science research projects should address identified stakeholder management needs at the outset, and engage stakeholders throughout the project cycle.
- Additional avenues for interinstitutional communications may lead to further partnership opportunities.
- The SRT recommends that the SW CSC and university consortium leadership strive for increased diversity of institutional co-PIs, especially with respect to early-career stage and other dimensions, and find additional ways to enhance formal and diverse communication among consortium members at all levels (PIs, postdoctoral associates, graduate students, etc.) to further grow the research community.
- While the SRT recognizes resource limitations, the need for more time and support to assist in the initial collaborative engagement between science users and producers was singled out as important by both focus groups. Similarly, a process for assisting researchers in communicating with science users during execution and at project conclusion would benefit successful actionability.
- Clarify the complementary roles of the SW CSC and the LCCs with which it collaborates.
- Work to develop metrics to evaluate actionable science successes in addition to traditional metrics (e.g., papers published).

Science Communications Strategy

The SW CSC's communications strategy is evolving and progressing with the hiring of a dedicated communications manager (Christine Schirmer) and the development of a communications and outreach plan in 2015. The communication strategy now targets a range of audiences, including

- Climate response partners—LLCs, SAC members, USGS leadership, other CSCs, NCCWSC.
- Resource managers—federal, tribal, and state resource managers; local governments; private land owners; NGOs.
- Policymakers—U.S. Congress, tribal leaders, state elected officials, legislative staff, department and agency leadership.
- Scientists—USGS and university consortium scientists, affiliates; may also include subsets of CSCs, NCCWSC.
- General public—media and other interested people.

The SW CSC communications and outreach plan (2015) identifies the following as its goals:

- To facilitate user-inspired science through collaboration among climate scientists and climate science users—resource managers, policymakers, stakeholders—to ensure that SW CSC projects result in data, analyses, projections, or tools that can support decisions regarding the management of the risks and impacts of climate change.
- To facilitate the development and dissemination of products that effectively communicate research results to resource managers, policymakers, stakeholders, and the public in the forms that best meet their needs.
- Increase access to and understanding of Southwest climate-related science, data, and information to both the scientific and management communities, as well as policymakers and the general public.

Among the main achievements of the SW CSC communications strategy since 2011, several stand out:

- The SW CSC hosted two climate summits, one in 2012 (Tucson, 120 participants) and one in 2015 (Sacramento, 250 participants), designed to bring together government agency and tribal resource managers, NGO leads, private-sector interests, and academic scientists to expand working relationships and networks and to share information. A third climate summit is being planned for 2018.
- The SW CSC convened a meeting of the western LCC members, as well as the California-Nevada Applications Program (CNAP) RISA, Southwest Climate Hub, and State of California agency representatives in fall 2016, to develop a broader conservation and environmental management vision for the Southwest region as a whole.
- The SW CSC prepares detailed annual reports highlighting the progress and outcomes of funded research projects, publications and presentations, professional development, outreach efforts, and other achievements. The SW CSC also prepares separate science work plans—although these plans have been released at a frequency less than annually—outlining anticipated milestones and goals for upcoming years.
- Southwest Climate Science Center staff and university partners regularly participate in professional society conferences, LCC workshops and strategy sessions, face-to-face discussions with policymakers, and public presentations to a wide range of audiences. The SW CSC also meets annually or biennially with its SAC and communicates more regularly with SAC members on an individual basis (although as discussed previously, progress can still be made in fully re-engaging the SAC as a resource).
- Use of traditional media and social media outlets, including a well-designed Web site, Facebook page, incorporation of SW CSC information into newsletters and press releases, and fact sheets. The success of various communications efforts is now being tracked to determine which communications best reach their target audiences.

The current multifaceted communication strategy is well developed, reaching multiple audiences and highlighting the SW CSC role in fostering partnerships in environmental management. However, the essential role of tracking specific science producer–science user partnerships and successes is still being developed and formalized. The communications strategy would benefit from enhancing the components matching specific science user needs to science producer capabilities, to track how science users are actually employing the results of SW CSC-supported projects. This would help to verify that science producers are helping managers make the best use of their scientific products, perhaps fostering greater interest from additional science users in the region.

The SW CSC would benefit by enhancing communication focused on how CSC funds have been applied to support projects that are relevant to, and applied by, shareholders.

The SRT believes that communicating the SW CSC's role in fostering and ensuring such partnerships through the actionable science process is a crucial element in demonstrating its overall success. We urge the SW CSC to highlight successful projects or management uses by agencies of SW CSC-supported science as widely as possible. The SRT also suggests that including elements of an annual science work plan (forward looking) into the annual report of accomplishments (backward looking) would allow resource managers to better evaluate both what has been done so far and what is planned to be accomplished in the future on specific management needs, encouraging a more management-needs-focused orientation. In short, the SW CSC would benefit greatly by positioning itself to demonstrate that SW CSC funds support projects that are relevant to and applied by stakeholders. Communication needs to be linked directly to actionable science, and outreach, training, and decision support tools directly to land managers, planners, decision makers.

Communication Recommendations

Like the SW CSC itself, the communications strategy is relatively new and has evolved greatly in 5 years. The SRT is impressed by the current strategy and direction, particularly in recognizing staff and funding limitations, and believes that going forward, the program would benefit by emphasizing the following:

- Communicate directly to stakeholders about actionable project results, accompanied by technical assistance to apply results, as needed.
- Collect feedback from stakeholders on how they applied the results, and communicate that feedback to other stakeholders and policymakers to demonstrate success.
- Consider including elements of aspirations articulated in an annual work plan into successes documented in the annual report, and refocus the annual report to emphasize stakeholder engagement, as well as the excellent applied science that has been produced.

Communication to all audiences should emphasize actionable science applications, with training and decision support tools provided directly to land managers, planners, and decision makers (federal, state, municipalities, tribal).

Capacity Building

These measures are intended to capture how well the SW 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.

Science Users' and Producers' Engagement in Coproduction of Knowledge

(see Appendix D for complete results of the HDRU survey and focus group process)

Respondents to the HDRU survey reported on their beliefs about coproduction of knowledge in general. An overwhelming proportion of both science users (94%; $n = 44$) and producers (89%; $n = 70$) 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.

Responses to the survey indicated that 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 experienced 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 four phases of research with which at least 30% of science users had experience: identifying research questions (44%), applying research results (42%), determining research priorities (35%, and communicating results of a research project (31%). Both science users and science producers perceived collaboration between scientists and decision makers to be less common in designing research methods (science users—27%; science producers—55%), determining data sets to be used (science users—27%; science producers—51%), collecting data (science users—22%, science producers—55%), and analyzing data (science users—18%; science producers—47%) (Figure 4).

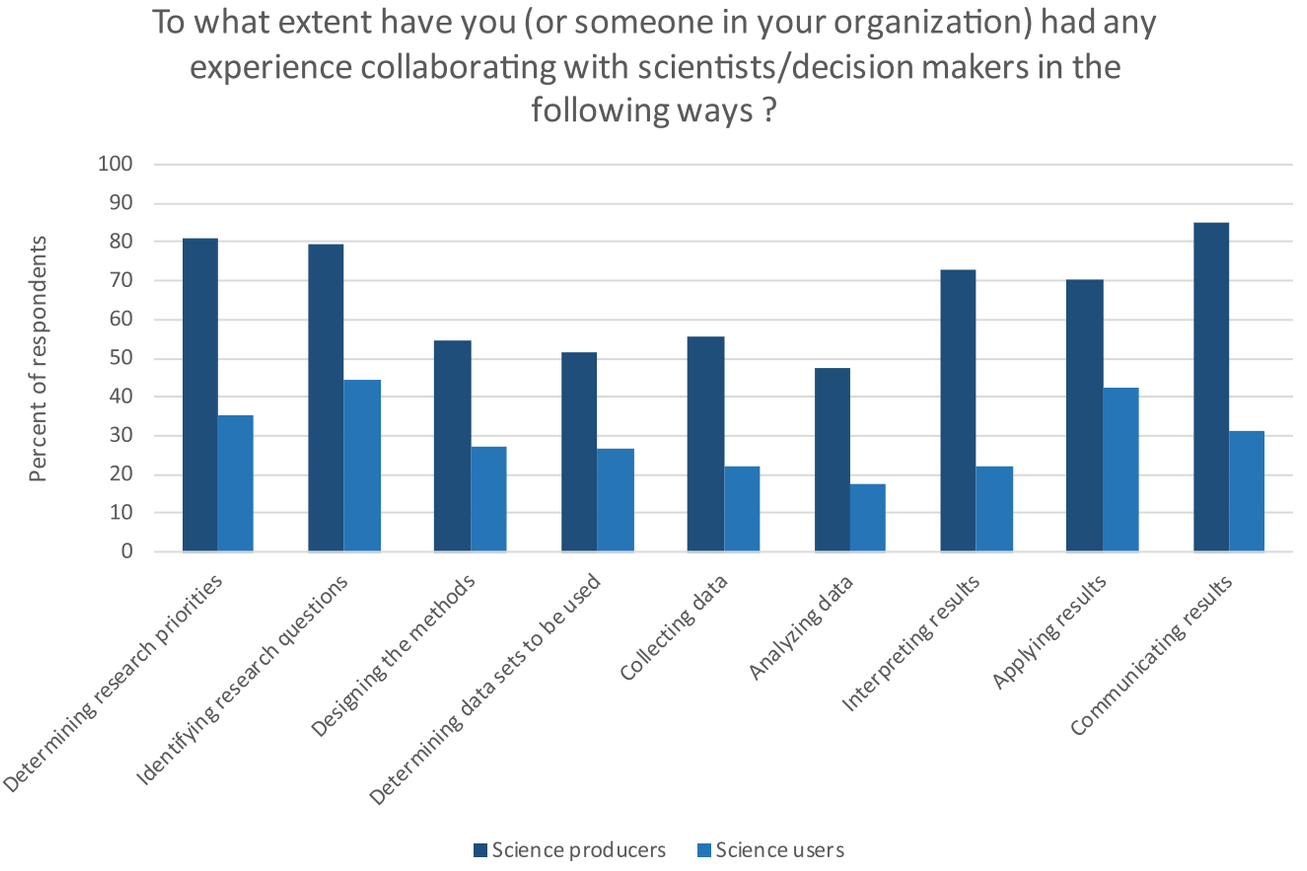


Figure 4. Science user and producer experience collaborating with scientists/decision makers. Note: text in items shortened for presentation in graph, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown. Additionally, the text of the question varied slightly for science producers and users (e.g., the users' version referencing "you or someone in your organization" and specifying a SW CSC project). Full results and text in tables in an Appendix D.

Focus group participants pointed out that one of the factors making coproduction easier in the Southwest region was that the SW CSC had invested resources in better understanding what made coproduction work. The CSC also made an effort to give its partners the training they needed to work well with certain groups, such as the tribes.

Factors Limiting Involvement

Respondents to the HDRU survey indicated that the factors most likely to limit science users' involvement in research projects were scientists not reaching out to them (41% agreed or strongly agreed; n = 19), followed by different perspectives on what science is needed (39%; n = 18) and funders (not specific CSC) not supportive of collaboration between scientists and science users (33%; n = 15). Other factors were perceived to limit the involvement of smaller numbers of respondents: the science users not having enough time (24%; n = 11), different perspectives on how research projects should be conducted (20%; n = 9), and scientists not interested in listening to them (13%; n = 6).

Based on results of the HDRU survey, the factors most likely to limit science users' involvement in research projects were scientists not reaching out, different perspectives on what science is needed, and funders (not specifically CSC-funded projects) not supportive of collaboration between scientists and science users.

Survey respondents felt that the SW CSC has helped facilitate various connections (Figure 5). The most common connections reported were with climate adaptation scientists (55%; n = 66) and climate adaptation science (53%; n = 64). Nearly half also reported getting connected with resources needed to conduct science (48%; n = 57). Fewer reported help in connecting with professionals who might communicate science (43%; n = 51) and decision makers who might use science (34%; n = 41).

The SW CSC has helped facilitate various connections with climate adaptation and climate adaptation science but to a lesser extent with professionals who might communicate science and decision makers.

More than half of respondents to the HDRU survey agreed that the SW CSC made a wide variety of contributions to the region (Figure 6). The contributions that were most widely perceived were collaboration between scientists (74%; n = 88), awareness of available science (68%; n = 80), interdisciplinary science (66%; n = 78), and communication between scientists and those who might use the science (65%; n = 77).

In addition, potential users often do not have the resources to implement actions informed by the scientific information they receive. Consequently, one recommendation was to devote more resources to train decision makers in how to make use of science. Finally, participants recommended more investment in evaluating the outcomes of projects funded by the SW CSC.

The SW CSC has made significant contributions to increasing collaboration between scientists, awareness of available science, and interdisciplinary science.

Training the Next Generation of Scientists and Managers

A core mission of all CSCs nationwide is "education and training of a core [group] of climate scientists that will provide expertise in the future" (NCCWSC Fact Sheet, 2013). Building this capacity for conducting and applying actionable science "is accomplished through training and supporting "students and

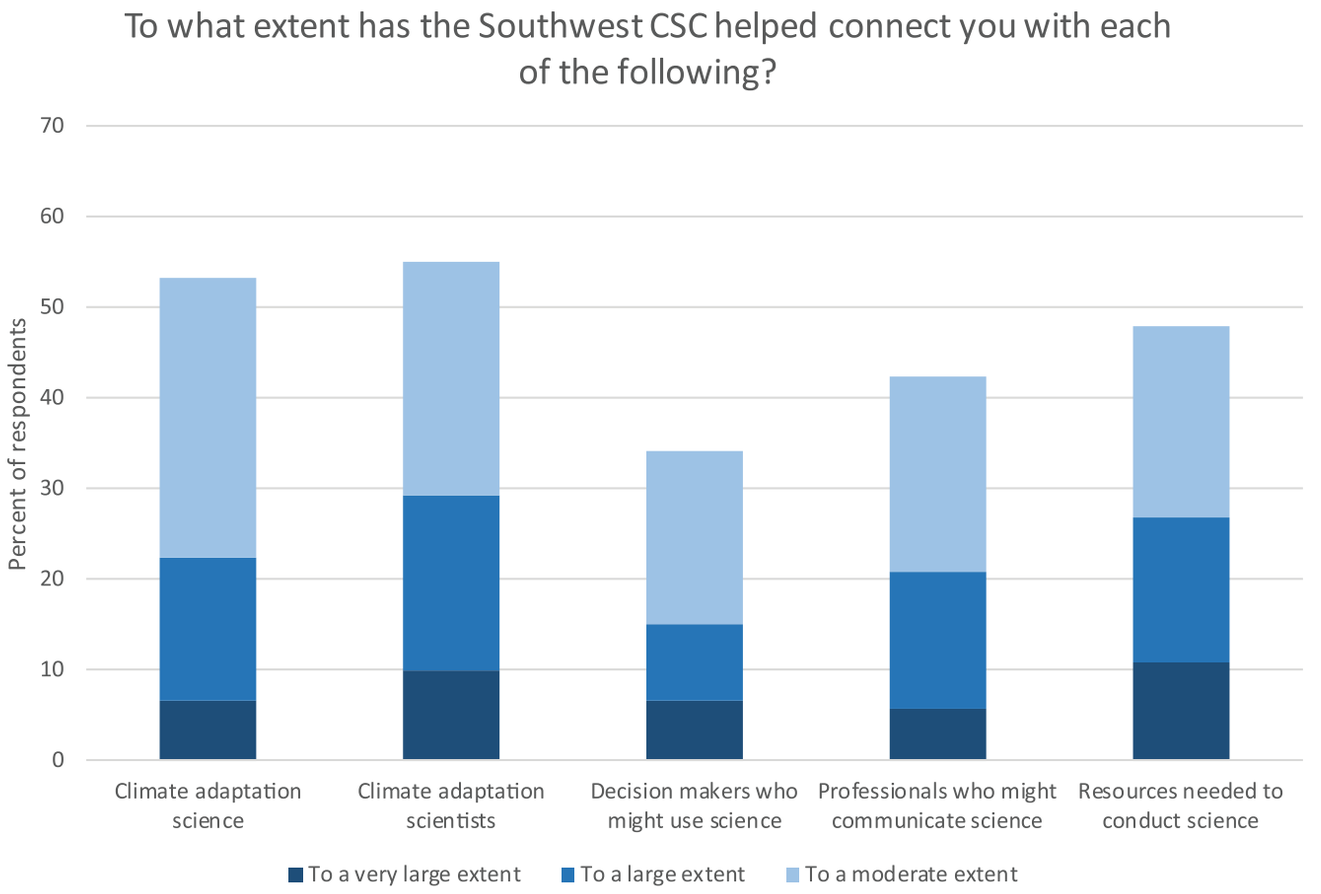


Figure 5. Southwest Climate Science Center's facilitation of connections for science users and producers. Note: text in items shortened for presentation in graph, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown. Full results and text in tables in Appendix D.

early-career scientists in conducting climate research, developing skills in science communications and stakeholder engagement, and establishing a valuable network of peers.This commitment is manifested through programs across the country that target students from high school through post-doctoral levels" (Climate Science Centers & National Climate Change and Wildlife Science Center, https://nccwsc.usgs.gov/content/science-approach).

