DRAFT FOR PARTNER REVIEW - Last Update 6/20/19

North Central CASC Strategic Science Plan

Who we are, how we do business, broad goals and strategies

Executive Summary and Note to Readers

This is a DRAFT Plan.

- It was written after multiple inquiries about the decisions facing managers in the region and the science they believed necessary.
- It identifies several thematic areas in which NC CASC is working and expects to continue or expand and some we hope to add.
- It also identifies areas in which the new Consortium that hosts the NC CASC provides expertise and capabilities.
- It does not yet fully reflect the decisions and needs of tribal nations in the region. Ongoing dialogue will provide additional material.
- It commits to working with partners to identify issues and design and implement research so that it is most useful to those users.
- It identifies the Department of the Interior, state fish and game agencies, and tribal nations as our primary beneficiaries, but acknowledges the need to work across ownerships to achieve shared goals.

We plan to listen and revise this plan.

- The Joint Stakeholder Committee (JSC) will be the first external reviewers of the plan, starting at their June 2019 meeting.
- NC CASC solicits comments from all partners, including but not limited to
    - Are we addressing an ***appropriate suite of issues***?
    - Is the science we propose ***already being done*** by others?
    - Are there ***partnerships*** to establish or build on that would help ensure success?
    - Are there ***resource-sharing opportunities*** that could hasten or expand needed investments?
- NC CASC solicits opportunities to explain and gather input on this plan and will make staff available for briefings and listening sessions for any **agency / organization, partnership, science center or lab, etc.**

The first part of the plan describes how we operate, who our partners are, etc.

Pages 10-19 describe proposed areas and mechanisms for scientific investment by NC CASC.

Comments should be provided to Aparna Bamzai-Dodson, NC CASC USGS Deputy Director (abamzai@usgs.gov)

Introduction to this Plan

This Strategic Science Plan for the North Central Climate Adaptation Science Center (NC CASC)[1] provides basic information on our

- nature,
- mission,
- governance,
- science strategy,
- key partners,
- expertise,
- key products and services, and
- resources.

It identifies *who we are and how we operate*, and it describes the strategies and approaches we use in our operations. This document also describes the broad management questions or challenges we hope to support, the scientific questions we have identified with partners, and the broader areas of research we believe can contribute to actionable science. The NC CASC hopes the information contained in this document will help partners frame their input on how the NC CASC should invest its resources over the medium term.

This document DOES NOT yet address in detail how the NC CASC will engage with or support tribes and tribal interests in the region. The NC CASC is the host for a Tribal Resilience Liaison," funded by the Bureau of Indian Affairs Tribal Resilience Program[2] and employed by the Great Plains Tribal Water Alliance.[3] This individual will work on fostering dialogue with tribal partners, and with them, identifying appropriate roles, products, and services that could be of benefit to tribal communities. This document will be revised to reflect these activities in late 2019 or early 2020.

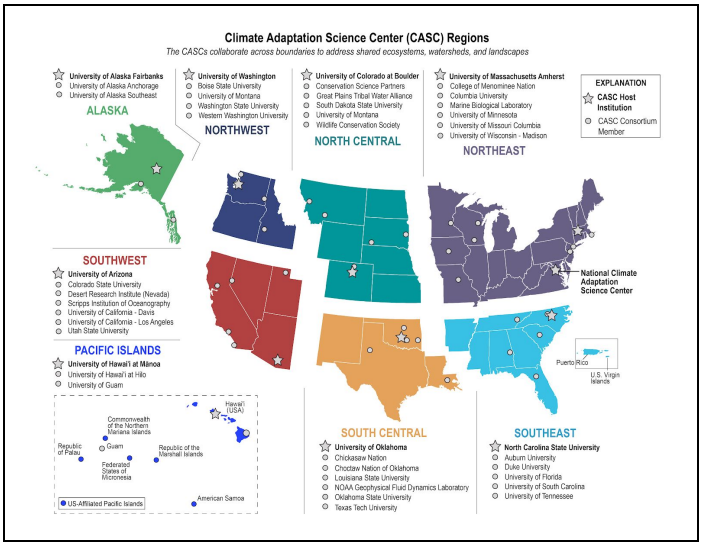
[1] With passage of the fiscal year 2018 budget on March 23, 2018, the name of the Climate Science Centers (CSCs) was changed to the Climate Adaptation Science Centers (CASCs). The name of the USGS National Climate Change & Wildlife Science Center (NCCWSC), which manages the eight regional centers, was changed to the National Climate Adaptation Science Center (NCASC).
[2] BIA Tribal Resilience Program: https://www.bia.gov/bia/ots/tribal-resilience-program
[3] Great Plains Tribal Water Alliance: http://www.tribalwateralliance.org/

Mission and Operations

Mission of the North Central Climate Adaptation Science Center

Work with resource managers to identify and gather the information they need to understand and adapt to a changing world.[4]

The NC CASC[5] was established in 2012 as part of a national network of regional centers intended to support decision making about fish and wildlife, their habitats, and the many benefits people derive from these systems. Changing environmental conditions have resulted in increasing demands for scientific support as managers seek to understand potential effects on their resources and identify adaptation strategies. We focus primarily on issues in our region but work closely with the National CASC and the seven other regional CASCs to address multi-region issues.



