DRAFT IN REVISION - 2/16/2023

North Central Climate Adaptation Science Center Regional Science Plan: 2023-2028

This is a draft Regional Science Plan to focus dialogue with partners and frame their input on how the center should invest its resources in the future. **Comments and requests for briefings on the Regional Science Plan should be addressed to Aparna Bamzai-Dodson, NC CASC USGS Deputy Director (abamzai@usgs.gov)**

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Acknowledgements

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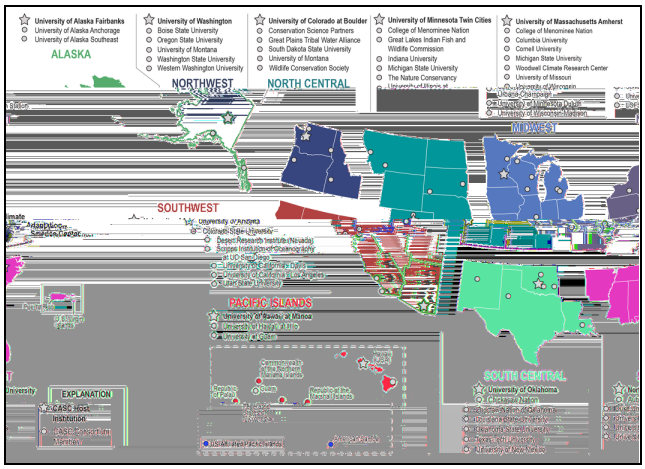
Introduction

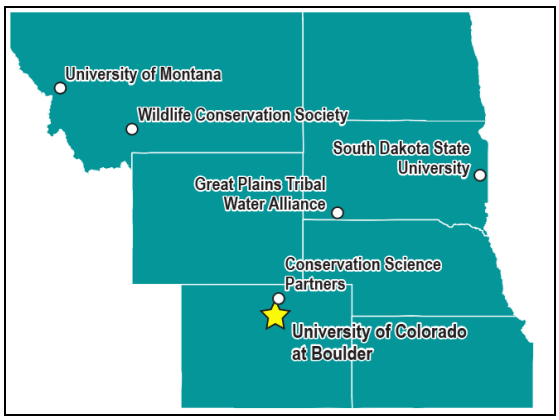
Organization and Operations

The U.S. Geological Survey (USGS) North Central Climate Adaptation Science Center (NC CASC)[1] was established in 2012 as part of a national network of regional centers intended to support climate-informed 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 work closely with the National and Regional CASC network[2] to address multi-region issues.



Map of the National and Regional Climate Adaptation Science Centers.

The NC CASC is a joint enterprise involving the USGS and the University of Colorado (CU) Boulder as primary partners, and five additional academic and non-governmental partners.[3] The NC CASC is jointly managed by a USGS Regional Administrator and a University Director, and includes both Federal and university-supported program and scientific staff and students. This relationship is re-competed periodically.[4] In 2018, CU Boulder was selected to serve as the NC CASC host until 2024, along with the named consortium members. Input on



Map of the North Central Climate Adaptation Science Center.

[1] North Central Climate Adaptation Science Center: https://nccasc.colorado.edu/
[2] On March 23, 2018, with passage by Congress of the fiscal year 2018 budget, the name of the Climate Science Centers was changed to the Climate Adaptation Science Centers. The name of the National Climate Change and Wildlife Science Center, which manages the regional centers, was changed to the National Climate Adaptation Science Center.
[3] Conservation Science Partners, Great Plains Tribal Water Alliance, South Dakota State University, University of Montana, and Wildlife Conservation Society.
[4] CASC Host Recompetition Information: https://www.usgs.gov/programs/climate-adaptation-science-centers/casc-host-recompetition

priorities and the usefulness of the NC CASC's science is provided by an Advisory Committee[5] composed of state, federal, and tribal government representatives.

The NC CASC is the host for two Tribal Resilience Liaisons, funded by the Bureau of Indian Affairs Tribal Resilience Program[6] and employed by the Great Plains Tribal Water Alliance.[7] The Tribal Resilience Liaisons have a lead role at the NC CASC for communicating with tribes, identifying challenges and needs, and ensuring strong working relationships. They work on fostering dialogue with tribal partners, and with them, identifying appropriate roles, products, and services that could be of benefit to tribal communities. Work conducted by the liaisons is guided by a regional Tribal Engagement Strategy.[8]

The NC CASC is uniquely placed at the intersection of scientists and managers working to support resilient ecosystems. Our vision for the future is that natural and cultural resource managers use actionable and open data, tools, and innovative science and information to make climate-informed decisions that support resilient ecosystems. Our core values are: Equity, Trust, Communication, and Accessibility.