Given this core mission, developing a cadre of graduate students and postdoctoral researchers who are well-trained in the issues of climate and conservation science, impacts of climate change on natural and cultural resources, and potential climate adaptation and mitigation strategies for resource managers should be a key activity of CSCs. This requires a major commitment to fund graduate students and postdoctoral researchers and to engage them in the coproduction of climate science with natural resource managers and policy developers. This also requires coordinated and sustained efforts across institutions and regular engagement of stakeholders to foster collaborative linkages to create actionable science.

The SW CSC-funded projects have provided opportunities for graduate students and postdoctoral researchers to work with leading climate scientists. From 2011 to 2016, the SW CSC directly supported more than 40 graduate students and postdoctoral researchers through project and core agreement funding. More recently (2016), the SW CSC initiated a formal Fellows Program (a group of graduate students, postdoctoral researchers, and early-career scientists) who participate in monthly science calls with the SW CSC university consortium PIs. Some SW CSC fellows also participated in training opportunities offered by other CSCs, including the Alaska CSC summer school course, Northwest Cli-

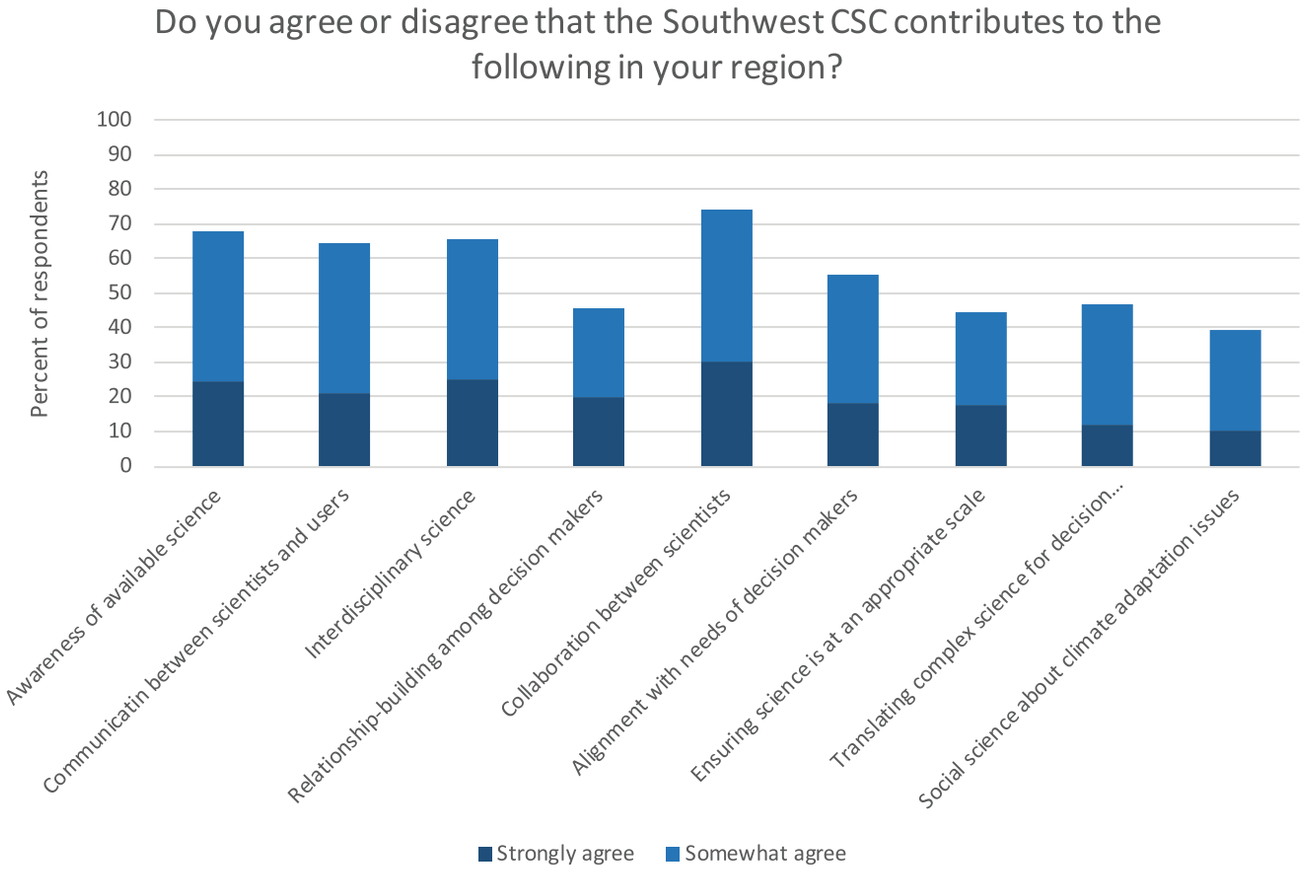


Figure 6. Science users' and producers' perceptions of SW CSC contributions. Note: text in items shortened for presentation in graph, and only "strongly agree" or "somewhat agree" responses are shown. Full results in table in Appendix D.

mate Science Center Climate Boot Camp, South Central CSC early-career training, and the nationwide student and early-career training held at the North East CSC. The SW CSC is also partnering with other academic institutions to help build new student and professional development programs at UCD, UA, and Utah State University.

Next Generation Capacity Building Recommendations

- The SRT commends the SW CSC for developing a more robust Fellows Program within the past year and encourages the SW CSC to increase efforts to engage early stage career faculty from all partner institutions
- All institutional partners must invest and engage in the recently developed Fellows Program to be successful. The coordination and oversight of postdoctoral researchers across the partner institutions is an important need to improve coordination and accountability of the postdoctoral associates across the institutional partners
- The training of graduate students and postdoctoral researchers appears to be primarily vested in the co-PIs at each of the institutions, but greater emphasis needs to be placed on engaging early-career faculty at their institutions in the research enterprise by funding graduate students and postdoctoral researchers for these early-career colleagues. This will allow the SW CSC to capitalize on the extensive research capacity of other faculty at their own institutions
- Recognizing the time constraints of the USGS director and deputy director, every opportunity should be taken (as feasible)in the mentoring and training of graduate students and postdoctoral researchers

by serving on graduate research committees and other roles to draw these students closer to the SW CSC partnership.

- Mentors and advisors should strive to expand the opportunity for graduate students and postdoctoral researchers to build their science communications skills beyond technical presentations by enhancing their capacity for effective public engagement and science communication
- The SW CSC may benefit from formulating a plan to actively recruit and engage graduate students, postdoctoral researchers, and early-career faculty with diverse skill sets and backgrounds (age, gender, ethnicity, etc.) that could potentially serve as the next generation of institutional partners.

Partner/Stakeholder Capacity Building

Spanning multiple states, diverse ecoregions, and large urban centers, the Southwest region poses many unique challenges for understanding, adapting to and mitigating the effects of climate change. Further, the landscape is dominated by large federal land ownership. Consequently, solutions to conflicts between land use and climate change adaptation and mitigation will emerge from a multitude of complex decisions across a very diverse stakeholder network.

From 2011 to 2016, the SW CSC directly supported/engaged stakeholders via multiple work-shops, summits, panels, and professional meeting symposia to define capacity needs, engage participants in building collaborative partnerships, discuss the latest climate science from across the region, and help build capacity for climate adaptation among state, federal, academic, tribal, NGO, and other interested groups.

The SW CSC has been a national leader in developing the theory and framework for evaluating the impact of climate science on resource management decisions. Using an outcome mapping process, a framework is applied to evaluate the effects of research on the actual outcomes of resource management actions and decisions. The framework has been applied to several SW CSC science projects as case studies, but the results of the assessment are not yet available.

The SW CSC has been a national leader in developing the theory and framework for evaluating the impact of climate science on resource management plans.

With more than 200 federally recognized tribes in the region, tribal engagement is a major challenge for the SW CSC. While work with individual tribes starting early in the SW CSC existence has set the stage for tribal collaboration, the SW CSC has notably partnered with the University of Arizona's Center for Climate Adaptation Science and Solutions (CCASS) to develop the Native Nations Climate Adaptation Program (NNCAP). The goals of this program are to promote collaboration, share best practices, and build capacity of tribal nations to adapt to climate change. Additionally, with recent funding from the BIA, the SW CSC partnered to support a tribal climate science liaison to coordinate CSC activities with tribes.

The SW CSC is making very positive moves toward expanding and integrating tribal research and management priorities through CCASS and NCAP.

Partner/Stakeholder Capacity Building Recommendations

Many aspects related to stakeholder capacity building have been discussed in earlier sections of this report. The observations and recommendations below encapsulate many of these afore-mentioned discussions.

- The SW CSC has made concerted investments and efforts to engage key partners in training and capacity building; measuring the impact of these efforts on the implementation of actionable science by resource managers within state and federal resource agencies and tribal nations would help to better communicate accomplishments.

- The SW CSC science program has been exceptional; enhancing future projects to be models of true coproduction with stakeholders will make the program even stronger.
- As part of an effort to further engage resource managers, the SW CSC should assess the need for developing applied decision-support tools.
- The SW CSC may want to consider developing a tribal engagement strategy to clarify the various roles of CCASS, NNCAP, and the SW CSC for meeting these tribal nation needs.
- To improve the already extensive communication with stakeholders, the SRT recommends soliciting stakeholder input on ways to improve communication and developing guidelines to ensure that stakeholder communication preferences are used in the future.
- To improve engagement with end-user stakeholders, deliverables for science projects should incorporate technical guidelines for management application, in addition to the already-encouraged peer-reviewed publications.
- Interaction with stakeholders on the applied uses of research results through work-shops/webinars, conference calls, and other means would contribute to increased use of SW CSC-generated science.

Partnerships

Effective partnerships are critical for the success of CSCs and essential for delivering actionable science across the diverse suite of partners who have a stake in the CSC enterprise. The CSC network was formed expressly to foster collaborative linkages between climate scientists, resource managers, and policymakers to create actionable science. Consequently, a major indicator of success of CSCs is the degree to which partners are effectively engaged and benefit from the work of the CSC.

As noted previously, the SW CSC partnership network is complex and diverse. Substantial efforts have been made by the SW CSC to engage partners via participation on the SAC, workshops and symposia, and leveraging the outreach activities of partners. The five LCCs in the region are key SW CSC partners, providing direct access to a wide diversity of natural and cultural resource managers from federal, state, tribal, and other entities throughout the Southwest region. The SW CSC'S federal director serves as an ex officio member and actively participates on each of the LCC steering committees. In 2016, the SW CSC co-organized a workshop with four LCCs to identify shared objectives and build collaborations across California. Engagement with tribes by the SW CSC has largely been facilitated through the recently established NNCAP as part of CCASS at UA.

Partner Benefits of Involvement

(see Appendix D for complete results of the HDRU survey and focus group process)

The two most important benefits that respondents to the HDRU survey of science users and science producers believed the SW CSC provided were "access to a broader network of people interested in climate adaptation science" (73% described as "important" or "very important"; $n = 82$) and "access to climate adaptation science" (71%; $n = 79$) (Figure 7). Both of these benefits were discussed in the focus groups. The value of the networks the SW CSC created was described by both science producers and science users. Science producers often mentioned how networking opportunities led to the development of new collaborative projects.

The top benefits of involvement with the SW CSC identified by participants in the HDRU survey were providing access to a network of people interested in climate adaptation science and providing access to the science itself. Focus group participants spoke about both of these benefits as well as the opportunities the SW CSC provided to connect scientists with decision makers and the critical needs SW CSC funding could fill.

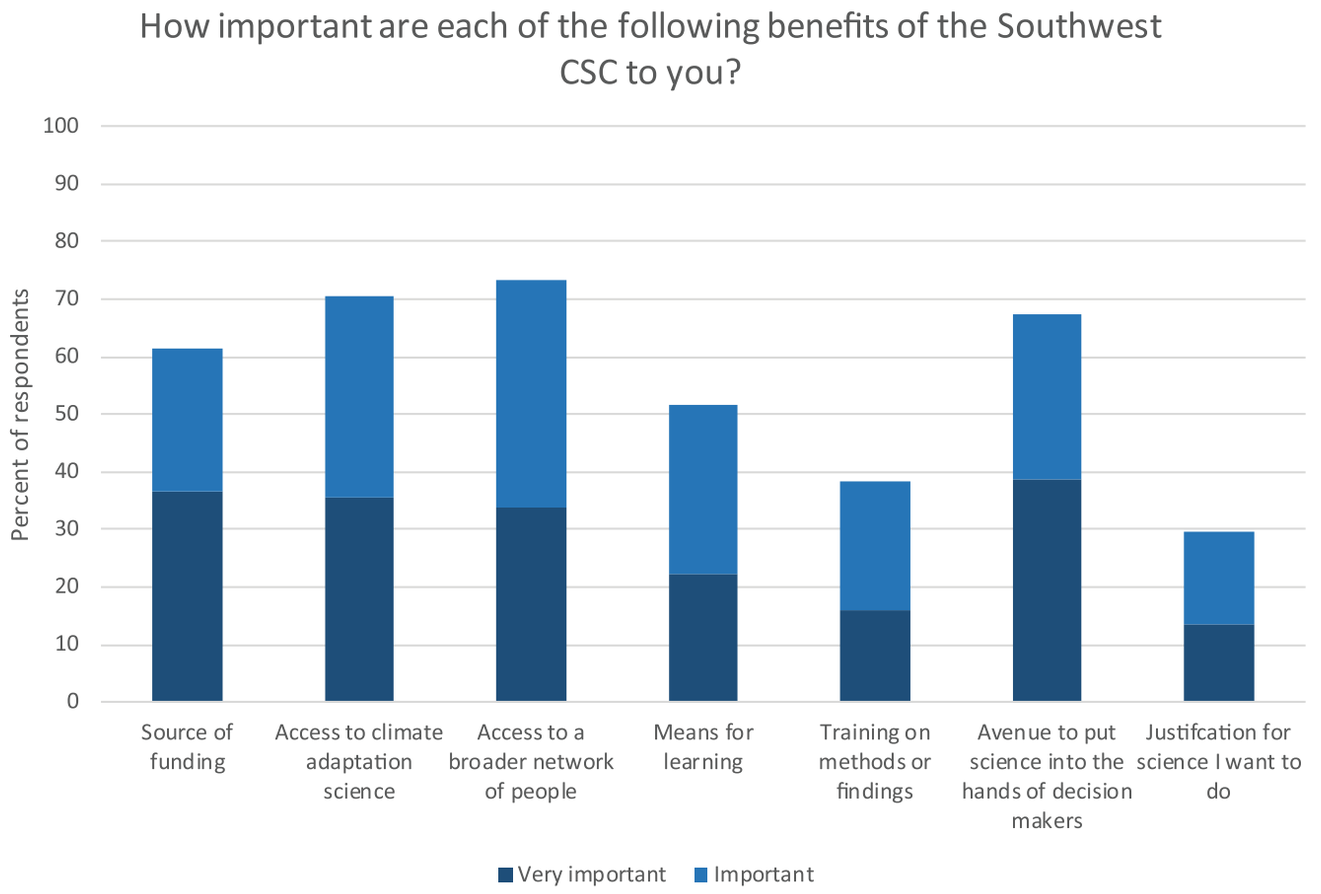


Figure 7. Benefits of Southwest Climate Science Center science users and producers. Note: Based on survey question 9. Text in items shortened for presentation in graph, and only "important" or "very important" responses are shown. Full results in table in Appendix D.