Key foundations of our work include:

- Ensuring that science is *actionable*[6] -- immediately accessible and provided in ways that facilitate its use in planning or decision making;
- Including people and communities as fundamental elements in any resource decisions;
- Fostering interactions between researchers and managers to ensure our science can be used;
- Aligning our actions with other agency partners to efficiently and effectively use public funds; and
- Using a full set of tools -- including primary research, synthesis, training and capacity building, and communications strategies -- to help support the integration of science into management.

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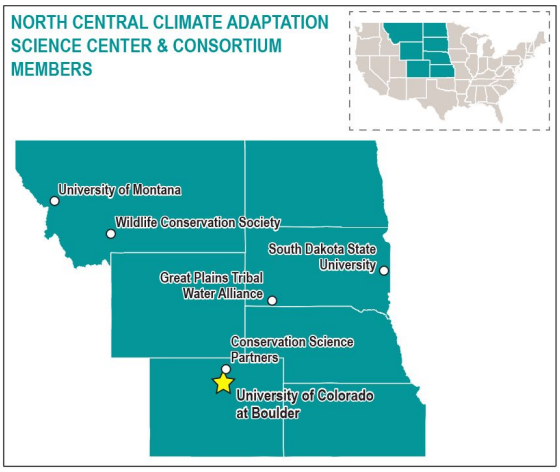
[4] This statement is provisional, and we invite comment on a succinct statement that characterizes NC CASC goals and objectives.

[5] North Central Climate Adaptation Science Center: https://nccasc.colorado.edu/

[6] *Actionable science* is described as "provid[ing] data, analyses, projections, or tools that can support decisions regarding the management of the risks and impacts of climate change" by the Advisory Committee on Climate Change and Natural Resource Science in Report to the Secretary of the Interior, 2015, Retrieved from: https://www.sciencebase.gov/catalog/item/5c1d05d3e4b0708288c9bc2a

Organization and Operations

The NC CASC is a joint enterprise involving the USGS and the University of Colorado - Boulder (CU) as primary partners, and five additional academic and non-governmental partners.[7] The NC CASC is jointly managed by a USGS Director and a University Director, and includes both Federal and university-supported staff. This relationship is re-competed every five years. CU was recently selected to serve as the NC CASC host until 2023, along with the named consortium members.



Input on priorities and the usefulness of the NC CASC's science is provided by a Joint Stakeholder Committee[8] comprised of state, federal, and tribal government representatives. This committee is managed by both the NC CASC and the USDA Northern Plains Climate Hub.[9]

Consortium Partners

- Conservation Science Partners (CSP)
- Great Plains Tribal Water Alliance (GPTWA)
- South Dakota State University (SDSU)
- University of Montana (UMT)
- Wildlife Conservation Society (WCS)

NC CASC supports and facilitates science to meet high priority regional needs by scientists from multiple institutions across the region: NC CASC staff are complemented by CU and consortium partner institutions, and other USGS labs and research units, and in collaboration with federal, state, tribal, nongovernmental, and private management partners. Students and post-doctoral researchers are directly engaged in NC CASC science, providing exposure to real-world application of their science.

Who We Serve

The NC CASC provides information to ***support resource management planning and decision making primarily by bureaus of the Department of the Interior, state fish and game agencies, and tribal nations.*** While these entities form our core users and beneficiaries, we use an "all lands and waters" approach that focuses on fish, wildlife, their habitats, and the benefits people receive from them, rather than on specific ownerships. NC CASC also recognizes that other

[7] Conservation Science Partners (CSP), Great Plains Tribal Water Alliance (GPTWA), South Dakota State University (SDSU), University of Montana (UMT), and Wildlife Conservation Society (WCS).
[8] Joint Stakeholder Committee: https://nccasc.colorado.edu/partners/stakeholder-advisory-committee
[9] The JSC met for the first time in over two years, on an October 12, 2018, teleconference. A face to face meeting is planned for Summer 2019, and this Strategic Science Plan and related documents will be reviewed at that time.

entities (e.g. US Forest Service and Department of Defense) are often necessary partners in specific landscapes. This includes managers, irrespective of their agency affiliation, with responsibilities across a wide spectrum: fish and wildlife, parks and protected areas, multiple use management, water supply agencies, water quality managers, invasive species control programs, among others. It may also include agencies with other missions, such as transportation, whose plans and activities have impacts on natural or cultural resources.

Information developed by the NC CASC can be useful to ***private landowners, municipalities*** and the like. The NC CASC collaborates with individuals and organizations specializing in outreach and extension to these partners to ensure access and integrate this information with other relevant guidance. Key among these science partners are the USDA Northern Plains Climate Hub[10] and the Western Water Assessment,[11] a NOAA-funded program.