The mission of the NC CASC is to deliver science to help fish, wildlife, water, land, and people adapt to a changing climate.

[5] Advisory Committee: https://nccasc.colorado.edu/partners/stakeholder-advisory-committee
[6] BIA Tribal Resilience Program: https://www.bia.gov/bia/ots/tcr
[7] Great Plains Tribal Water Alliance: http://www.tribalwateralliance.org/
[8] Tribal Engagement Strategy: 2019-2024: https://nccasc.colorado.edu/index.php/resources/tribal-partners

Partners We Serve

The NC CASC's region includes the states of North Dakota, 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.

Priority partnerships for the North Central CASC.

The NC CASC provides climate science and adaptation information to support climate-informed natural and cultural resource management planning and decision making primarily by bureaus of the U.S. Department of the Interior (DOI), state fish and wildlife 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. The NC CASC also recognizes that other entities (e.g., U.S. Forest Service) are often necessary partners in specific landscapes.

The NC CASC collaborates and seeks input from other academic and public science partners, conservation organizations, and other not-for-profit groups such as grazing associations in the region. Information developed by the NC CASC can also be useful to private landowners, municipalities, and other local entities. While these partners may not have direct public land and resource management responsibilities, they do have important contributions to make to frame and identify solutions. The NC CASC collaborates with individuals and organizations specializing in outreach and extension to these partners to ensure information access and integration with other relevant guidance. We strive to incorporate people and communities in our work, so that they can be fully considered in resource decision making.

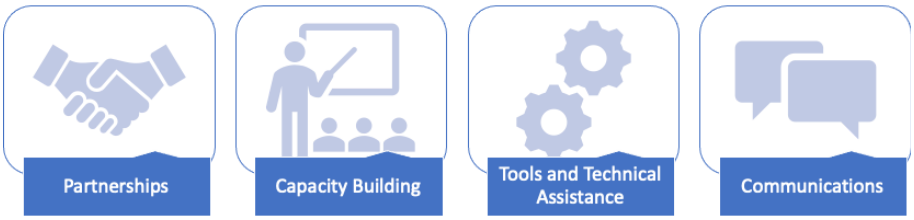
Tribal nations are key partners in the generation of science and expertise at the NC CASC. Federally Recognized Tribes are sovereign governments, with substantial legal and traditional resource management roles. Tribal nations are often challenged by intense competing priorities, resource limitations, and legal constraints. DOI has a major role in relations between the United States government and tribal nations, and our work supports 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.

Approach to Actionable Science

The primary objective of the NC CASC is to produce science that is directly usable in making resource management plans and decisions; that is, we create ***actionable science***.[9] We do not make, recommend, or endorse specific decisions, policies, or actions. Rather, the NC CASC seeks to proactively and intentionally engage with our stakeholders[10] to identify and satisfy information needs. These needs are often related to high priority resource management decisions or actions that may be impacted by climate variability and change.

NC CASC science activities include both conducting original research and synthesis and translation of existing scientific information into forms useful to managers. Effective use of science for management involves a broad suite of support activities, including:

- ***Partnerships*** with regional stakeholders and rights holders that enable us to respond to high priority natural and cultural resource management challenges and foster substantive, sustained engagement between scientists and managers.
- ***Capacity building*** that builds a community of skilled researchers and managers and fosters their leadership in science-based resource management.
- ***Climate tools and technical assistance*** that advance our understanding of the impacts of climate change and support sound resource management and adaptation.[11]
- ***Communicating our science*** so that it is accessible and usable.



Science support activities of the North Central CASC.

[9] 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

[10] Stakeholder engagement covers a continuum of possible interactions with stakeholders, spanning from communication of results to co-production of science, whereby stakeholders are an integral part of the science team. For more information, see this USGS-produced short video regarding stakeholder engagement for actionable science: https://youtu.be/5_OW0kAJIzk

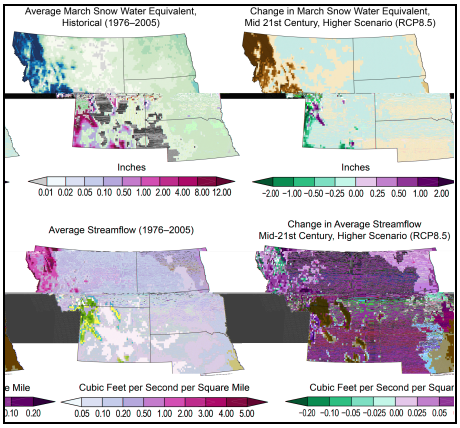
[11] CU Boulder convenes the NC CASC Climate Science Support Platform, a community of practice of consortium scientists and partners who seek to bridge gaps in the delivery of climate adaptation science by conducting transdisciplinary research, shared learning, and technical support.