Limitations on Involvement

Most HDRU survey respondents (79%; $n = 102$) reported limits to their involvement with the SW CSC (Figure 8). The most common (46%; $n = 60$) limit was not having enough time, followed by not having enough funds (22%; $n = 29$). Focus group participants also referred to these types of constraints on their ability to be involved.

> *Respondents to the HDRU survey reported that they were limited in their involvement with the CSC by a variety of factors with the most common one being limits on their time.*

Recommendations for Partnerships

The theme "partnerships" is interwoven throughout various sections of this report and hence, recommendations may be drawn from some of the previous sections:

- The ongoing efforts to engage key partners should be expanded where possible to strengthen the relationship between applied stakeholder needs and SW CSC science projects.
- Improving the articulation of the roles, responsibilities, and processes of the SW CSC will increase understanding of the CSC program among all stakeholder groups; completion of the strategic plan will help with this.

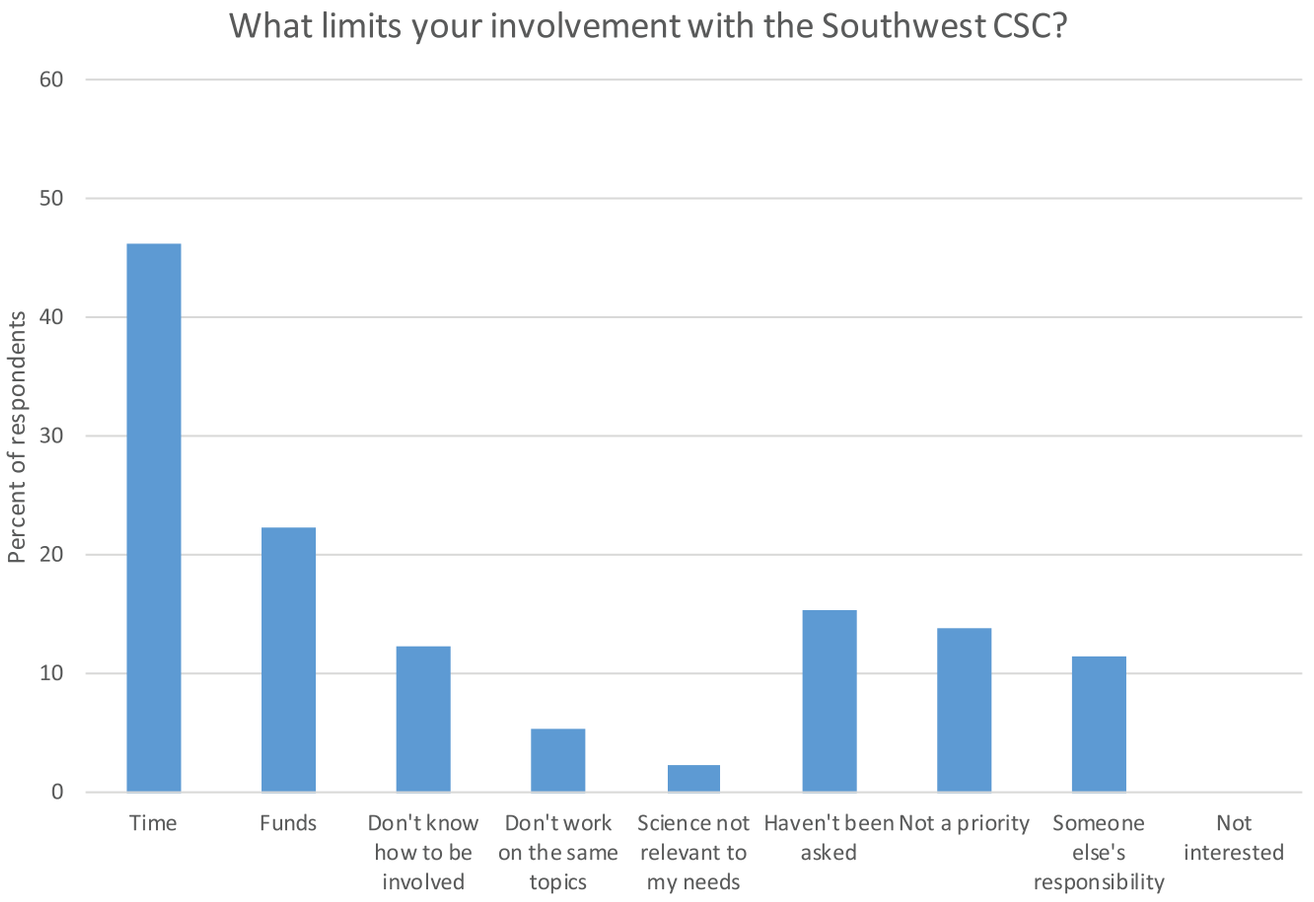


Figure 8. Limitations to involvement with the Southwest Climate Science Center for science users and producers. Note: text in items shortened for presentation in graph. Full text in table in Appendix D.

- Improving the integration of stakeholder input into the RFP and university-directed research development process will make the subsequent research program more responsive to stakeholder needs.
- While the SW CSC and LCCs engage in healthy communication and coordination of objectives and products, their respective roles are not well understood and should be better clarified.
- Efforts should be expanded to leverage the expertise of scientists and graduate students from the USGS Cooperative Fish and Wildlife Research Units into the research enterprise.
- The SW CSC could better leverage the networking expertise of the LCCs to be more responsive to the research needs of state and federal resource management agencies and other stakeholders.

The SW CSC would benefit by strengthening the direct connection with management, particularly at the state level.

Concluding Comments

The SW CSC was established with a proposal to bring to bear the capacities of major southwestern research institutions and the USGS to develop the science needed for climate-related resource management decisions using a stakeholder-driven process. Challenges in the management of the complex patchwork of federally managed and other public land, along with the highly varied terrain, climate-vulnerable ecosystems, and growing population centers across the geographic extent of the SW CSC, demand a high-level of science quality, adaptability, and applicability. This review aimed to provide observations about the first

5-year cycle of the SW CSC's program and recommendations helpful to future planning and execution.

One of the unanimous observations made by the SRT regarded the excellent climate science program being executed by a highly regarded team of researchers from throughout the university consortium members and USGS scientists who are recipients of SW CSC research funds. Given the urgent need for climate-related science to inform resource-management needs, actionable science is an essential product of all CSCs. Consistent with its proposed model of stakeholder-driven science, the SW CSC has invested into innovative social-science research with significant potential to define processes of knowledge coproduction and the development of actionable science.

The SRT believes that these strengths and investments will aid the SW CSC in addressing the primary challenges observed during the review. Specifically, the SRT observed a need to more effectively utilize its SAC as a core platform for a regularly occurring collective dialog about regional resource-management priorities. These identified priorities, especially if regularly updated, can serve as a starting point for pursuing and executing consistently actionable climate science. The SRT offers the following as a summary of key observations and recommendations from the review process:

- The SW CSC enterprise is conducting excellent science with a highly acclaimed scientific community.
- The SW CSC is commended for pioneering social science research to promote and evaluate coproduction of actionable science.
- The SRT observed a good working relationship between the university consortium partners.
- The SW CSC is making very positive moves toward engaging Native Nations to expand and better integrate research and management priorities of Native Nations. A tribal engagement strategy, including a better description of roles, responsibilities, and approach (including functions of NNCAP, BIA tribal liaison, and CCASS) would assist the CSC in succeeding with tribal engagement.
- The science agenda and projects have not always been aligned with the management priorities of stakeholders. Recommended actions include enhanced engagement of the SAC, continued effort to build on stakeholder interaction outside of the SAC process, and increased participation by university PIs in identifying stakeholder priorities.
- Consider the production of an annual science work plan, refocus annual report to emphasize stakeholder engagement, and use the paired documents to annually link planning and accountability.
- Increase engagement of the full science and extension capacities within host institutions and across USGS Science Centers, Cooperative Fish and Wildlife Research Units, and so forth.
- Integrate a process of actionable science into appropriate aspects of the research enterprise and document through metrics to show that the elements have been met.
- Link communication about actionable science and outreach, training and decision support tools directly to land managers, planners, and decision makers (federal, state, municipalities, and tribal).
- Strive to increase diversity of institutional co-PIs across the consortium, especially with respect to early-career stage and other dimensions.
- Develop and implement metrics to demonstrate that CSC funds support projects that are relevant to and applied by stakeholders.

References

ACCCNRS (Advisory Committee on Climate Change and Natural Resource Science). 2015. Report to the Secretary of the Interior, March 30, 2015. Available: nccwsc.usgs.gov/sites/ default/files/files/ACCCNRS_Report_2015.pdf. (December 2015).

Dayer, A. A., T. B. Lauber, and R. C. Stedman. 2016. Quality and extent of partnership involvement in Climate-Science Centers in Alaska, the Northwest, & the Southeast. Human Dimensions Research Unit, Cornell University, Ithaca, New York.

Garfin, G., A. Jardine, R. Merideth, M. Black, and S. LeRoy, editors. 2013. Assessment of climate change in the Southwest United States: a report prepared for the National Climate Assessment. Island Press, Washington, D.C.

NCCWSC (National Climate Change and Wildlife Science Center). 2009. Proposed 5-year strategy (2009–2014), version 7-13-09. NCCWSC, U.S. Geological Survey, Reston, Virginia. Available: nccwsc.usgs.gov/sites/default/files/documents/NCCWSC_5_year_strategy_ver_7-13-09b.pdf. (September 2016).

NCCWSC (National Climate Change and Wildlife Science Center). 2011. Providing science for climate adaptation. NCCWSC and DOI Climate Science Centers, progress report—fall 2011, Reston, Virginia. Available: https://nccwsc.usgs.gov/sites/default/files/documents/other/Progress%20Report_FINAL%2002-06-12.pdf. (November 2016).

NCCWSC (National Climate Change and Wildlife Science Center). 2014. Climate Science Center Stakeholder Advisory Committee (SAC) terms of reference. NCCWSC, Reston, Virginia.

Salazar, K. 2009. Department of the Interior, Secretarial Order 3289, Subject—Addressing the impacts of climate change on America's water, land and other natural and cultural resources. U.S. Department of the Interior, Washington, D.C.

Schirmer, C.L., C.F. Enquist, A.T. Govert, J.T. Overpeck, and S.T. Jackson. 2016. Department of the Interior, U.S. Geological Survey Southwest Climate Science Center five-year summary report 2015–2016. U.S. Geological Survey, Reston, Virginia.

TWS (The Wildlife Society) and ESA (Ecological Society of America). 2009. USGS National Climate Change and Wildlife Science Center: final report on outreach and recommendations. TWS, Bethesda, Maryland. Available: https://nccwsc.usgs.gov/sites/default/files/documents/TWS-ClimChgReportFINAL.PDF(September 2016).

USGS (U.S. Geological Survey). 2009. National Climate Change and Wildlife Science Center proposed 5-year strategy (2009–2014). USGS, Reston, Virginia.

USGS (U.S. Geological Survey). 2012. Advisory Committee on Climate Change and Natural Resource Science charter. USGS, Reston, Virginia. Available: https://nccwsc.usgs.gov/sites/default/files/fies/Charter-Final-ACCCNRS.pdf. (March 2017).

USGS (U.S. Geological Survey). 2013. Providing science for climate adaptation. The National Climate Change and Wildlife Science Center and DOI Climate Science Centers, Progress report—summer 2013. USGS, Reston, Virginia.

USGS (U.S. Geological Survey). 2014. Annual funding opportunity – fiscal year 2015. Available: www.swcsc.arizona.edu/sites/default/files/data/CSC_FY15_RFP.pdf. (December 2017).

Varela-Acevedo, E., and R. O'Malley. 2013. The National Climate Change and Wildlife Science Center annual report for 2012, version 1.1, November 14, 2013. U.S. Geological Survey, Circular 1387, Reston, Virginia. Available: http://pubs.usgs.gov/circ/1387. (November 2016).

Wall, Tamara U., A. M. Meadow, and A. Horganic. 2017. Developing evaluation indicators to improve the process of coproducing usable climate science. Weather, Climate, and Society [online serial] 9:95–107.

Appendix A
Southwest Climate Science Center Review Team Members

Science Review Team Members:

Chair
James Leenhouts
U.S. Geological Survey Arizona Water Science Center Director
520 North Park Avenue
Tucson, Arizona 85719, USA
E-mail: leenhout@usgs.gov

Gustavo A. Bisbal
Department of the Interior Northwest Climate Science Center Director
777 NW 9th Street, Suite 400
Corvallis, Oregon 97330, USA
E-mail: gbisbal@usgs.gov

Curtis Griffin
Professor and Department Head
Department of Environmental Conservation
School of Earth and Sustainability
University of Massachusetts Amherst
205 Holdsworth Hall
Amherst, Massachusetts 01003, USA
E-mail: cgriffin@eco.umass.edu

Frances O'Donnell
Assistant Professor
Department of Civil Engineering
Auburn University
209 Harbert Engineering Center
Auburn, Alabama 36849, USA
E-mail: odonnell@auburn.edu

Dave Rhode
Research Professor
Division of Earth and Ecosystem Sciences
Desert Research Institute
2215 Raggio Parkway
Reno, Nevada 89512, USA
E-mail: dave.rhode@dri.edu

Jennifer (Nifer) Wilkening
Wildlife Biologist; HCP Coordinator
Southern Nevada Fish and Wildlife Office
U.S. Fish and Wildlife Service
4701 North Torrey Pines Drive
Las Vegas, Nevada 89130, USA
E-mail: jennifer_wilkening@fws.gov

Cornell Human Dimensions Team:

T. Bruce Lauber
Senior Research Associate,
Department of Natural Resources,
105 Fernow Hall
Cornell University
Ithaca, New York 14853, USA
E-mail: tbl3@cornell.edu

Richard C. Stedman
Associate Professor
Department of Natural Resources
104 Fernow Hall
Cornell University
Ithaca, New York 14853, USA
E-mail: rcs6@cornell.edu

American Fisheries Society Management Team:

Douglas Austen
Executive Director
American Fisheries Society
425 Barlow Place, Suite 110
Bethesda, Maryland 20814, USA
Phone: 301-897-8616 ext. 208
E-mail: dausten@fisheries.org

Andrew J. Loftus
3116 Munz Drive, Suite A
Annapolis, Maryland 21403, USA
Phone: 410-295-5997
E-mail: aloftus@andrewloftus.com

Appendix B
Southwest Climate Science Center Schedule of Activities

February 13–16, 2017
The University of Arizona
Institute of the Environment
1064 East Lowell Street
Tucson, Arizona 85721, USA
ENR2 Building
Rooms N604 (Mon–Wed), N595 (Thurs)

Monday, February 13, 2017

Time	Activity	Desired output	Lead entity/ person(s)
5:00–6:00 pm	Pre-meeting of **Review Members only**. • Review schedule of meetings/ discussions • Overview of goals and expected products • Writing expectations • Identification of additional information needs		
6:00 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?		