The NC CASC collaborates and seeks input from other ***academic and public science partners*** in the region, ***conservation organizations, and other not-for-profit groups such as grazing associations***. While these partners may not have direct land and resource management responsibilities, they do have important contributions to make to framing and identifying solutions. This includes both input on priorities and collaborative implementation of co-developed science activities.

Tribal Engagement - A Priority Partnership

Tribal nations are key partners in the generation of science and expertise at the NC CASC. Tribes are sovereign governments, with substantial legal and traditional resource management roles. Tribes are also challenged by intense competing priorities, resource limitations, and legal constraints. Lastly, the Department of the Interior has a major role in relations between the United States and tribal nations, and our work will support that fiduciary role. The NC CASC seeks to foster a continuing dialogue with tribal nations and inter-tribal organizations in the region to identify resource challenges that might benefit from climate-related science, capacity building, convening, and similar activities.

To support expanded partnerships between the CASCs and the nation's tribal communities, the Bureau of Indian Affairs (BIA) supports tribal resilience liaisons" in selected CASCs, including NC CASC. These individuals are employed by tribal organizations and co-located with a CASC. BIA has funded the Great Plains Tribal Water Alliance[12] (GPTWA) to support a Tribal

[10] USDA Northern Plains Climate Hub: https://www.climatehubs.oce.usda.gov/hubs/northern-plains
[11] Western Water Assessment: http://wwa.colorado.edu/
[12] GPTWA is also a member of the CU-Boulder consortium that hosts the NC CASC. These two roles arose independently, but are obviously complementary.

Resilience Liaison located at the NC CASC. That individual has a lead role at the NC CASC for communicating with tribes, identifying challenges and needs, and ensuring strong working relationships with tribes. A key product from the liaison process will be a **tribal engagement strategy** to be adopted as part of this overall Strategic Science Plan.

Scientific Support Activities

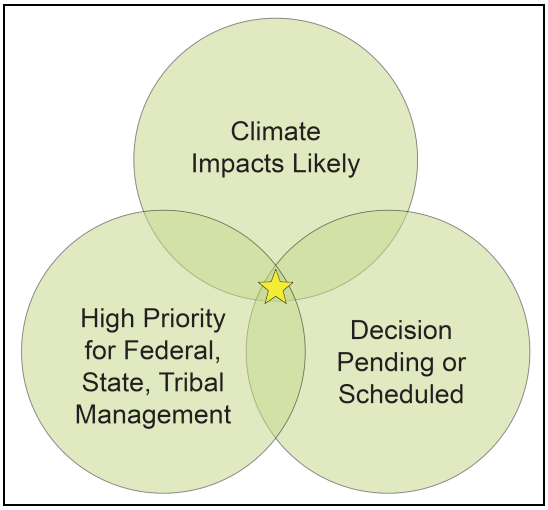
The network of CASCs is intended to provide ***scientific information*** to resource managers. This primary objective includes both original research and solutions development, but also synthesis, assessment, and "translation" of existing scientific information to forms useful to managers as they make concrete plans.

Scientific best practices clearly acknowledge that effective use of science for management involves a broader suite of activities than might have been the case in the past. In addition to the core scientific activities (e.g. research, synthesis), it is clear that there are critical activities, goals, and objectives that round out the CASC strategic approach. These are

- *Skill building for practitioners and the next generation of scientists and managers:* ensuring that management practitioners have the skills needed to use NC CASC-generated science; building a "pipeline" -- the next generation of scientists and managers, trained in climate science and management applications.
- *Building partnerships* to identify common, high priority climate needs and ensure the delivery of relevant adaptation science and tools where and when needed
- *Communicating our science* so that it is accessible and useable.

Science

Science Approach



The primary objective of the NC CASC is to produce science that is directly usable in making resource management plans and decisions: ***actionable science.***[13]

Using input from stakeholders to identify high priority decisions or management actions, NC CASC scientists work ***closely with partners to identify and satisfy information needs*** related to climate variability and change, its impacts, and adaptation to enhance resilience to those impacts.[14]

The NC CASC seeks to work on issues and with partners where:

- the issue is of ***high priority to federal, state or tribal managers***, with the potential for significant economic, social, or ecological consequences;
- there is an ***identified endpoint*** -- a decision, plan, or other concrete use or user that is ready and willing to apply the science; and
- ***climate related information is needed*** for an informed decision or action.

Science undertaken through the NC CASC will

- ***focus on useable -- actionable -- products***, with a focus on direct interactions between users and scientists. NC CASC also links more-applied science directly to the fundamental science needed to support it.
- ***build knowledge and trust*** among a community of scientists and managers in the region, enabling rapid and targeted response. NC CASC scientists will be familiar with the major processes, institutions, and decisions made by our partners.

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[13] As a science agency, USGS and NC CASC provide information towards but do not make, recommend, or endorse specific decisions, policies or actions.

[14] The practice of joint problem definition and research implementation is often called “co-development” or “co-production.”