Science Challenges and Priorities

Climate Challenges of North Central U.S. Ecosystems

Resource managers and local communities are faced with a variety of climatic impacts associated with warming temperatures and changing precipitation patterns that result in changes to physical and biological processes, such as hydrologic cycles, primary production, disease transmission, and migration patterns. Although people and ecosystems across the region have adapted to past climate challenges, the magnitude and rate of expected changes and impacts will exceed those of previous experience.

Precipitation across the region has changed, with decreases in the West and Southwest and increases in most of the Northern and Southern Plains.[12] These changes affect snowpack, streamflows, and water availability both in the region – such as in the Missouri River, one of the region's primary freshwater arteries – and in downstream regions – such as the Rio Grande River Basin. Precipitation is forecasted to continue to be highly variable in the future, with a likely shift toward more arid conditions in the southwestern states in this region. Temperatures have increased throughout the region, and are expected to continue to rise. Hotter temperatures will have both direct impacts, as well as indirectly increase the likelihood of drought conditions over larger swaths of the North Central region.



Fourth National Climate Assessment figure of historical (left; 1976–2005) and projected hydrological changes (right; 2036-2065) under a higher scenario (RCP8.5) in average snowpack (top row) and annual streamflow (bottom row).

Changes in temperatures and precipitation have led to more intense disturbance and severe weather events, such as increased flooding, incidence of large forest fires, or intensity of drought in some areas. This increase in the variability of the climate is predicted to increase with future climate change. These and related trends have and will continue to impact the landscape and ecosystems, with varying effects on people, fish and wildlife, crops, and other resources of human and ecological value. Climate change impacts will vary in their influence across the ecosystems found in the North Central region and lead to unique management challenges and research opportunities.

[12] See 2018 Fourth National Climate Assessment for more information; the sections on the Great Plains (Montana, Wyoming, North Dakota, South Dakota, Nebraska, Kansas) and the Southwest (Colorado) cover states in the NC CASC region: https://nca2018.globalchange.gov/

Ascertaining Partner Needs

The NC CASC has undertaken (and will continue) 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 and stakeholders, accompanied by a series of webinars.
- A funded project[13] 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 state fish and game agency staff, and a survey of and facilitated face-to-face meeting with key federal resource management agency partners.
- A Snow Collider[14] virtual event in 2020 that brought together scientists and natural resource managers to discuss and iterate on snow-related data and information needs, model limitations, and potential next steps for modeling future snow projections
- Virtual listening sessions in 2021 on "Fire in Forests and Grasslands"[15] and the "Future of Grasslands Management"[16] to connect with Advisory Committee members and learn about their climate-related priorities regarding these topics.
- Ongoing in person and virtual tribal engagement activities by the Tribal Resilience Liaisons.[17]

Through these engagement activities, resource managers prioritized four regional ecosystems and identified important climate-related natural resource management challenges. Similar management issues were identified across multiple ecosystems leading to the development of six key management priorities (see following section on Science Priorities and Objectives). The ecosystems are inexorably linked and the management issues are critically connected through the ecology of the ecosystems. As such, resource managers expressed a need to focus on the mechanisms and interactions that support ecosystem function to accomplish management goals, even when addressing the needs of individual species.

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[13] 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

[14] Snow Collider meeting summary: https://nccasc.colorado.edu/sites/default/files/2020-08/2020%20June%2011%20Snow%20Collider%20Summary.pdf

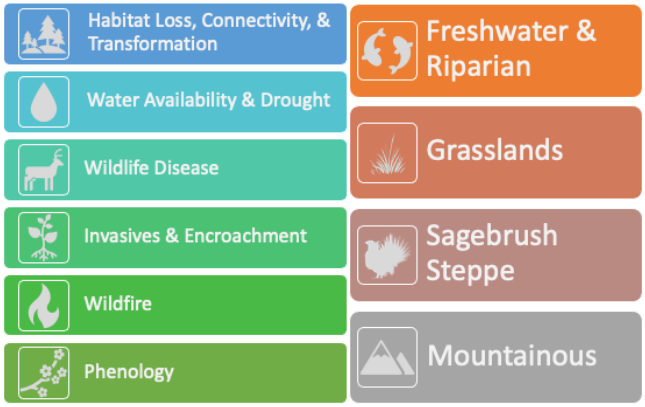
[15] Fire Listening Session meeting summary: https://nccasc.colorado.edu/sites/default/files/2021-06/NC%20CASC%20%26%20Hub_JSC%20Future%20of%20Fire_Summary.pdf