Tuesday, February 14, 2017

Time	Activity	Desired output	Lead entity/ person(s)
8:00–8:30 am (ENR2, N604)	Convene		
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 Jackson, Overpeck
9:00–10:00 am	Brief review of points from preparatory conference calls focusing on structure,	Ensure that SRT has full understanding of	Austen, Leenhouts

Tuesday, February 14, 2017 (continued)

Time	Activity	Desired output	Lead entity/ person(s)
	funding, staffing, and related aspects of the Tucson component of the SW CSC. • Q&A and discussion of issues raised from the calls. • Identification of additional information needs. *Questions to be gathered by Austen/SRT chair resulting from the calls and conveyed to SW CSC staff prior to site visit to allow for preparation of responses.*	the structure of the the CSC, including core documents and key processes.	
10:00–10:15 am	Break		
10:15–11:15 am	**Establishment of the climate change science and conservation context of the CSC.** Selected 10-minute presentations on significant climate change issues and conservation challenges that characterize the CSC operational area. • Jonathan Overpeck – Introduction • Brad Udall (Colorado State University) – Conservation Implications of Declining Colorado River Flows • Erica Fleishman (Colorado State University) – Measuring Faunal Responses to Climate Change in the Arid Southwest • Don Falk (University of Arizona) – Forest Management and Fire • Glen MacDonald (UCLA) – A Comprehensive Field Measurement and Geospatial Modeling Approach to Sea Level Rise Effects and Specific Habitat Loss in California Coastal Marshes	Presentations and discussion will enable the SRT to recognize the linkage between these issues and the strategic plan and science agenda of the SW CSC	CSC director and PIs
11:15–noon	**University Consortium Discussion—** review of partners, mechanisms for engagement, assessment of strengths, weaknesses, and opportunities of the consortium. Overview of university work. Jonathan Overpeck (University of Arizona), overview and moderator Tim Brown (Desert Research Institute) Dan Cayan (Scripps Institution of Oceanography) Mike Dettinger (Desert Research Institute) Erica Fleishman (Colorado State University)	Status of consortium coordination, involvement, management, adequacy of coverage, etc.	Partner university leads

Tuesday, February 14, 2017 (continued)

Time	Activity	Desired output	Lead entity/ person(s)
	Alexander (Sasha) Gershunov (Scripps Institution of Oceanography) Glen MacDonald (UCLA) Brad Udall (Colorado State University)		
Noon–1:30 pm	CSC and host-university research forum – Graduate and postdoctoral research updates, outreach, and engagement. ***This time slot includes a working lunch*** Series of presentations highlighting projects (Carolyn Enquist moderates) • Kathy Jacobs (University of Arizona) – Partnerships in Capacity Building • Lynn Rae (University of Arizona) – Graduate Student Engagement with Tribal Communities • Alexander Gershunov (Scripps Institution of Oceanography) – Regional Weather Extremes in a Varying and Changing Climate • Alison Meadow (University of Arizona) – Evaluating the Process and Impacts of "Actionable" Science: How Do We Know When It's Working? How Do We Know What "Working" Means?	Understanding of the main drivers 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.
1:30–1:45 pm	Break		
1:45–3:45 pm	Partnership Dialogue #1 (Cornell Team) – **Science "producers":** Tim Brown (Desert Research Institute) Christopher Castro (University of Arizona) Dan Cayan (Scripps Institution of Oceanography) Karletta Chief (University of Arizona) Jesse Dickinson (U.S. Geological Survey) Don Falk (University of Arizona) Ty Ferre (University of Arizona) Erica Fleishman (Colorado State University) Alexander (Sasha) Gershunov (Scripps Institution of Oceanography) Kathy Jacobs (University of Arizona) Alison Meadow (University of Arizona) Connie Millar (U.S. Forest Service) Nathan Stephenson (U.S. Geological Survey) Brad Udall (Colorado State University)		Bruce Lauber and Rich Stedman

Tuesday, February 14, 2017 (continued)

Time	Activity	Desired output	Lead entity/ person(s)
	Juan Valdes (University of Arizona) Phillip vanMantgem (U.S. Geological Survey) Connie Woodhouse (University of Arizona)		
3:45–4:00 pm	Break		
4:00–5:00 pm	**Review Team only, closed session #1** (SW CSC team and partners meet elsewhere) 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 pre-site visit conference calls but should be leading to team members accepting authorship responsibility.		

Wednesday, February 15, 2017

Time	Activity	Desired output	Lead entity/ person(s)
8:00–8:15 am (ENR2, N604)	Convene Review day-1 notes and day-2 schedule of activities.		Austen, Leenhouts
8:15–8:45 am	Building tour and overview—LEED platinum certified		Govert, Overpeck
8:45–9:45	**CLOSED SESSION** Review team briefing and discussion with **University/Host Institution** principal investigators and relevant other university partners only. Jonathan Overpeck (University of Arizona) Tim Brown (Desert Research Institute) Dan Cayan (Scripps Institution of Oceanography) Mike Dettinger (Desert Research Institute) Erica Fleishman (Colorado State University) Alexander (Sasha) Gershunov (Scripps Institution of Oceanography)		Overpeck and other university representatives

Wednesday, February 15, 2017 (continued)

Time	Activity	Desired output	Lead entity/ person(s)
	Anita Govert (University of Arizona) Glen MacDonald (UCLA) Christine Schirmer (University of Arizona) Brad Udall (Colorado State University)		
9:45–10:00 am	Break		
10:00 am–noon	Partnership Dialogue #2 (Cornell Team) – **Science "users"**		Bruce Lauber and Rich Stedman
	Holly Barton (American Indian Higher Education Consortium) Matt Grabau (Desert LCC) Todd Hopkins (Peninsular Florida LCC, formerly Great Basin LCC) Chrissy Howell (U.S. Forest Service) Carly Jerla (Bureau of Reclamation) Genevieve Johnson (Desert LCC) Chad Marchand (Native Nations Climate Adaptation Program) Claudia Menglet (California LCC) Louise Misztal (Sky Island Alliance) Kenneth Nowak (Bureau of Reclamation) Larry Rabin (U.S. Fish and Wildlife Service) John Rice (Southern Rockies LCC) Aimee Roberson (American Bird Conservancy) Esther Rubin (Arizona Game and Fish Department) Jennifer Ruyle (U.S. Forest Service) Sarah Sawyer (U.S. Forest Service) Debra Schlafmann (California LCC) Selso Villegas (Tohono O'odham Nation)		
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.		Austen, Leenhouts, Loftus to facilitate
2:45–3:00 pm	Break		
3:00–3:15 pm	**Review Team only** – preparation of notes for closed session with USGS.		
3:15–4:30 pm	**CLOSED SESSION** Review panel briefing and Q&A with **USGS staff only**.	Review responses to submitted questions and information	Jackson and Enquist

Wednesday, February 15, 2017 (continued)

Time	Activity	Desired output	Lead entity/ person(s)
		requests, open discussion of CSC	
4:30–5:30 pm	**Review team only, closed session #2** – compilation of notes from day 2		
Evening	Working dinner – for Review Team only.		
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.		

Thursday, February 16, 2017

Time	Activity	Desired output	Lead entity/ person(s)
8:00–8:15 am	Review day-1 notes and day-3 schedule of activities.		
8:15–9:45 am	Flex time available for additional discussion topics. This may include 1. Communications and engagement of constituents. 2. Capacity development – training of students, training opportunities provided to partners, building the next generation of climate scientist and climate science trained conservation managers and administrators Topics and speakers to be determined through discussion of CSC directors, Leenhouts, Austen, and Loftus.	Time allocated to allow SW CSC to hold discussions on any variety of topics that are unique to the the CSC and have not been addressed in other previous session.	Jackson, Overpeck, Enquist. Input from Leenhouts, Austen, and Loftus
9:45–10:00 am	Break		
10:00–12:30 pm	**Review team only, closed session #3**	Identify key initial observations. Discuss writing assignments	
12:30–1:30 pm	Lunch and release SW CSC staff.		
1:30–3:00 pm	CLOSED SESSION: Working time for review team only.		
3:00–4:30 pm	Report out of review team to SW CSC, as needed.	• Open discussion and Q&A about initial observations	All participants are invited to this open presentation

Thursday, February 16, 2017 (continued)

Time	Activity	Desired output	Lead entity/ person(s)
		• Develop list of follow-up items, responsibilities, and timelines Draft report development, review, and finalization timeline	by the Review Team and discussion
5:00 pm	Complete working sessions of Review Team		
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 Unit: Southwest Climate Science Center 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

Our intention was to survey partners and potential partners of the Southwest CSC, but this population is not well defined. 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). 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-nine percent (n = 49) 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-nine percent (n = 49) reported that they have produced climate adaptation science through an affiliation with the Southwest CSC, while 24% (n = 30) have produced climate adaptation science but never with such an affiliation. We refer to both of these groups as science producers (63%; n = 79). Twenty of the respondents (16%) were both science users and producers. Eighteen respondents (14%) were neither users not producers.

The work of all of our respondents involved climate adaptation science, management, or policy to at least some extent. We found that nearly two-thirds of our respondents (65%, n = 85) were involved in climate adaptation science, management, or policy to a large or very large extent (Table SW-1). Only one-tenth (11%, n = 14) were involved only to a small extent. Those respondents who were only producers were most involved with climate change adaptation; 44% (n = 26) were involved to a very large extent and 73% (n = 43) were involved to a large or very large extent.

Most respondents (88%; n = 113) reported that they have had at least some interest in or involvement with the Southwest CSC (Table SW-2). Just 10% (n = 13) reported that they had no involvement but someone

Table SW-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	10%	9%	5%	28%	11%
To a moderate extent	28%	19%	35%	17%	23%
To a large extent	31%	29%	35%	39%	32%
To a very large extent	31%	44%	25%	17%	34%

Table SW-2. Respondents' relationships with the Southwest CSC.

Extent of involvement	User	Producer	Both user and producer	Neither user nor producer	Total
Heard of the Southwest CSC, but no interest or involvement	0%	0%	5%	6%	2%
No involvement with the Southwest CSC, but someone else in my organization involved	21%	2%	15%	11%	10%
At least some interest or involvement with the Southwest CSC	79%	98%	80%	83%	89%

else in their agency or organization did and another 2% (n = 2) had no interest or involvement at all. Those respondents who were producers (but not also users) were most likely to be interested or involved with the CSC. Ninety-eight percent had at least some interest or involvement compared to 79-83% for the other groups.

Respondents worked in states throughout the Southwest region, but particularly in California and Arizona (Table SW-3). Half (50%; *n* = 65) also worked in states or regions outside of the Southwest region.

A majority of respondents worked at the regional/multi-state scale (75%; *n* = 98), the state scale (59%; *n* = 76), and the watershed scale (52%, *n* = 67) for some or all of their work. Smaller percentages worked at the local (43%; *n* = 56), national (36%; *n* = 47), or international (30%, *n* = 39) scales.

Most respondents were affiliated with either federal agencies or universities (Table SW-4). Smaller percentages were affiliated with state agencies or non-profit organizations. Only one individual was affiliated with a tribal government and none were affiliated with private industry or local government.

Most respondents held either leadership/administration (44%; *n* = 57) or research positions (42%; *n* = 54). Only a few were in operations (7%; *n* = 9) or policy (3%; *n* = 4).

Extent of Involvement with the CSC

On average respondents have been involved with the Southwest CSC for 3.5 years. Respondents reported involvement with the CSC in a variety of ways (Table SW-5). Most common was as a participant in

Table SW-3. States in which respondents work.

State	Percentage of respondents	*n*
California	52%	68
Arizona	45%	59
Nevada	30%	39
Utah	20%	26

Table SW-4. Respondents' affiliations.

Affiliation	Percentage of respondents	*n*
Federal agency	42%	54
University	36%	47
State agency	12%	15
Non-profit organization	10%	13
Tribal government	1%	1

Table SW-5. Types of involvement with Southwest CSC in the last five years.

Affiliation	Percentage of respondents	*n*
Participant in a CSC training, webinar, workshop, or conference	45%	59
CSC grant recipient, applicant, or partner on a grant	30%	39
LCC steering committee member	26%	34
University member affiliated with the CSC	20%	26
Resource managers or decision maker who has used the science produced by the CSC	17%	22
CSC Stakeholder Advisory Committee member	15%	19
LCC staff member	14%	18
CSC-funded graduate student or postdoctoral fellow	6%	8
CSC USGS staff	4%	5

a CSC training, webinar, workshop, or conference (45%; *n* = 59). Nearly one-third (30%; *n* = 39) were CSC grant recipients, applicants, or partners on a grant, and about one-quarter (26%; *n* = 34) were LCC steering committee members. Relatively few (6%; *n* = 8) were resource managers or decision makers who had used the science produced by the CSC or CSC USGS staff (4%; *n* = 5).

The respondents reported on their frequency of interaction with five types of CSC representatives and affiliates (Figure SW-1). For their interactions with 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." For their interactions CSC Stakeholder Advisory Committee members, the modal level of interaction was between "not at all" and "up to a few times a year." Respondents interact with CSC graduate or post-doctoral fellows the least, but 52% interacted with them at least some of the time.

Benefits of Involvement

The two most important benefits that survey respondents believed the CSC provided were "access to a broader network of people interested in climate adaptation science" (73% described as "important" or "very important"; *n* = 82) and "access to climate adaptation science" (71%; *n* = 79) (Figure SW-2). Both of these benefits were discussed in the focus groups.

The value of the networks the CSC created was described by both science producers and science users. Science producers often mentioned how networking opportunities led to the development of new collaborative projects.

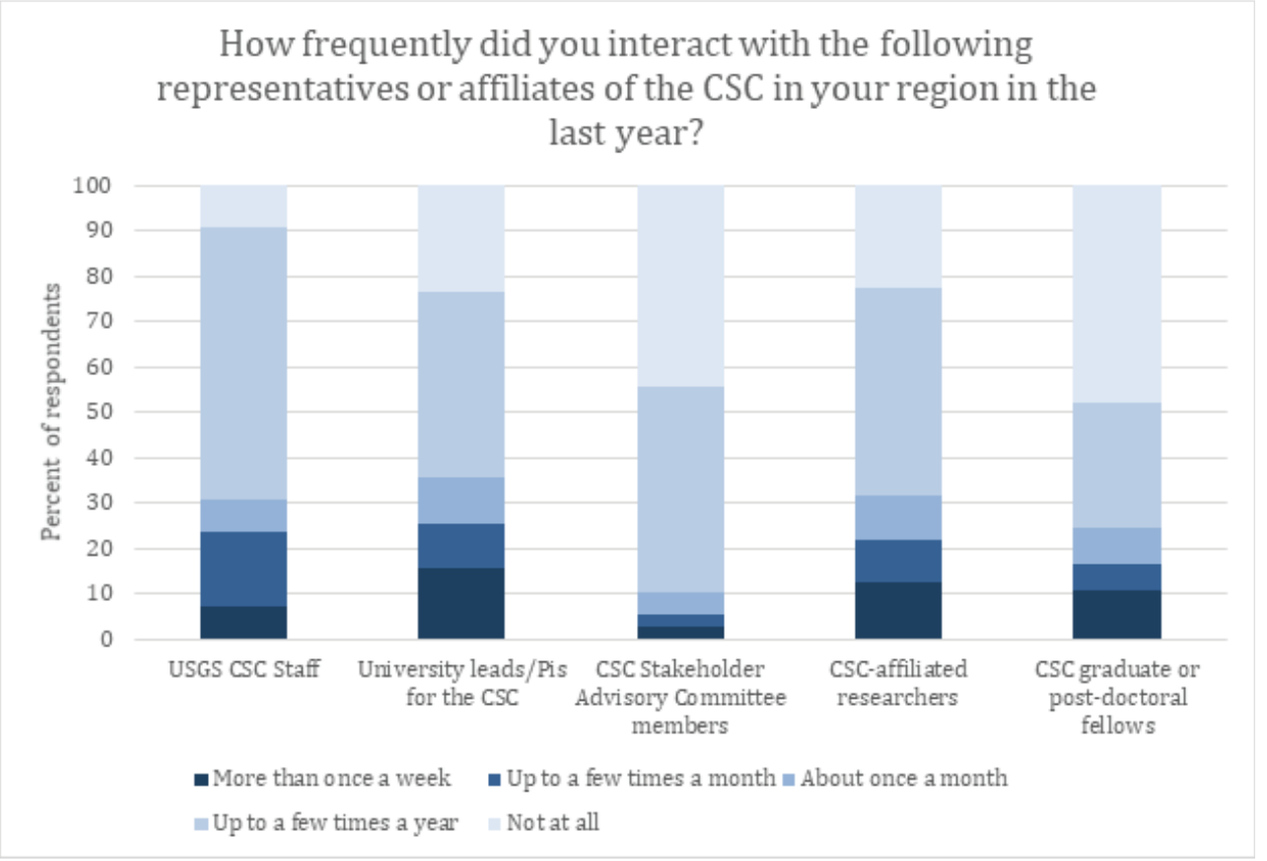


Figure SW-1. Based on survey question 8.