Beier, P., et al. (2017). "A How-to Guide for Coproduction of Actionable Science." Conservation Letters 10(3): 288-296. http://dx.doi.org/10.1111/conl.12300

Meadow, A. M., et al. (2015). "Moving toward the Deliberate Coproduction of Climate Science Knowledge." Weather, Climate, and Society 7(2): 179-191. https://doi.org/10.1175/WCAS-D-14-00050.1

- ***consider people, livelihoods, and the goods and services they derive from ecosystems*** as we evaluate the effects of climate, land use, invasive species, and other changes, and engage the needs of people in identifying solutions
- ***use multiple tools*** -- including primary research based on field work and modeling, synthesis, technical assistance, training and capacity building, and communications strategies. NC CASC relies upon expertise from both within the USGS network and from its university host and consortium partners.
- ***be aligned with the work of partners --*** both science and management -- to ensure efficient and effective use of public resources
- ***seek to provide sustained support*** for our partner, past the term of a single research project

Climate Challenges of the North Central U.S.

The NC CASC's region includes the states of North and South Dakota, Nebraska, Kansas, Colorado, Wyoming and Montana. This diverse landscape includes a variety of ecosystems and wildlife affected by climate change, ranging from the alpine ecosystems of the Rocky Mountains to the grasslands of the Great Plains.

Resource managers and local communities are faced with a variety of climatic impacts associated with changing seasonality of precipitation; warming trends affecting migration and seasonality of species and communities; and impacts on primary production, hydrological cycles, and biotic responses. Although the people and ecosystems across the region have adapted to past climate challenges, the magnitude of expected changes and impacts will exceed those of previous experience.

As an example, streamflows across the region are changing, with decreases in the West and increased in the East, with accompanying effects on terrestrial hydrology and soil moisture. These and related trends can change the landscape and affect people, fish and wildlife, crops, and other important human and ecological values, both in the region and in downstream regions dependent upon Missouri River flows.

2012-2017 Science Focus

The NC CASC's 2012-2017 science agenda[15] highlighted the importance of integration across three principal domains; physical climate (*what will the future bring)*, ecological impacts (*how will those changes affect valued resources)*, and adaptation (*how will people address these changes)*. In addition, it identified ***precipitation and hydrologic extremes (****including* ***drought)*** as

[15] NC CASC Science Agenda 2012-2017: https://pubs.usgs.gov/of/2012/1265/OF12-1265.pdf

the core focal areas for both management support and scientific inquiry. The NC CASC's plans envisioned the Resource for Vulnerability Assessment, Adaptation and Mitigation Planning (ReVAMP) as a strategy in which the NC CASC would bring state of the art visualization and collaborative strategies to working with managers.[16]

Focal Areas for 2019 and Beyond

Over the course of 2018 and 2019, the NC CASC utilized a variety of engagement strategies with management partners to identify focal areas for investment over the 2019-2023 period.

Identification of Management Needs

Over the past two years, NC CASC has undertaken (and is continuing) a series of activities intended to elicit information on the needs of partners in the region.

- A short survey sent out broadly in 2018 to NC CASC partners, stakeholders, and interested parties including federal,state, tribal, and local government, academia, and non-profit organizations. This was accompanied by a series of webinars.
- NC CASC partnered with Molly Cross, Wildlife Conservation Society, and Shelley Crausbay, Conservation Science Partners,[17] to systematically identify climate-related information gaps that, if addressed, would support state fish and wildlife and federal resource management decisions within the North Central region. This included:
    - A series of semi-structured interviews with 23 state fish and game agency staff in senior leadership roles (e.g."fish chief, wildlife chief")
    - A survey and facilitated face-to-face meeting of key federal resource management agencies in the region (Fish and Wildlife Service, Bureau of Land Management, National Park Service, Bureau of Reclamation, USDA Forest Service, Animal and Plant Health Inspection Service and Natural Resources Conservation Service, National Oceanic and Atmospheric Administration, and USEPA). This meeting reviewed and amplified on the results of the state surveys.
- The NC CASC Tribal Resilience Liaison and a member of the CU Boulder-led consortium are gathering information on tribal plans, expectations, and needs. For example, as part of BIA-funded tribal training effort, NC CASC is administering a survey to ascertain the training and development needs for the tribal partners involved in that