[16] Grasslands Listening Session meeting summary: https://nccasc.colorado.edu/sites/default/files/2022-03/NC%20CASC%20%26%20Hub_JSC%20Grasslands_Summary%20Aug%202021.pdf

[17] Tribal Engagement Strategy: 2019-2024: https://nccasc.colorado.edu/index.php/resources/tribal-partners

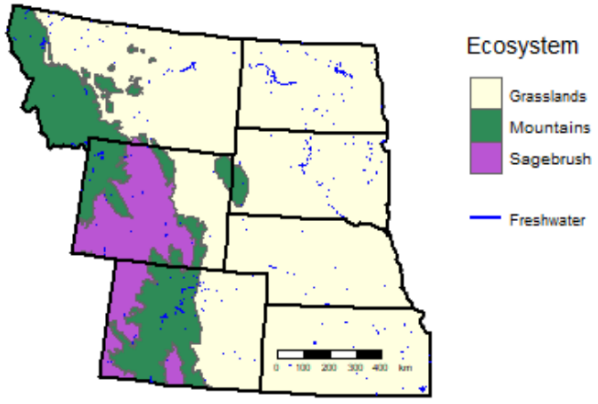
Science Priorities and Objectives

Based on the priorities identified by our management partners, the NC CASC will focus our science on six cross-cutting management issues that represent physical or structural properties, ecological processes, or disturbances and that have the potential to transform the ecosystems and associated habitats of concern. Emphasis will be placed on science involving four priority ecosystems: freshwater and riparian, grasslands, sagebrush steppe, and mountainous.



Priority management issues and ecosystems for the North Central CASC.

Freshwater and riparian ecosystems rely on water resources to support their diversity of flora and fauna, and can include aquifers, ponds, lakes, rivers, drainage ways, streams (both permanent and ephemeral), and the contiguous riparian landscapes shaped by these surface and subsurface hydrologic features. Grasslands are a varied ecosystem type dominated by graminoids. Within our region, grasslands include both tall, short, and mixed grass prairies; grasslands have been severely reduced in geographic area and transformed due to agriculture, grazing, and changing fire regimes. The sagebrush steppe includes areas dominated by sagebrush (*Artemesia* sp.), other shrubs, and perennial grasses; these 'seas of sagebrush' host a unique diversity of protected vertebrate species and form ecotones with grasslands. Mountainous ecosystems include alpine, subalpine, montane meadow, and forested ecosystems with high topographic heterogeneity (e.g, large changes in elevation, slope, and aspect) and in our region consist of both the 14,000 foot Rocky Mountain peaks and the lower elevation Black Hills.



Ecosystem areas were determined by EPA Ecoregions III and coarsely represent areas with biotic conditions suitable for each ecosystem type. Freshwater areas were mapped with the USGS National Hydrography Dataset, subsetting to water bodies greater than 3 sq.km and rivers greater than 2 km in length.

We see particularly strong actionable science opportunities focused on ecological drought in freshwater and riparian systems, mountains, and sagebrush steppe; invasive species in freshwater and riparian and grasslands systems; fire in mountains, sagebrush steppe and grasslands; and phenology in grasslands and shrublands. Research opportunities focused on habitat loss, transformation, and connectivity are applicable to all priority ecosystems.

1. Habitat Loss, Connectivity, and Transformation

Climate change can completely transform ecosystems through changes in habitat availability (most commonly due to habitat loss) and connectivity. Habitat loss represents the reduction in total area or the area of individual patches of habitat. Connectivity represents both structural and functional connectivity of habitat patches (the physical arrangement and proximity of patches and the ability for organisms or genes to move between patches) as well as the connectedness of the landscape that allows for natural processes (such as the degree to which a river is connected to floodplains). Transformation entails the wholesale change of ecosystem composition, structure, and function that affects habitats and the ecological services provided.

Science Objectives:

1.1 Examine how a changing climate influences habitat quality and quantity.

1.2 Understand climate-driven changes to patterns of structural and functional connectivity, and the corresponding impact on species range shifts or genetic connectivity.