> In terms of the funded projects I have … They came out of meetings that the center put together with Fish and Wildlife Services folks and USGS folks and conversations … saying, "You know, I have an idea for something…. What do you think? Let's toss it around."… So my funded projects have been snowballed from there. (SW Producer FG)

> We knew the work that [other researchers] were doing in California. I think they knew about our work, but we hadn't collaborated previously. And this absolutely catalyzed that so that was at the level of the research and PI collaboration. And then you know we work with ten national parks really closely with sampling in each one of them. And those were existing relationships, but they were expanded and activated for this particular purpose. And so there was no question that that would not have happened to that level of detail, and I think that's created opportunities for ongoing collaboration that at least in our case would not have existed. (SW Producer FG)

Science users described how the networks allowed them to share ideas and concerns and find opportunities to coordinate in their work.

> One of the things I valued about the Southwest Climate Science Center and also … in the northwest is that we would initially have calls where all three of us and other LCCs, too, we'd get on the call and talk about the challenges, meeting managers demands, how to coproduce science…. It was just really helpful to have a network of colleagues and know that you're not alone trying to push the ball uphill, that others are facing similar challenges. (SW Users FG)

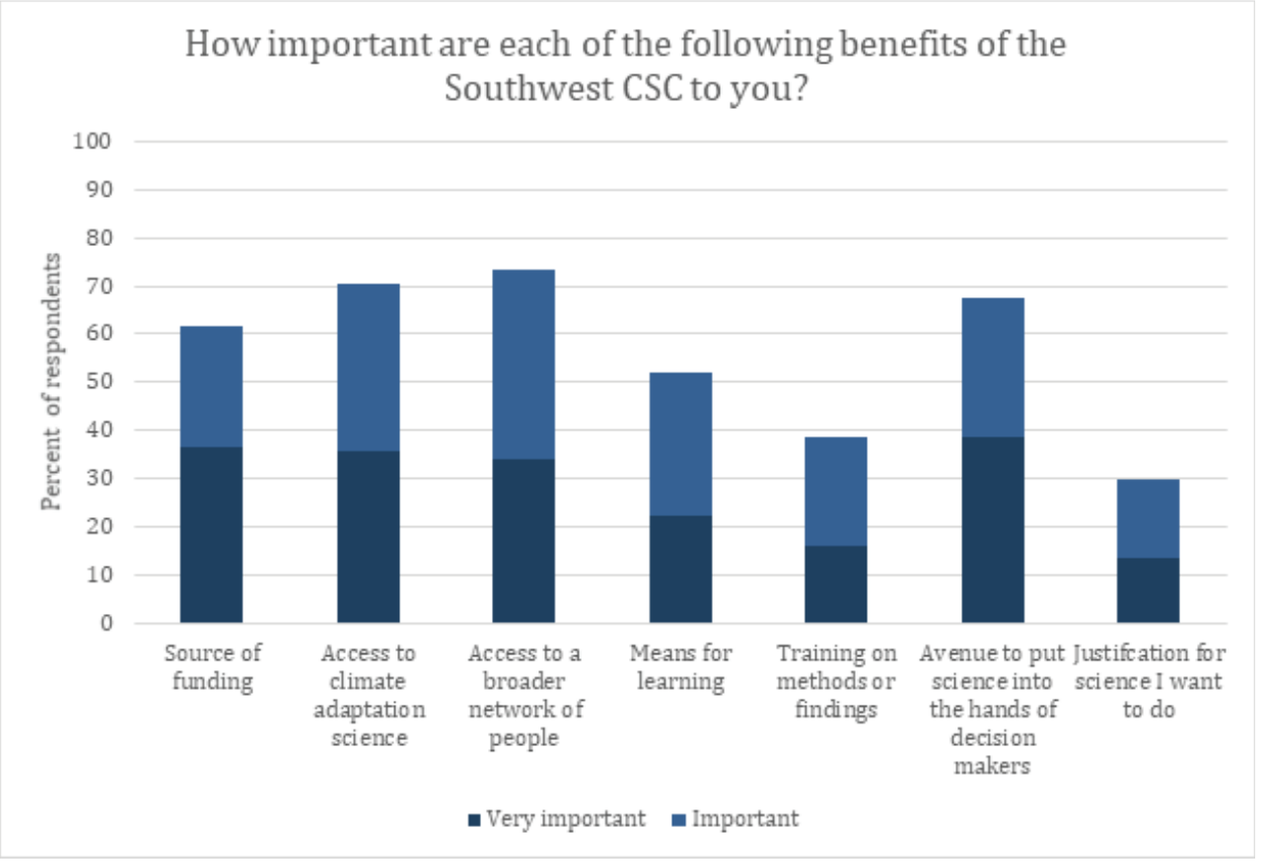


Figure SW-2. Based on survey question 9. Text in items shortened for presentation in graph, and only "important" or "very important" responses are shown.

> Knowing where Southwest CSC was going with … tribal issues…. Their investigators really set the stage to allow the Great Basin LCC to just add on to the tribal adaptation cause and training. (SW User FG)

Science users also discussed the value of having access to climate adaption science through the CSC.

> One of the things … that the Southwest did recently was led the Southwest Climate Summit which was a great success. There were an awful lot of people and an awful lot of good conversations that came out of that…. It was focused on science and getting information to specific user groups. I thought that was a really good benefit for the Great Basin LCC. (SW Users FG)

> We'll be relying on the Southwest Climate Science Center … to help us define what's possible in terms of long-term conservation planning in the southwest. In terms of what we can expect through climate and other things. And then using that to help support what the adaptation strategies are that we can use to maximize … our potential to achieve on the ground conservation goals with our partners. (SW Users FG)

Science producers believed that CSC support allowed them to make science and data more broadly available to those who wanted access to it.

> The CSC allowed us to build some data infrastructure for data delivery that would not have likely happened otherwise. And while it was originally aimed at the PIs of this group, it's actually getting

> used now quite a bit externally to much broader audience…. While at the moment probably geared a bit more for the researcher, we want … to see also how to do some tuning or some applications of it directly for management. (SW Producer FG)

More than two-thirds of the survey respondents also believed that the CSC provided an "avenue to put climate adaptation science into the hands of decision makers" (68%; *n* = 75). Science producers in the focus groups discussed the importance of connecting their work with stakeholders.

> I got involved by submitting a proposal because it's one of the few programs that funds science that also supports collaborations with stakeholders. (SW Producer FG)

> My work for many decades actually has been connecting science and decision making and they provide you know a good avenue for that so the partnership was very obvious. (SW Producer FG)

> I don't think we would have the Native Nations Climate Adaptation Program in anything like its current version without the Climate Science Center. I really think it's got fundamental components, maybe a third of the total funding but I think maybe more than a third in terms of the commitment to making it happen. (SW Producer FG)

Some particularly valued the opportunity to engage in coproduction of science.

> The opportunity to be in an … environment that steers towards coproduction in a very real sense…. That was written in the RFPs…. I've had to go out and work with the stakeholders from the very beginning setting the stage. It was very exciting to me and you know that has really helped spread that idea…. So it really is that coproduction piece … in the commitment of the centers that attracted me. (SW Producer FG)

The CSC not only provided the opportunity to coproduce science, but to study and improve the way that coproduction occurred.

> Given my interest in studying that process and how to do that better, it also gave me an opportunity to use all of them as guinea pigs and understand how to do that better. And so I think that has been a really unique and fascinating experience that I would not have had especially watching them, watching the whole network grow up over the last 5 or 6 years. (SW Producer FG)

A majority of survey respondents thought that the CSC served as an important "source of funding" (62%; *n* = 69). Several focus group participants described how this funding could meet needs that other sources of funding could not.

> I think its funding has been timely and I'll call it nimble. The nimble part is we had this unprecedented drought in California that has gone beyond any of the historical records in severity. And we have [a project] that's meant to try to use it as a preview of the future…. It's really hard to get funding on real short turn around. Yet the Climate Science Center listened and was able to give us funding on a short turn around. We still had to submit a full proposal, but they were nimble in recognizing that the data we wanted to get were perishable and if we didn't get them now we would never get them. (SW Producer FG)

> In continuity of research, that has been really critical … where we've had to just kludge together emergency funding. We got a bunch … together in 2015. 2016 was going to be a gap in our data, and yet it

> was a critical year. And they filled that gap and now we're back on the bandwagon with other sources of funds. (SW Producer FG)

A number of producers maintained that the CSC was willing to fund different types of science.

> I honestly don't think we could have done the kind of work we were doing without this type of funding. Again to go back to the more traditional sources, NSF, you know they really want theoretical component, and we have that but our interest was much more applied. And honestly applied research is always a harder sell in the very competitive programs. Those of us who believe it's at least as important if not more important are often frustrated by that but that's a reality. And so I think that the orientation of this program is unique. (SW Producer FG)

> I would echo a lot of comments that have already been said on the issue of disciplinary boundaries and the more traditional funding … like NSF or NOAA. So for me particularly doing regional atmospheric modeling with integrated with hydrologic modeling … the combination of those two things, I think was for me very advantageous to seek the interaction of the CSC. (SW Producer FG)

Just over half of survey respondents thought the CSC provided a "means for learning about climate adaptation" (52%; *n* = 58). Focus group participants discussed both learning about the science behind climate adaptation and putting that science to use.

> The ability to work with people whose expertise is climate. I'm an ecologist. There's a lot of not very good understanding of climate in ecology. People are thinking about climate all the time …. But it's rare that you have the opportunity to really understand, as an ecologist, understand climate as a discipline and to be able to work with people that have that expertise and vice versa so on the science side it's been extraordinary to have that chance. (SW Producer FG)

> I went back to the Nation … where I'm the Director of Water Resources. And I … met a lot of people from the Southwest Climate Science Center. And they started updating me and giving me information that I needed to start to put together a climate change adaptation plan. And I initially went to the center for climate adaptation science and solutions … We've completed our draft so there's a direct effect right there…. In September, we'll get a council resolution. And so we've come a long way, and that's how there is a direct effect there. (SW User FG)

Fewer than half of the partners we surveyed thought that "training on climate adaptation science methods or findings" (38%; *n* = 43) or "justification for science I want to do" (30%; *n* = 33) were important benefit of the CSC.

Limitations on Involvement

Most survey respondents (79%; *n* = 102) reported limits to their involvement with the CSC (Figure SW-3). The most common (46%; *n* = 60) limit was not having enough time, followed by not having enough funds (22%; *n* = 29). Focus group participants also referred to these types of constraints on their ability to be involved.

> I really care about the goals of the Climate Science Center. I've come to really care about a lot of the people that I work with in the Climate Science Center. But at some point there aren't enough hours in the day for things that are labors of love. And we want to sustain it and most of us will put in a lot of unpaid work, but we still would like to get paid, and we still have obligations that the money is coming

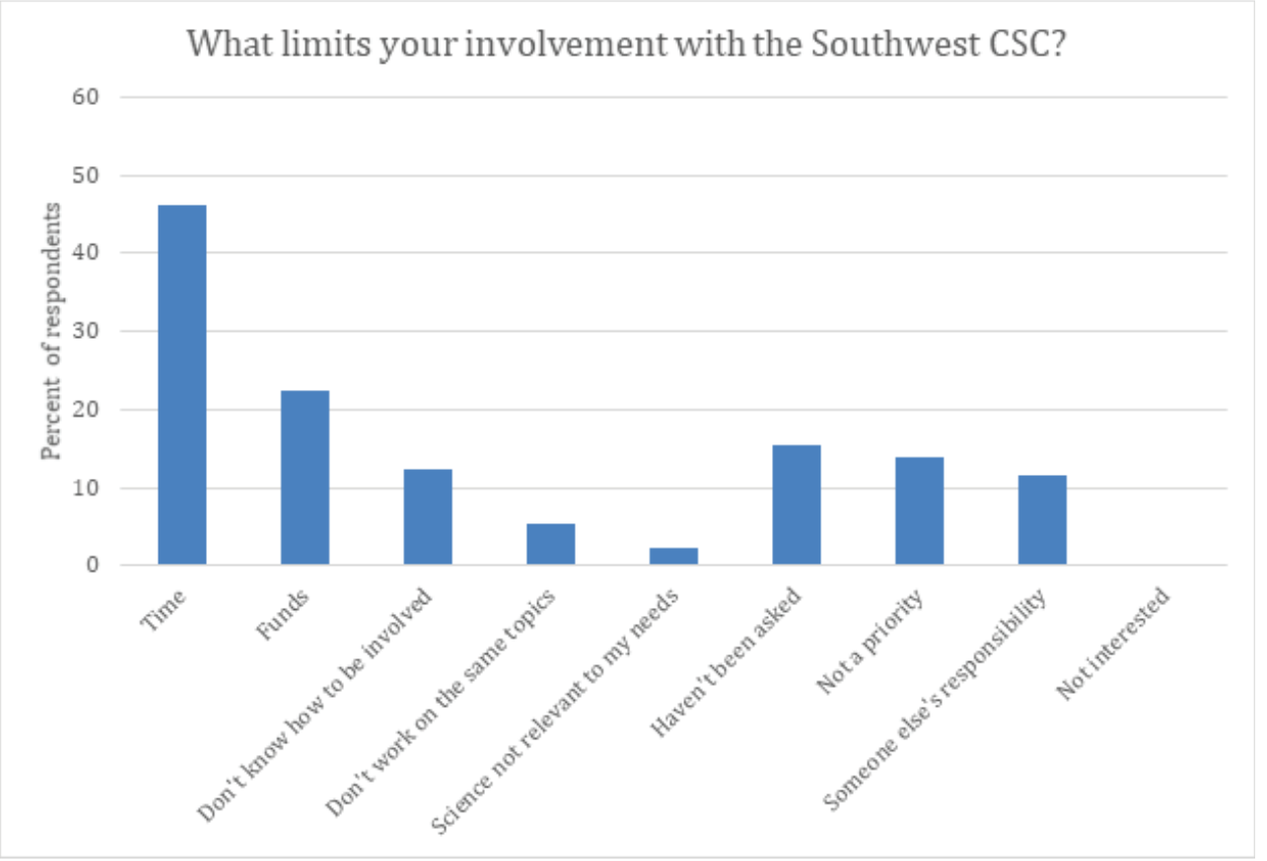


Figure SW-3. Based on survey question 10. Text in items shortened for presentation in graph.

> from. And so you just at some point get maxed out…. I think that for a lot of the programs that are being established now a trend towards more realism about what can be accomplished through the dollars that are available…. But let's be honest about what is not going to be accomplished with the dollars, what's going to be accomplished by labors of love. (SW Producers FG)

A minority of survey respondents reported that their involvement with the CSC was limited by not invited/being asked to be involved (15%; $n = 20$) or not knowing how to be involved (12%; $n = 16$). One survey respondent described shortcomings they perceived in how the CSC made efforts to engage partners.

> They don't seem very organized and don't always alert me to their meetings in a timely manner. They don't seem very interested in engaging with their stakeholders and they haven't made it clear what their mission is. They also seem to constantly have staff turnover so I'm not always clear who the correct contact is. (SW CSC Survey)

Related topics also arose during the focus groups. Some participants pointed out the fact that limitations existed on who could apply for CSC funding.

> My colleagues in USDA have felt somewhat excluded by the RFP requirements, PIs needing to be part of the CSC host institution or USGS Science Center. Of course, it stimulates working relationships with people there but it's one more place where you can't be the initiator. So that's just been a bit of filter for people in USDA. (SW Producer FG)

Both science producers and science users described barriers to effective integration of the work of the CSCs and the LCCs.