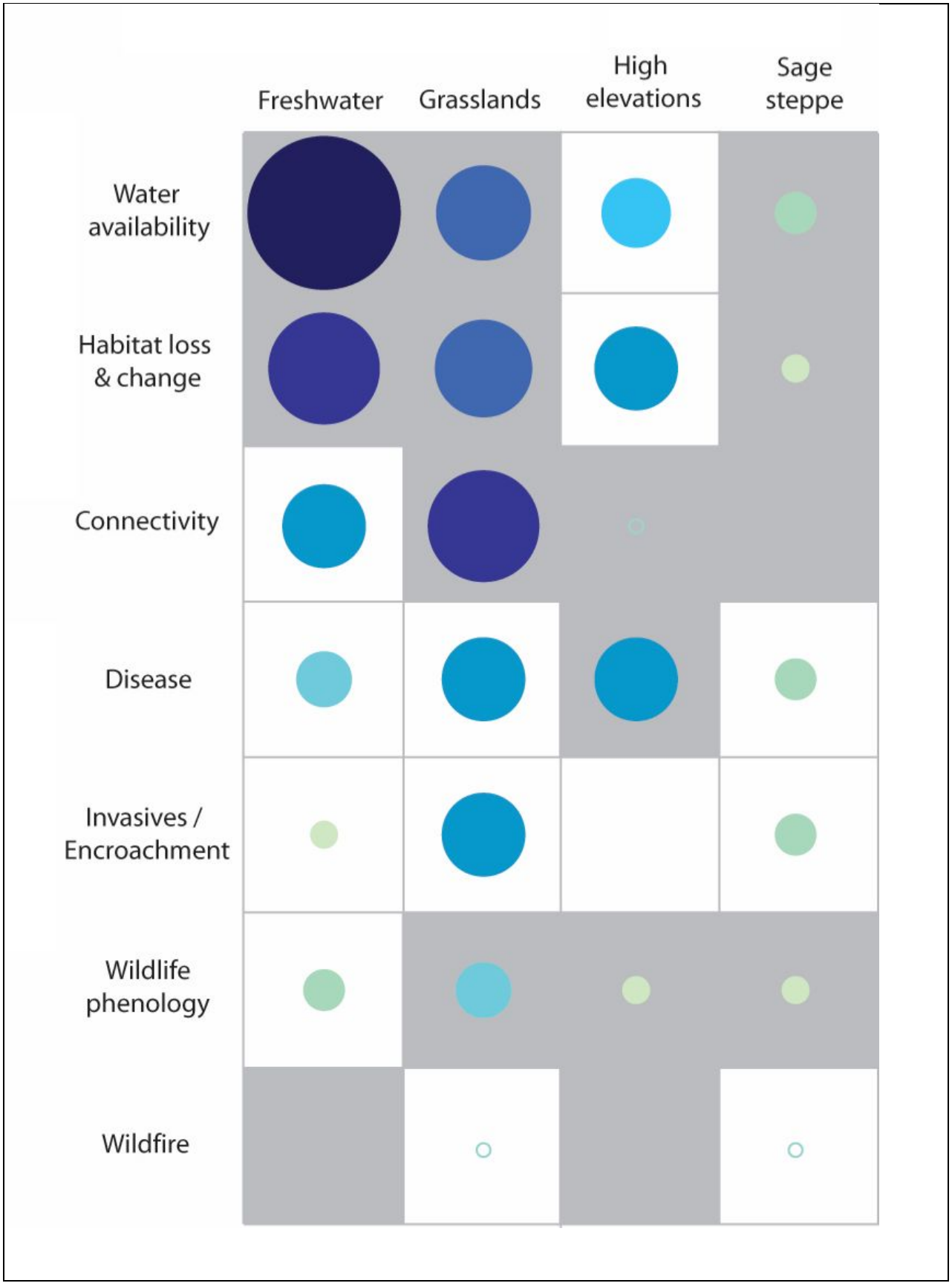
[16] See 2011-2018 NC CASC Consortium Final Report: https://www.usgs.gov/land-resources/climate-adaptation-science-centers/north-central-casc

[17] Enabling Climate-Informed Planning and Decisions about Species of Conservation Concern in the North Central Region: Phase 1: https://www.sciencebase.gov/catalog/item/596f58ebe4b0d1f9f0645e82

training. **Information from these processes will be incorporated into this plan in late 2019 or early 2020.**

Through this engagement process, both state and federal resource managers expressed a preference in focusing on the habitat level in order to accomplish their management goals -- even when addressing the needs of individual species. Four priority habitats within the region were identified: freshwater ecosystems, grasslands, high elevations, and sagebrush steppe. Participants identified key management priorities in each habitat type, and it was clear that similar issues arose across multiple habitats. The seven cross-cutting management priorities were: water availability, habitat loss and change, connectivity, disease, invasives and encroachment, wildlife phenology, and wildfire.

In the figure below, the size and color of the dots convey the number of times the intersection of a habitat and management priority occurred in a state agency interview, while the grey shading indicates that the intersection occurred in a federal agency survey response. The NC CASC recognizes that there were limitations inherent to this process and that, as a result, occurrence does not necessarily correlate with relative importance.


Freshwater
Grasslands
High elevations
Sage steppe
Water availability
Habitat loss & change
Connectivity
Disease
Invasives / Encroachment
Wildlife phenology
Wildfire

Strategic Directions: Continuity and Added Capabilities

As resources permit, the NC CASC will respond to the needs expressed by its partners, and illustrated by the diagram above, in several ways:

- *Continue and extend existing lines of research and synthesis in areas with strong stakeholder engagement and support*
- *Expand NC CASC's portfolio, with significant reliance upon consortium and other partners, to address other key needs*
- *Provide technical assistance and consulting*

Priority Habitat: Freshwater Ecosystems

Core objective: Aid resource managers in understanding changes in flow, temperature, seasonality, chemistry, and habitat conditions in a climate changed future, and assist managers in ensuring the health of dependent populations (thus avoiding the need for Federal listing) and generally, identifying and evaluating options for increasing resilience and adaptation to change.