> This is not actually specific to the Climate Science Center, but the integration between what's going on with the Landscape Conservation Cooperative and the Climate Science Centers, at least to me seems really impenetrable…. I don't actually know what the problem is. I don't actually think it is the Climate Science Centers, but somehow these programs need to be better integrated…. And, of course, their boundaries are absolutely no relationship to each other. And anyway the whole thing is really complicated…. I'm not having problems interacting with the Climate Science Center, but I am very confused about what's going on in the intersections that these programs have. (SW Producers FG)

> The challenge I'm going to bring up actually applies to all of the LCCs…. Early on we each got our funding, different amounts of funding. You know the CSCs got their funding…. But one of the challenges early on was just funding opportunities coming at different times and sometimes a little out of the blue. And we have since coordinated on that to where the Great Basin is funding every other year and those are opposite years of the Climate Science Centers and that's helping us coordinate. But early on it was a bit of a scramble in that you got money and had to get it out the door. And RFPs would come out a week later, and you'd be like, "Oh, I wish I knew they were going to put that in the RFP."… But that process has improved greatly and that's just a growing pain to me. (SW User FG)

A small number of survey respondents also said that their involvement with the CSC was limited by this involvement being as high of a priority as other work for respondents (14%; $n = 18$) and it being someone else's responsibility within their organizations (12%; $n = 15$).

Within the focus groups, participants occasionally referred to the fact that the CSCs own capacity to engage with its partners and pursue its mission was limited.

> You know the only problem I see is that it's not scaled up to the level of support and activity that's going to be needed to address the challenge. Proof of concept, yes. Scale, not yet. (SW Producer FG)

> I think the challenge … is the time chiefly…. There's not a … lot of staff at the Climate Science Center. Effectively there's currently about four full time people that are consistent and, and they are there all the time…. I would say that really all of the challenges are based on just time and the resources… (SW User FG)

These limitations were sometimes aggravated by cumbersome administrative procedures within the federal government.

> The other really big issue … is we have internally within the federal government a lot of administrative burdens on how we can fund things, and challenges for how we can actually truthfully move money around. (SW User FG)

In addition, the geographic limitations that had been placed on the CSCs work sometimes made it more difficult to address important scientific questions.

> The geography at the U.S. border – complete ecological continuity between our part of the southwest and the Sierra Madre Oriental and Occidental. It would be great to be able to study that continuity fully within this purview. And the same questions apply to Mexico … a really interesting contrast in

many ways in terms of land management and forest industry. So I realize that constraint comes from on high but it's interesting to think about and maybe something we could look, look to in the future. (SW Producer FG)

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* = 87) agreed or strongly agreed that climate adaptation science in the Southwest region is available to decision makers (Figure SW-4). A majority also believed that it was used to inform management decisions by water managers (85%; *n* = 93), fish and wildlife managers (70%; *n* = 78), and land managers (59%; *n* = 66). Only about one-third (36%; *n* = 40), however, believed that policymakers used this science to inform policies. More than half (60%; *n* = 69) maintained that what is known about climate adaptation does not necessarily influence actions taken by decision makers in the region. Nearly as many (59%; *n* = 57), 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 Southwest CSC science specifically, respondents (90%; *n* = 102) strongly or somewhat agreed the CSC science can contribute to policy or management (Figure SW-5). Respondents were also positive about other characteristics of the CSC science, finding it to be of high quality (90%; *n* = 98) and

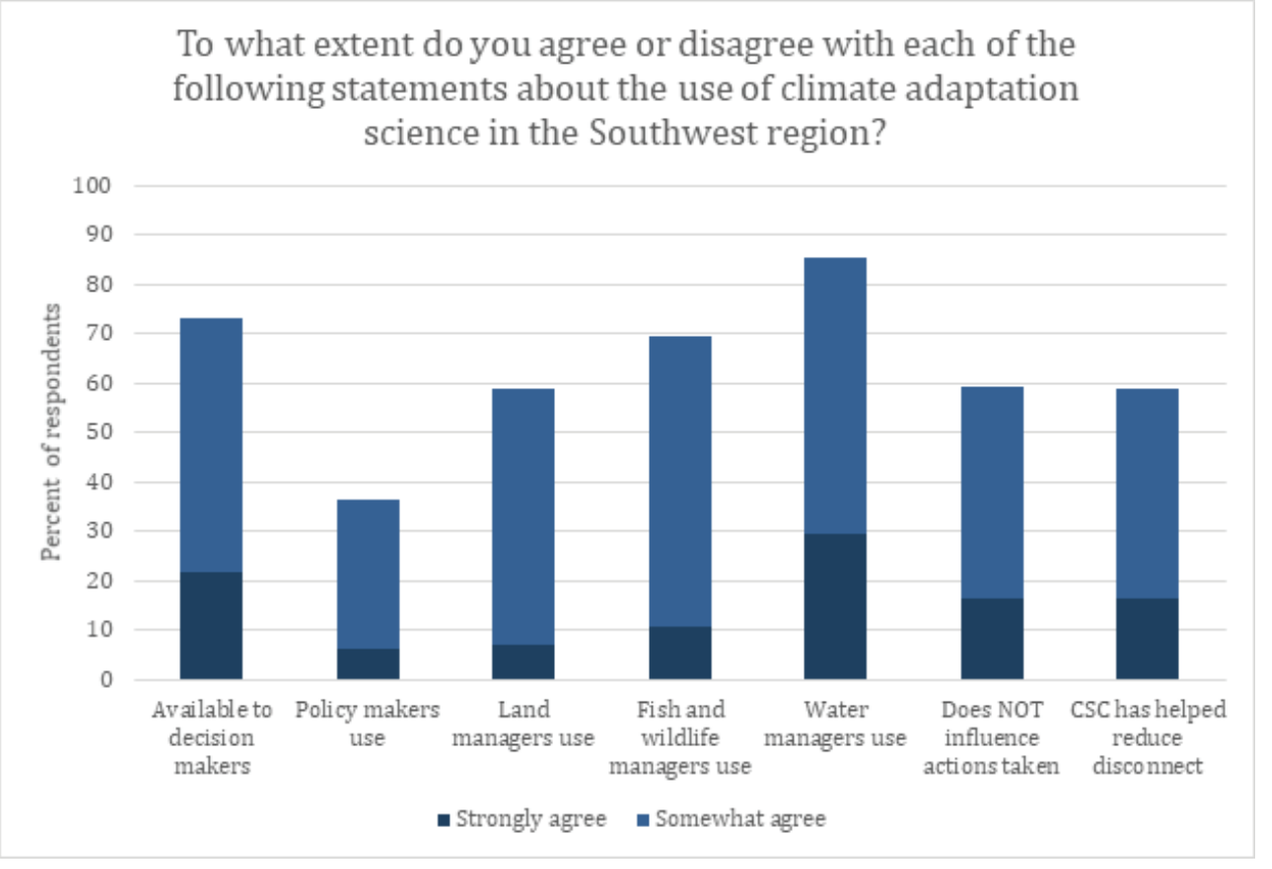


Figure SW-4. Based on survey question 11. Text in items shortened for presentation in graph.

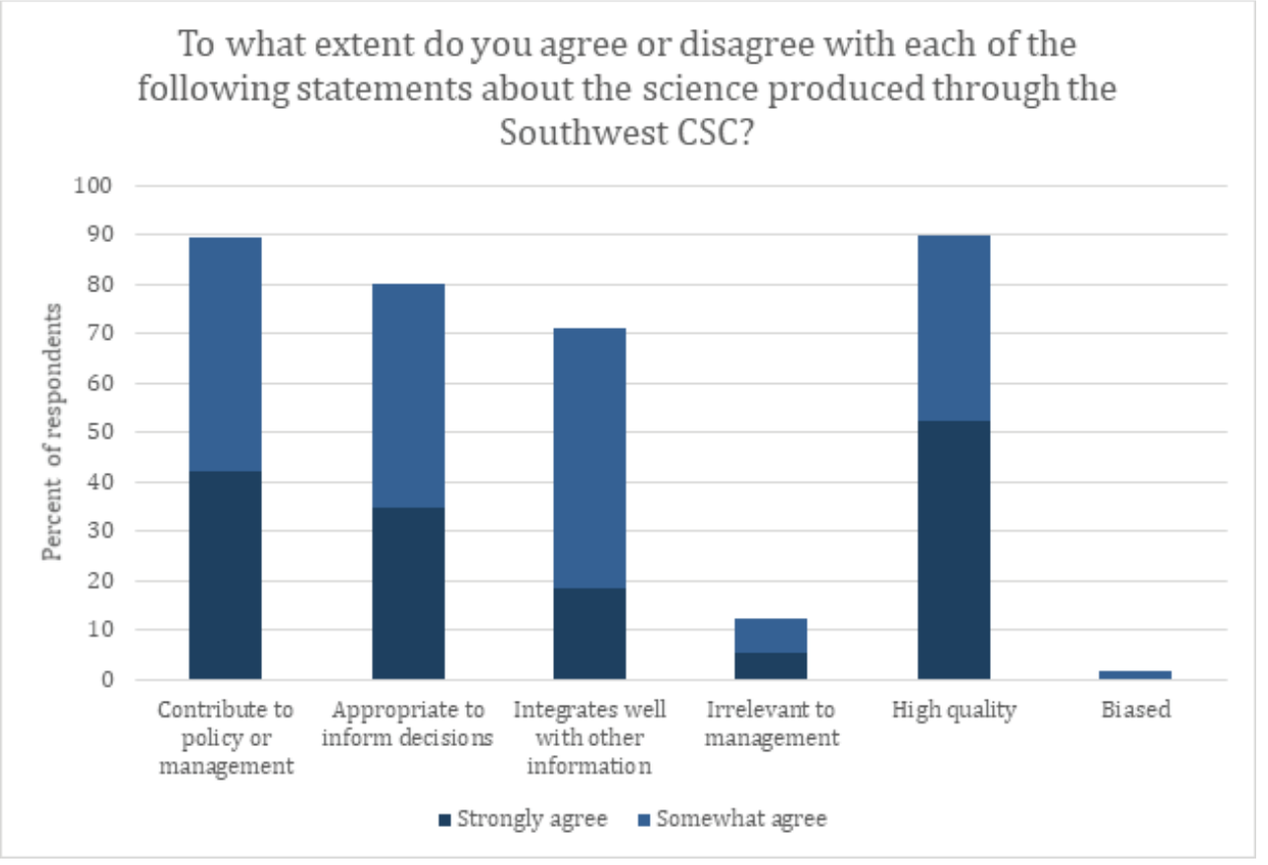


Figure SW-5. Based on survey question 12. Text in items shortened for presentation in graph, and only "strongly agree" and "somewhat agree" responses are shown.

appropriate to inform the types of decisions being made (80%; *n* = 90). A majority also thought that it integrated well with other information (71%; *n* = 77). Few thought that the Southwest CSC's science was irrelevant to management (13%; *n* = 14) or biased (2%; *n* = 2).

Science Users' and Producers' Use of Climate Adaptation Science

Among respondents who reported that they were science users, 74% (*n* = 25) reported that they or someone in their organization used climate adaptation science from sources affiliated with the Southwest CSC. Slightly more (86%; *n* = 36), 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 Southwest CSC science were to inform management plans (55%; *n* = 27; Figure SW-6). Forty-three percent reported using it to inform management actions (*n* = 21), and nearly as many used it to inform training of conservation professionals (41%; *n* = 20). Slightly more than one-third (37%; *n* = 18) used it to inform the public about climate change and its impacts. It was less frequently used to inform policy (18%; *n* = 9), and no one reported using it to inform land acquisition priorities.

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 (although not identical), but the absolute frequency was greater. More than four-fifths (82%; *n* = 65) said their science had

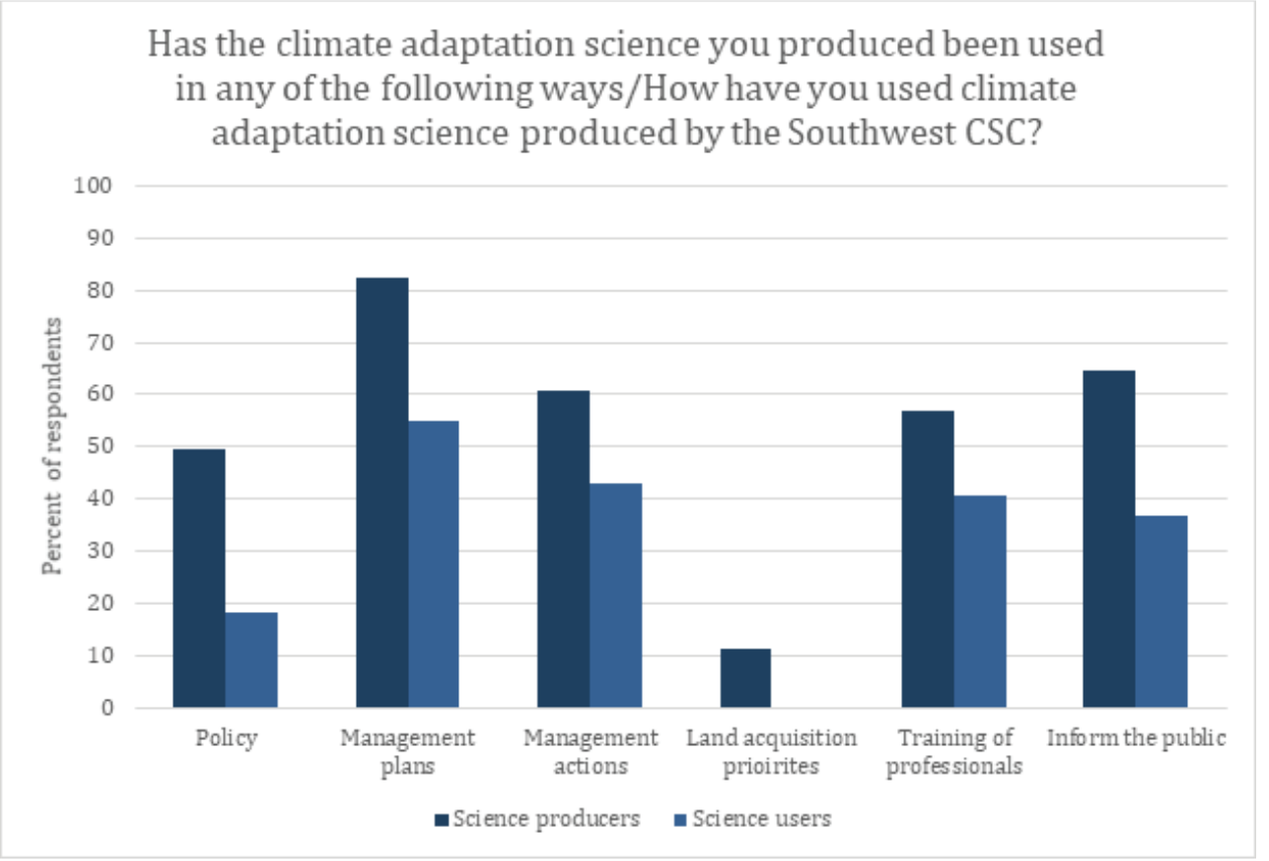


Figure SW-6. Based on survey questions 15 and 21. Text in items shortened for presentation in graph.

been used to inform management plans. Nearly two-thirds (65%; *n* = 51) had work that had been used to inform the public. More than half said their work had informed management actions (61%; *n* = 48) or had contributed to the training of professionals (57%; *n* = 45). Nearly half (49%; *n* = 39) reported that their work had informed policy, which was relatively much more frequently than the science users had reported. 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.

Some of the focus group discussions explored the conditions under which CSC science could be useful to decision makers. Some participants argued that stakeholder engagement was a key to ensuring that the science was used.

> It takes time to be able to take the climate science and have it applied…. That takes time and it also takes the connections. I think the connections are being made with the right folks through the LCCs and through the agencies and tribes…. The structure is starting to happen but we're just still at the beginning basically. (SW User FG)

> We have questions that may or may not be directly amenable to a research project, where we actually need something at the end of the day…. That almost sounds more like the contractor group services. So that's a fine line we encounter a lot, and I think that you know strong stakeholder engagement is the key to finding that middle ground. (SW User FG)

In some cases, scientists engaged stakeholders from the beginning of their projects to be sure that they understood their needs.

> We incorporated that element in the project design from the get-go and we had a series of meetings that, one, was work formulation of project methodological approach, and then the other was particularly for review of project results. It was in that first initial meeting where we reviewed project methodological approach that we had an entire section of the meeting devoted to presentations and discussions by our water resource providers. And we know from the get-go what their priorities are, how they use information and, more importantly from the technical standpoint, how did we need to work with them to format information so it would be useful to them? And that's an often overlooked issue. (SW Producer FG)

In other cases, the LCCs were involved in intensive efforts working with stakeholders helping them to understand the CSC science and translated it into forms that were useful for decision making.

> One project that we talk about often is the sea level rise effort that USGS has done … The Northwest Climate Science Center was involved. The Southwest Climate Science Center was involved. Very labor intensive effort where specific sites all along the Pacific Coast from California to Washington were measured primarily looking at National Wildlife Refuges but state areas as well…. And then scaled up models, climate models to show on a specific site … what is predicted for sea level rise and very, very applicable for, for the refuge managers there…. The LCCs then helped with supporting workshops where the managers and the scientists were there together and there was eleven different workshops up and down the coast to spend one-on-one time in a small group translating what the science says, what it's really going to do on the ground. And to help as a small partnership, how are these folks going to address that now and how are their goals going to change? (SW Users FG)

One participant maintained that the CSC science helped decision makers understand the range of conditions they might encounter in the future, which informed their planning efforts.

> Some of our partners are a little long with the dire outlook … really interested in one specific outcome…. The CSC has helped us with that … to look at broader planning goals. So instead of planning for something that is not within the range…. So again it's more just dealing with reality of like the scenarios as well as the uncertainty that we're struggling. (SW User FG)

Science users and producers differed in their perceptions of what limits the use of CSC science (Figure SW-7). In virtually 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. At least sixty-four percent of the producers believed that the use of the CSC's science was limited by all of the factors listed, except for three factors having to do with the nature of the science itself: the science not being interdisplinary enough (51%; $n = 38$), the science models or results not being refined enough (47%; $n = 35$), and a lack of quality of the science (10%; $n = 7$). Producers believed that the top barriers were lack of awareness of the science (77%; $n = 58$), scientists not working closely enough with decision makers (76%; $n = 57$), and science not being communicated understandably (74%; $n = 55$). The most frequently cited barriers for science users also included scientists not working closely enough with decision makers (50%; $n = 22$), science not being communicated understandably (40%; $n = 17$), and decision makers not being aware of the science (38%; $n = 17$). The science users were much less likely to consider a lack of skills and training among decision makers to be a barrier (16%; $n = 7$) than science producers did (71%; $n = 53$).

Focus groups participants discussed these and other limitations to the use of the Climate Science Center's

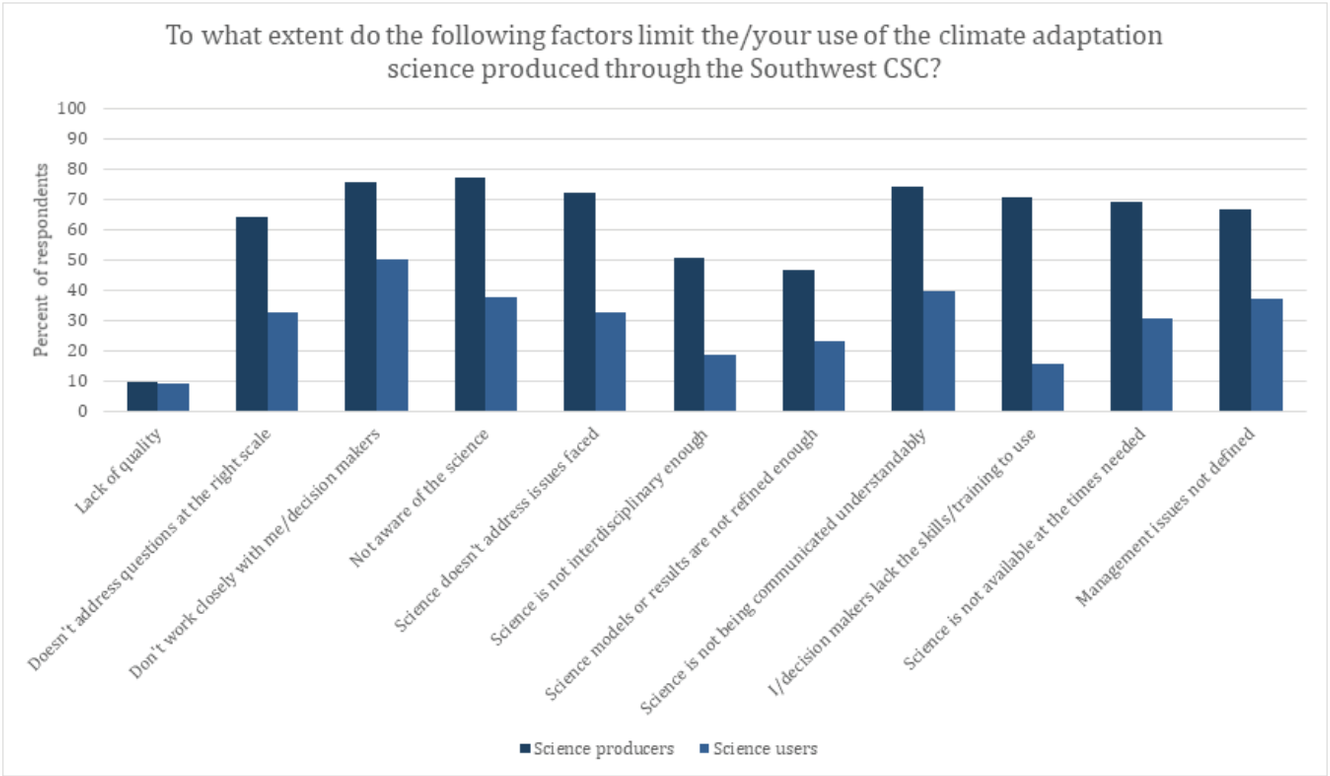


Figure SW-7. Based on survey questions 16 and 22. Text in items shortened for presentation in graph, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown. Also, text varied slightly for science producers and users.

science. To begin with, they argued that applying climate science in decision making is a complex process that takes time:

> It takes time to be able to take the climate science and have it applied. That means changing goals potentially, re-evaluating your targets, making adjustments on the ground. Even if you know what you're doing, it still takes five years….The expectations that's going to be applied immediately, and we'll see some changes on the ground, that's going to take decades. (SW User FG)

That process is even more challenging if there is a mismatch between the type of science being produced and the types of products that decision makers would like to see.

> Well, I think one of the … most important things that comes out of the back end of these projects is the question of, "Where do we go from here?" In our project … we did climate change projections from water resources. And … they weren't as much interested in this IPCC-based water resource projections for forty years in the future as they were issues of "Can you do an historical water resource projection?" using historical re-analyses or … sub-seasonal to seasonal forecasting. So it was a little confounding to me as a principal investigator. How do we communicate all of this great feedback that's coming from our water resource people? (SW Producer FG)

> I think one of the challenges that you encounter is … that fine line between … a contracting service for a very specific deliverable that will in fact be useable in your process… vs. more of the research paradigm where you may or may not get something … that really meshes well. (SW User FG)

Consequently, both science producers and science users argued that different types of products might be needed.

> There's a lot of people in the upper levels with the policy world that actually have tons and tons of reports on climate. They have all kinds of reports on climate change, okay? But they're, they're not actually doing anything with them, and part of it's capacity but part of it is we're not sending up something that says, "You have to do this right now. This is action that needs to be taken." … We're not actually sending stuff for most cases that is actually actionable, that says this is the problem and this is what you can do about it…. So I think we kind of got to be real here in terms of what we're delivering as a product and maybe we need to kind of rethink that a little bit. (SW Producer FG)

> Another benefit that I think … is really fundamental for us is to take climate science and get it to the form that actual users can use. It takes several steps. And where I feel like the Southwest Climate Science Center is that initial broad step as well as getting a few levels down. And where … the LCCs can help pick that up and take that … a few levels … where it can be more relevant to the users themselves. So it, it takes several different I'd say partnerships. (SW User FG)

The challenges in producing products that decision makers would find useful is aggravated by an ineffective system for identifying stakeholder priorities.

> This stakeholder advisory committee tends to be regional scale. It's bigger questions. But I know from talking to almost all of you that you're working with the ground levels managers for the most part, if not exclusively. And so there's some disconnect within the agencies about what's necessary at what scale of decision… We're sort of codifying that in the way that the CSCs got designed and said, "Oh well … these CSCs … have to draw from big scale managers and leaders within the agencies." But that's not always reflecting those individual needs…. My understanding is at the beginning the LCCs were supposed to be making some of those links and making some of those partnerships more clear. And I just don't think that that's the way the network evolves. (SW Producer FG)

Focus group participants believed that scientists needed to find better mechanisms for connection with users.

> We still need improvement of the mechanism by which the science demands out there come to us, and we can see what the priorities are. What are the things that a number of people are talking about that fit what we in partnership with the Department of Interior … can tackle? And I think that we still need that. (SW Producer FG)

> Creating an easier path for engagement with municipalities, with the public health sector, with things that are more immediately tied to people's day-to-day lives … It would be great to have an entity to do that. (SW Producer FG)

Some potential users, such as tribes, did not initially have their priorities addressed by the Southwest CSC's science because their needs were different than many other users.

> It's just my perception that everybody got territorial in the beginning…. And the tribes, for a while they were not in the loop or not at the table. I was at the table, but I don't represent the 562 tribal nations in the United States, so I can't speak for all of them…. The challenge was that some of the projects that … I thought … were significant, they were being pushed out … by a consensus of more people…. And I think that was kind of a problem because then why were we involved, you know?... It's changed, and I'm glad. (SW User FG)

In addition, potential users often do not have the resources to implement actions informed by the scientific information they receive.

> In the land management agencies … there's a very complex operational hierarchy, right? That goes from a district level all the way up to national policy, and the disconnects along that gradient are truly breathtaking…. Policy proclamations are made and they sound great and they resonate with the kinds of things the CSC does…. The people on the ground don't see any of that…. They certainly don't get any resources to implement this, and so it poses for us a real challenge…. We get the buy-in at the local level, but resources are not coming down to put this on the ground…. We're basically having to ask them to redirect resources they're using already say for thinning or prescribed burning or for long duration fires or for insect studies or what have you…. Although the will may be there, the lack of resources to do anything different is a serious obstacle. Obviously, that's not a challenge that CSC can solve, but it's clearly a challenge that the CSC needs to recognize. (SW Producer FG)

> The problem, it's not the planning. People can plan. It's actually finding out if there's projects out there … that the tribes can tap into that are really ongoing. … A lot of tribes … they don't have a full staff. So they're asking one person to write a climate adaptation plan. That's hard. So maybe that's where some of the planning and scenario planning can help tribes by saying if they don't have an environmental person … and how can we help you to put that template together? And also to collaborate and communicate with federal and state agencies…. Why invent the wheel when people are already doing research?... You can train the Native people, but we still need to know somebody to help us write it. And after you help us write it then we'll still need to be current. And then by being current I mean that we don't want to do research that everybody else in the area is doing. (SW User FG)

> What do we need in the realm of climate change? One of the things that we really need is technical assistance. You know I have field offices who come to me and say, "We have a permittee who is interested in developing a habitat conservation plan, and they don't have the expertise to draft the climate change sections….And we don't have the expertise in-house." …. With that in mind, I think one of the things that would be really helpful is to find a way to have technical assistance provided whereby program experts in climate science would be able to provide that technical assistance to our folks in-house. (SW User FG)

Consequently, one recommendation was to devote more resources to train decision makers in how to make use of science.

> Regardless of how much research is out there, I think the resource managers still … don't feel equipped to take it and apply it. So … our LCC has changed gears a little bit and are putting a lot of emphasis on training and how to move forward with uncertainty and how to recognize that … we can apply the climate science…. It's not that difficult to get folks past paralysis, and we're finding out that that's been helpful. It is desired by many to have this training, so we can't put on enough of them. It would be great to have the Climate Science Center as part of that … to just be able to translate some of the information … what's … coaching more one-on-one…. And so if we could do that in a more structured setting, I think that would be helpful for us.(SW User FG)

Current institutions do not typically support the engagement of scientists in providing technical assistance.

> The challenge … is that faculty at the research institutions … aren't necessarily in a role where they are recognized for technical assistance…. What they're recognized for is traditional research and publications…. I just think it's something that we all need to work through is to bring out ways of researchers

> being rewarded and incentivized to provide technical assistance to decision makers and conservation practitioners. (SW User FG)

Finally, participants recommended more investment in evaluating the outcomes of projects funded by the CSC.

> We do have opportunities to be much more systematic in the way that we harvest information and outcomes from all of the projects and demonstrate that…. I am essentially talking, evaluating projects and seeing which ones were have been really successful. (SW Producer FG)

Science Users' and Producers' Engagement in Coproduction of Knowledge

Respondents reported on their beliefs about co-production of knowledge in general. An overwhelming proportion of both science users (94%; $n = 44$) and producers (89%; $n = 70$) 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 SW-8). For all phases of research projects except for "analyz-

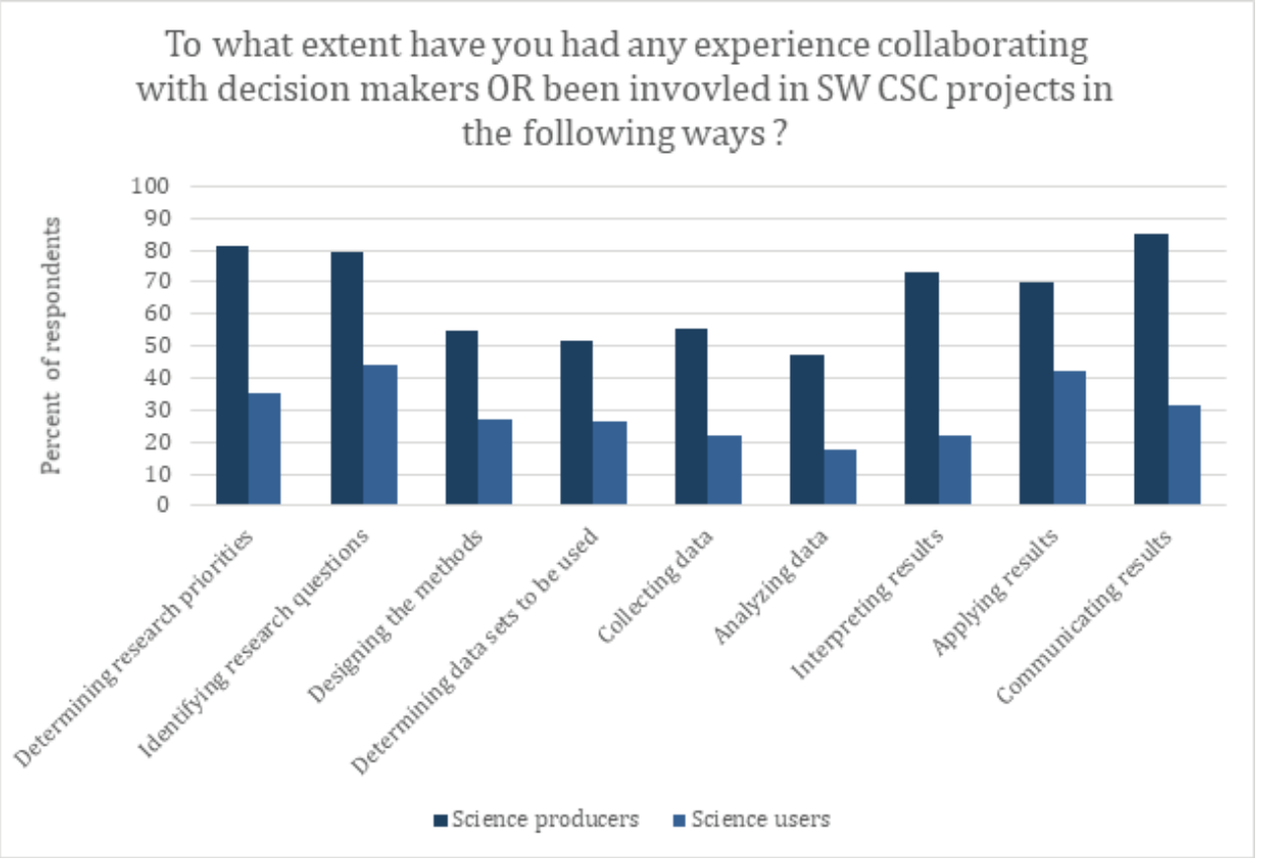


Figure SW-8. Based on survey questions 18 and 24. Text in items shortened for presentation in graph, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown. Additionally, the text of the question varied slightly for science producers and users (e.g., the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

ing data," at least half of the science producers had experiencing 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 four phases of research with which at least 30% of science users had experience: identifying research questions (44%), applying research results (42%), determining research priorities (35%, and communicating results of a research project (31%). Both science users and science producers perceived collaboration between scientists and decision makers to be less common in designing research methods (science users – 27%; science producers – 55%), determining data sets to be used (science users – 27%; science producers – 51%), collecting data (science users – 22%, science producers – 55%), and analyzing data (science users – 18%; science producers – 47%).