Ongoing research and synthesis:

- NC CASC has launched an effort to work with state fish managers to address concerns about fish populations in "plains-to-mountain transition rivers and streams."[18] Coldwater fish (trout) have received significant research attention but transition stream fish have not.
- Expanding the area in which high quality lake temperature measurements are available and useful, primarily for fisheries management, by combining existing monitoring data with innovative Process-Guided Data Driven temperature modeling to reconstruct daily contemporary lake temperatures in the Dakotas from 1979 to 2018.[19]
- Development of tools for predicting and monitoring drought. Products to date include new tools for estimating how much water the atmosphere draws from the land surface and plants[20] and for evaluating land surface responses to drought.[21]

Opportunities for expansion:

- Managers across the region expressed the need for information on how climate would affect both aquatic systems (e.g. lakes, streams, riparian areas, wetlands)

[18] Enabling Climate-Informed Planning and Decisions about Species of Conservation Concern in the North Central Region: Phase 2: https://www.sciencebase.gov/catalog/item/5b33b928e4b040769c172ee0
[19] Understanding Historical and Predicting Future Lake Temperatures in North and South Dakota: https://www.sciencebase.gov/catalog/item/5b33da85e4b040769c1735ea
[20] Evaporative Demand Drought Index: https://www.esrl.noaa.gov/psd/eddi/
[21] Landscape Evaporative Response Index: https://www.esrl.noaa.gov/psd/leri/

and water as an element of other systems (e.g. water as a habitat element in grasslands; soil moisture as driver of restoration success). NC CASC has relatively limited hydrological expertise, and any significant investment in this area will require collaboration with other partners, e.g. the USGS Water Mission Area; and Western Water Assessment. NC CASC may play a connecting and convening role initially in order to help define and clarify needs and desired products and services.

Priority Habitat: Grasslands

Core objective: Support the development of a "system view" of grasslands and expected changes to support management and conservation of the overall system and both dependent and associated species. Reducing wildlife declines and avoiding the need for federal listing decisions are key management objectives that require such a system-level approach.

Ongoing research and synthesis:

- NC CASC will launch the initial two years of a "*Grasslands Climate Science Initiative*" with the aim of providing a climate-ecosystem context to assist managers in the Great Plains region as they confront a series of issues, including those posed by Species of Greatest Conservation Need or potential listings under the Endangered Species Act.
- NC CASC, in cooperation with both the Northeast and South Central CASCs and the CASC national office, is beginning an effort to identify climate change implications for migratory birds in the Central Flyway.

Opportunities for expansion:

- The interacting effects of climate and management (e.g., grazing and fire) on invasive/exotic grasses. Proposals may focus on issues at local scales, such as adaptive management strategies for invasive control at a given management unit, and/or regional scales, such as the spread of invasive grasses to new locations that may become suitable with a changing climate.
- The effects of climate change and other natural and anthropogenic stressors on specific elements of conservation concern in grasslands of the north central U.S. These include bison, grassland birds, eastern red cedar, pheasant / quail populations (upland game generally), prairie chicken species and other ground-nesting birds, prairie dog, swift fox, black-footed ferret, pollinators, and riparian habitats (including changes in cottonwood regeneration) as well as ecological processes (e.g., connectivity, hydrology, nutrient cycling, disturbance).

- Grassland restoration strategies and opportunities. Working with management partners to identify locations, strategies, and practices that ensure that grassland restoration is "climate-smart" (e.g. seed selection, restoration site selection, timing, etc.)

Priority Habitat: High Elevations

Core objective: Increase the availability of relevant science on issues related to migration, corridors, and interacting effects of climate and other change agents on montane / forest / alpine systems. As with other habitat types, significant management concern focuses on avoiding species declines leading to the need for Federal listing; most managers support doing so within an overall habitat management framework.

Ongoing research and synthesis:

- Examining the vulnerability of whitebark pine, mountain hemlock, and other key species in the Greater Yellowstone region in support of the Greater Yellowstone Coordinating Committee.[22]
- Evaluation of current and future forage availability for ungulates and the impacts of alternative treatment options.[23]
- NC CASC will be initiating an effort to project post-fire regeneration potential based on climate, location, fire severity and other factors.

Opportunities for expansion:

- Climate effects on high elevation forests remain of significant concern. Impacts are evident in both animal behavior and persistence (e.g., wolverine, fisher, mountain goat, white-tailed ptarmigan), in declining recruitment of key tree species, and in concern over the integrity and future availability of migratory corridors.

Priority Habitat: Sagebrush Steppe

Core objectives: Continue to support ongoing Federal-state conservation planning (i.e. Sagebrush Conservation Strategy[24]) by funding research with direct links to key planning documents and processes, and ensure that restoration and recovery actions are informed by the best science related to weather and climate.

[22] Science and Forecasting to Inform Implementation of the Greater Yellowstone Coordinating Committee's Whitebark Pine Management Strategy: https://www.sciencebase.gov/catalog/item/521ce546e4b01458f7857fd6
[23] Predicting Future Forage Conditions for Elk and Mule Deer in Montana and Wyoming: https://www.sciencebase.gov/catalog/item/5b33bd97e4b040769c172f82
[24] Sagebrush Conservation Strategy: https://sites.google.com/site/forumsagesteppe/sagebrush-conservation-strategy

Ongoing research and synthesis:

- NC CASC will continue research related to *sagebrush conservation and management,* with a focus on ensuring restoration success, refining and testing "resilience and resistance" categorization / prioritization schemes, and identification and evaluation of climate-relevant management practices. NC CASC currently has three ongoing research efforts in this area and one forthcoming.[25]

Opportunities for expansion:

- Improving the conceptual and information bases necessary to implement the "resistance and resilience" (R&R) strategy currently being developed / implemented – including identifying the most useful environmental variables to use as R&R indicators and collecting data to confirm the strength of the relationship between those environmental variables and actual ecological R&R.
- Prediction and management of the conversion of sage to annual grasses. Understanding the nature of and mechanisms for system-conversion events.
- Understanding the effect of the composition and management of fuel breaks on their immediate effectiveness and long term persistence. Fuel breaks are a large investment with major landscape implications and ensuring long term success is vital.
- Invasive species, fire ecology, risk, and behavior; sagebrush ecology; agency post-fire restoration practices and constraints, soil moisture influences; remote sensing of soil moisture and related landscape conditions.

Cross-cutting work:

- ***Changing landscapes - ecological transition and transformation:*** As climate changes, managers will be faced with the potential for significant shifts in vegetation and species. Fire and invasive-driven conversion of sagebrush to grass; expansion and contraction of pinyon and juniper; and decreasing recruitment of key forest species are examples in which prior conditions may simply not be feasible without major investment of resources, and even then are not certain. NC CASC has and will continue a research-to-management

[25] Forecasting Future Changes in Sagebrush Distribution and Abundance: https://www.sciencebase.gov/catalog/item/55195ee5e4b0323842782fd0
Big Sagebrush Response to Wildfire and Invasive Grasses in the 21st Century: https://www.sciencebase.gov/catalog/item/5b31653fe4b040769c13ffe5
Improving the Success of Post-Fire Adaptive Management Strategies in Sagebrush Steppe: https://www.sciencebase.gov/catalog/item/5b3160b9e4b040769c13ffca

theme around understanding why and how and when ecosystems change and what management responses are effective in different situations.[26]

- ***Wildlife disease:*** Managers in the North Central identified wildlife disease as a major concern with potential climate implications. There are many such diseases, in different species and geographic locations (whitenose syndrome, chronic wasting disease, sylvatic plague, whirling disease, avian influenza, Chytridiomycosis, and others). NC CASC is supporting an effort led by the USGS National Wildlife Health Center[27] to assess a range of wildlife diseases, explore climate influences, identify possible commonalities, etc.
- ***Big data and earth analytics:*** In addition to providing several training opportunities for stakeholders in cutting edge data and analytical skills,[28] EarthLab, which hosts the NC CASC, provides ongoing expertise for projects. For example, the orientation toward open and reproducible workflows is being incorporated into support for FWS Species Status Assessment activities.
- ***Technical assistance and consulting****:* NC CASC staff assist partners at all stages of climate-related science. Identifying and accessing appropriate data and models, providing scenario planning expertise and facilitation, and consulting on ecological model choice and specification.[29]
    - Experience includes, but need not be limited to, NPS Resource Stewardship Strategies, FWS Species Status Assessments, FS Forest Plan Revisions, and BLM Resource Management Plans.
    - NC CASC will continue and expand its work with FWS and states to provide climate science and related ecological support for listing, critical habitat, and related Endangered Species Act decisions.
    - *Scenario planning and ecological forecasting* is a specific subset of "consulting-type" expertise available at NC CASC. Scenario planning is a tool for addressing the uncertainties inherent in projections of future conditions. NC CASC has developed, in conjunction with the NPS Climate Change Response

[26] Ecology and Management of Pinyon-Juniper Woodlands: State of the Science: https://www.sciencebase.gov/catalog/item/5a3ba858e4b0d05ee8b74108
Mapping the Risk of Ecological Transformation Across Pinyon Woodlands and the U.S. West: https://www.sciencebase.gov/catalog/item/5b3165dde4b040769c13fff0
[27] Synthesizing Climate Change Impacts on Wildlife Health and Identifying Adaptation Strategies: https://www.sciencebase.gov/catalog/item/5b4f654ce4b06a6dd184402a
[28] Data Carpentry for Geospatial Data: http://www.datacarpentry.org/lessons/#geospatial-curriculum
[29] Model-Based Scenario Planning to Inform Climate Change Adaptation in the Northern Great Plains: https://www.sciencebase.gov/catalog/item/55159d7fe4b03238427817eb
Informing Climate Change Adaptation Planning in National Parks: https://www.sciencebase.gov/catalog/item/5970adb8e4b0d1f9f065c2c6
Refining Guidance for Incorporating Climate Science and Scenario Planning into National Park Service Resource Stewardship Strategies: https://www.sciencebase.gov/catalog/item/5b6c8fcfe4b006a11f7bd139
Integrating Climate Considerations into Grazing Management Programs in National Parks: https://www.sciencebase.gov/catalog/item/5cf6fba8e4b0d63728b9b4cc