During the focus groups, some examples of effective coproduction practices were discussed:

> One of the really positive experiences we have is working with Connie Woodhouse and her project on drivers of drought and temperature and precipitation in Colorado. Because I think that her engagement with the broad stakeholder group that she's identified has been very consistent and sort of agile in terms of having it really be a dynamic back and forth um as opposed to one-sided science to land managers. (SW Users FG)

Focus group participants pointed out that one of the factors making coproduction easier in the Southwest region was that the CSC had invested resources in better understanding what made coproduction work.

> Some of the work that was funded related to coproduction has been really important, and we're starting to use that information in the LCC. I'm using in a way that I'm developing some of the criteria for our own funding opportunities so that we can start incorporating some of the things into the way that we're doing our procedures. (SW User FG)

> This is a really complex landscape here and the Climate Science Centers are just a piece of that landscape. But I do feel like they're embracing what has been learned about coproduction …. They have actively been trying to get up that learning curve very quickly. (SW Producer FG)

The CSC also made an effort to give its partners the training they needed to work well with certain groups, such as the tribes:

> I mention tribes … They opened the door for us. They helped us get through…. I had no experience with tribes before. I changed my position, and so they helped me understand the protocols, sensitivities. I went to a TEK training in California…. I learned a whole lot but those opportunities were there because of the Climate Science Center, both the Northwest and Southwest. (SW User FG)

The factors most likely to limit science users' involvement in research projects were scientists not reaching out to them (41% agreed or strongly agreed; n = 19), followed by different perspectives on what science is needed (39%; n = 18) and funders not supportive of collaboration between scientists and science users (33%; n = 15). Other factors were perceived to limit the involvement of smaller numbers of respondents: the science users not having enough time (24%; n = 11), different perspectives on how research projects should be conducted (20%; n = 9), and scientists not interested in listening to them (13%; n = 6).

Focus group participants offered a variety of perspectives on the factors that made coproduction challenging. One of these was the need for extended periods of time.

> The two-year timeframe is just too short for the projects if you're trying to work with stakeholders, particularly if you don't have relationships. It's just way too short. I mean three years is better, but even that's too short. We really need longer periods. (SW Producers FG)

They also argued that not all scientists understand how to engage in coproduction.

> Some have worked with LCCs and Climate Science Centers for several iterations … or have worked with other users side-by-side, and they totally understand the coproduction of science. And others are new. Others have maybe … written proposals for NSF … or NASA, and they're now finding this RFP and are new to the applied science arena. (SW Producers FG)

They suggested increasing the expectations for building coproduction in to projects.

> Publications [should] be a middle point in the research cycle rather than an endpoint in the research cycle. And I think the traditional model is a peer-reviewed publication as an endpoint in the research cycle. But we're really talking about … to get research done which can be applied…. It's really working with decision makers to help them use that information. And so I think there are mechanisms that could be made available on … cooperative grants and agreements. And deliverables … would include things up to a draft document of peer-reviewed quality, but that will … really be a mid-point that would only be the first half of the deliverable. And the second half of the deliverable would then be how these researchers are actively going to work with conservation organizations, land managers, conservation practitioners to ensure that that information, that knowledge that was gained is given them into the decision making process. (SW Users FG)

> I think one thing that Climate Science Center could more strongly emphasize and maybe even do some coaching is … what constitutes applied science and what constitutes sort of working with potential users of that science in advance of even thinking through a project. How would that fit into the decision-making context? How would users use that science so that the research is … ready to go, and that stakeholders are engaged in the scoping of the research already? So I think there's a learning process and a coaching that needs to take place on the PIs side, on the scientist's side. And from reviewing those proposals some were clearly very knowledgeable about how to do that, and others were not. (SW Users FG)

In addition, they argued that more support for stakeholder engagement was needed during proposal development.

> I think that it's unreasonable to say, "Go out and find your partners. Get this all done in 2 years." I think what actually would be more important is continued and even greater emphasis on getting us together with the partners first before we put in the proposal. In other words, the proposals in a sense should be coproduced and I think any mechanism that we can have to put us in touch with the planners and the people that then need the data [so] that we can then coproduce that proposal. I think that's really important. (SW Producer FG)

> I think the question revolves around whether that partnership building process is considered part of the project or kind of external to it before the clock starts….If there had been a kind of a pilot partnership-building round, which would be a tenth of the funding to do the research just to get the people together and to work through the ideas…. I think it would have already had its legs on the ground…. Even to build a partnership around a particular question, that takes time. And if there were a mechanism for getting people together you know for even just a couple of days or virtually to work through that with support from the CSC and then the RFP is answered later on, I think we'd build a better

> proposal. We'd have a better timeline. And we'd… have a head start before the clock started running. (SW Producer FG)

They also perceived barriers to coproduction among decision makers. A chief barrier was that potential collaborators in coproduction among decision makers simply did not have the capacity to engage.

> Most of the state agencies in Arizona that have anything to do with natural resources have been … emasculated so there's really no capacity to engage in science per se. They're literally fighting fires … or whatever it is…. There needs to be capacity for people to engage, which is the same issue with tribes. (SW Producer FG)

Perceptions of the Role of the CSC

The Southwest CSC has helped facilitate various connections (Figure SW-9). The most common connections reported were with climate adaptation scientists (55%; $n = 66$) and climate adaptation science (53%; $n = 64$). Nearly half also reported getting connected with resources needed to conduct science (48%; $n = 57$). Fewer reported help in connecting with professionals who might communicate science (43%; $n = 51$) and decision makers who might use science (34%; $n = 41$).

Most than half of respondents agreed that the Southwest CSC made a wide variety of contributions to the region (Figure SW-10). The contributions that were most widely perceived were collaboration between

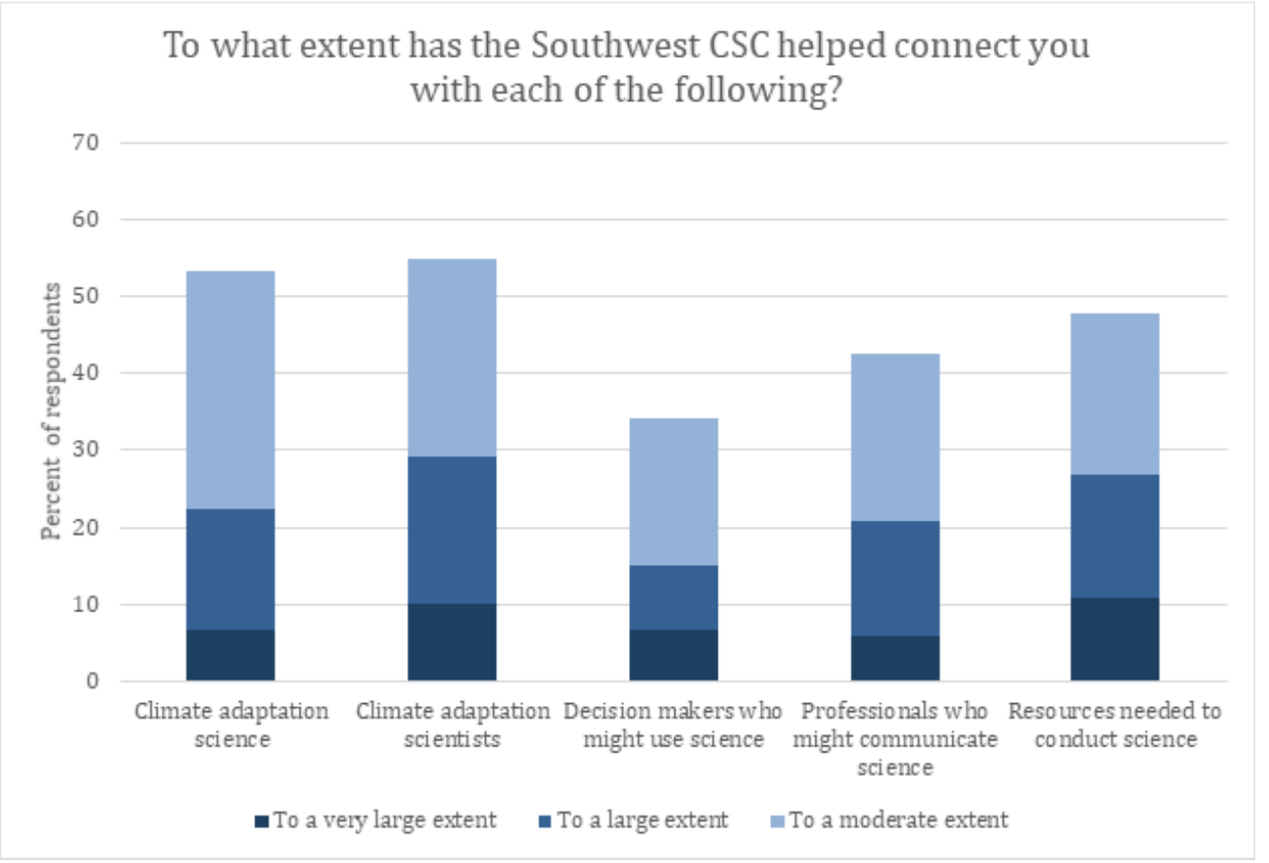


Figure SW-9. Text in items shortened for presentation in graph, and only "to a moderate extent," "to a large extent," or "to a very large extent" responses are shown.

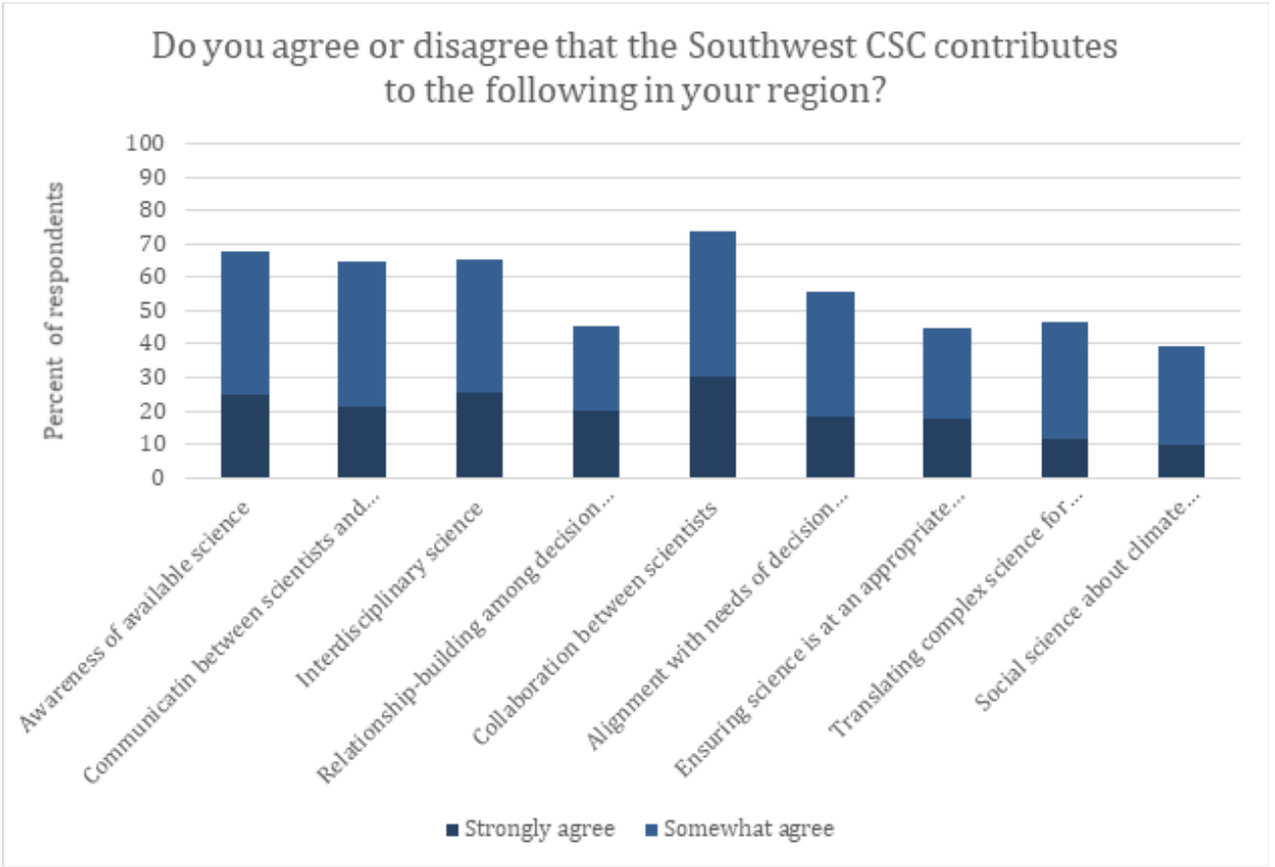


Figure SW-10. Text in items shortened for presentation in graph, and only "strongly agree" or "somewhat agree" responses are shown.

scientists (74%; *n* = 88), awareness of available science (68%; *n* = 80), interdisciplinary science (66%; *n* = 78), and communication between scientists and those who might use the science (65%; *n* = 77).

Summary of Southwest Results

Survey respondents were comprised of more than one-third science users, nearly two-thirds science producers, and some individuals who fell into neither group. All were involved with climate work to some extent, but producers were somewhat more involved than users. All were aware of the Southwest CSC to at least some extent. 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 Southwest 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 17% were resource managers or decision makers who had used the science produced by the CSC.

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 about both of these benefits as well as the opportunities the CSC provided to connect scientists with decision makers and the critical needs CSC funding

could fill. Survey respondents reported they were limited in their involvement with the CSC by a variety of factors with the most common one being limits on their time.

About three-quarters of the survey respondents felt that climate adaptation science in the Southwest region was available to decision makers, and many also believed that decision makers use the climate adaptation science to inform management. Nevertheless, many believed that climate adaptation science did not influence necessarily management actions taken, although a majority also believed that the Southwest CSC had reduced the disconnect between scientists and decision makers. When asked specifically about the science produced through the Southwest 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 high quality, appropriate to the decisions being made, and able to integrate well with other information.

The most common ways science users and producers reported that the Southwest CSC science was used were to inform management plans, inform management actions, and contribute to the training of professionals. Focus participants described effective stakeholder engagement as a key to having the CSC science used. This engagement might occur before, during, or after research was conducted.

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 participants maintained that one on the limits on the use of the science was the amount of time that needed to be invested to ensure that the science was used. This need posed a particular barrier because time was typically limited for both science producers and science users. Participants also pointed out that needs of scientists and decision makers were not always compatible, and so their priorities differed with regard to the type of science and scientific products to be produced.

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, applying, 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, having different perspectives from scientists on what science is needed, and funders not being willing to support collaboration between scientists and science users. In the focus groups, discussions of the limitations on coproduction centered on the amount of time required to coproduce science and a lack of understanding by some scientists about how to coproduce science. They argued for greater expectations and support for coproduction in CSC-funded science.

The majority of survey respondents noted a variety of contributions of the Southwest CSC, including contributions to collaboration between scientists, awareness of available science, interdisciplinary science, and communication between scientists and decision makers.