Program and Denver Service Center, a practice involving scenario planning linked with quantitative modeling (e.g. state and transition, agent-based, etc.). This is a powerful combination of qualitative and exploratory approaches with well-vetted tools for understanding likely response changes.

Annual Selection of Research Projects

NC CASC places high priority on research activities that are directly tied to management needs and applications. The degree to which a proposed project can demonstrate engagement with and responsiveness to specific managers or management settings will be a primary factor in selection for funding (along with science quality and creativity and budget considerations).

As part of this Strategic Plan development, NC CASC expects to develop a broad "schedule" for concentrating investment in the areas identified above, such that a core of work is funded in a topical area (e.g. four ongoing sage-related projects), followed by a period in which smaller projects focus on effective transfer to managers, evaluation of new needs, etc. The Joint Stakeholder Committee will be involved to ensure that the NC CASC addresses a diversity of management priorities as it moves through annual funding cycles.

NC CASC consortium partners are currently developing activities and approaches for using resources provided under the USGS hosting award to support the needs identified by NC CASC stakeholders. These activities will be phased (e.g. *X partner will focus on Y topic in Year Z of the agreement*) and this phasing will be paired with USGS-led research funding to magnify the resources focused on each topic.

For example, NC CASC has made multiple investments regarding sagebrush conservation and management. Management decision making on this topic is moving to an extended period of consultation with partners and the public, based on the results of existing research. This may provide an opportunity for a "pause" or reduced level of emphasis with opportunity for reflection on future needs.

THINGS TO KNOW ABOUT NC CASC RESEARCH FUNDING

1. Development and evaluation of adaptation strategies will be a significant emphasis in all NC CASC efforts. NC CASC will bring a focus on concrete actions, assessment of alternative approaches, and incorporation of climate-smart elements into existing management practices NC CASC will work with partners both to identify best practices and assess their transferability and to identify appropriate measures by which to evaluate adaptation actions across the full range of its work.
2. NC CASC generally selects projects following a request for proposals (RFP); these are targeted for release in December-January, with final award notifications during August-September. In some years, commitments to prior-awarded projects reduce the pool of funding to such a degree that an RFP-based approach is inefficient. In such cases, the NC CASC will directly fund projects, in keeping with this Plan.
3. Each project must have a Principal Investigator from one of the NC CASC consortium partners or a USGS center or program. Proposals may include investigators from other federal agencies, universities/research centers, private corporations, NGOs, etc.
4. Proposers are encouraged to frame their projects as responses to an identified management challenge and to include management partners as full investigators on their working teams. In limited instances, NC CASC will support "upstream" research -- not directly applicable, more basic, more exploratory -- but only where such work has a clear line of connection to a stated user need. For example, NC CASC supports paleo-hydrologic investigations to better understand how watersheds respond to extreme conditions. While "basic" in some sense, this work will enable the Bureau of Reclamation to better plan for climate-altered futures.
5. As a matter of policy, NC CASC will defer from supporting new atmospheric projections (dynamical or statistical) and large scale hydrologic projections; rather we will rely upon providers with greater technical resources and clearer mandate to produce such products.

Understanding Success

The National CASC conducted external reviews of the first five years of operation for each regional CASC consisting of an expert Science Review Team, focus groups of science users and producers, and a survey of partners and stakeholders in the region. Each review concluded with a final report on institutional development, partnerships, science, and communications.[30]

In addition to this external review process, the NC CASC is committed to developing our own framework for long-term evaluation in order to learn from our previous engagement and more thoroughly understand successful production of actionable science. We approach evaluation of our activities as a way to teach us how to better provide actionable science in support of stakeholder decision-making and planning and not as a project grading process.

Focal Areas for 2019 and Beyond

For the period of 2019 and beyond, the NC CASC will strive to document (and implement) best practices for effective engagement of stakeholders and co-production of knowledge by researchers and managers.

We have chosen to develop a survey instrument that we will distribute to stakeholders involved in our funded activities. The questions in this instrument broadly cover stakeholder engagement in the research process, use of information, and perceptions of relationship building. In 2019, we will conduct a pilot test of this instrument on completed projects from the first five years of operation, with the goal of developing a repeatable process that can be used by the center to conduct ongoing evaluation of future activities.

[30] C[A]SC external review reports:
https://www.usgs.gov/land-resources/climate-adaptation-science-centers/about/program-evaluation