1.3 Explore climate-driven vegetation transitions that will be irreversible or extremely challenging to reverse.

1.4 Define guiding principles (by species or systems) regarding whether transformation should be resisted, accepted, or directed through management actions.

Example Opportunities:

- Provide relevant science and data products in management-ready formats for inclusion in partner decision making and planning processes related to habitat conservation, restoration, and acquisition.
- Explore climate-driven losses of important habitat. Examples include, but are not limited to, intermittency of surface water flows, reductions in the distribution and structure of aspen stands due to increases in temperature and changing precipitation timing and quantity, and reduced availability of wolverine denning sites due to changes in snowpack depth and connectivity.
- Understand why, how, and when ecosystems change, expanding the information available to managers regarding the likelihood of significant landscape transformation, as well as for identifying more-likely and less-likely areas of refugia and transformation.
- Examine the effectiveness of varied management responses under scenarios of future transformation. Examples include, but are not limited to, fire and invasive-driven conversion of sagebrush to grass dominated landscapes, expansion and contraction of pinyon and juniper, and decreasing recruitment of pinyon forests.

2. Water Availability and Drought

The NC CASC focuses on "ecological drought" defined as the ecosystem-wide response to drought, as opposed to agricultural, hydrological, or meteorological drought.[18] Ecological droughts, by definition, have large impacts on ecological and human systems leading to species loss, economic loss, a shift in ecosystem feedbacks and function, or transformation of ecologically and societally valuable ecosystems. Ecological drought will be driven by not only the exposure to drought conditions, but also the sensitivity and adaptive capacity of systems experiencing the drought conditions.

Science Objectives:

2.1 Identify key climate drivers for ecological drought and critical thresholds for species and ecosystems.

2.2 Define key metrics that illustrate the impact of ecological droughts on individual species and entire assemblages.

2.3 Examine how resource management actions, land and water use, and ecological and landscape characteristics interact with meteorological drought to drive ecological drought.

Example Opportunities:

- Build science knowledge on the primary drivers and threshold responses of ecological drought and how climatic change may alter the frequency and distribution of ecological drought. Assist resource and water managers by developing and distributing tools for predicting and monitoring ecological drought.
- Relate projections of future snowpack and snowline to models for high elevation mountain habitats and connectivity, with direct management implications for species of concern such as wolverine, lynx, and ptarmigan.
- Develop or expand projections of future streamflow and temperature for use in management, such as recreational fishing, invasive species management and control, water diversion and use, forest planning and revisions, listing and habitat designation.

3. Wildlife Disease

Climate-driven migrations and range shifts of pathogens, hosts, and/or vectors may change population interactions, impacting disease transmission and geographic extent. Populations affected by disturbance, including those caused by climate change, are more vulnerable to disease emergence and impacts. While challenging, the complexity of disease dynamics coupled with sensitivity to changing conditions creates opportunities for predicting and managing wildlife disease.

[18] Crausbay et al. 2017. Defining ecological drought for the twenty-first century. https://doi.org/10.1175/BAMS-D-16-0292.1.

Science Objectives:

3.1 Identify where and for which species climate change will most greatly increase disease prevalence and transmission.
3.2 Examine how this increase will affect both populations and intra-species relationships.
3.3 Understand how community-scale disease impacts relate to ecosystem-scale impacts.
3.4 Investigate how resource management actions assist or buffer disease exposure and infection rates.
3.5 Explore how changing habitat structure, connectivity or shifting species ranges affects disease transmission.

Example Opportunities:

- Investigate strategies to manage population health for increased resilience to disease outbreaks and to prevent and/or manage disease outbreaks exacerbated by climate change. Examples include, but are not limited to, chytridiomycosis, brucellosis, chronic wasting disease, and White-nose syndrome.
- Develop or expand our understanding of disease interventions including their potential unexpected negative consequences.
- Investigate the impacts on disease dynamics of assisted migration, translocation, or reintroduction of species; for example, facilitated movement of temperature-sensitive fish impacted by warming water temperatures, such as bull trout.
- Forecast climate-driven expansion of zoonotic diseases, such as West Nile virus, and examine potential mitigation techniques.

4. Invasives and Encroachment

With changing climate, there is potential for increased spread of invasive species and the encroachment of woody species into alpine, riparian, and grassland habitat. The distributions of invasive and exotic species may expand with changing climate due to areas of newly suitable climate conditions and if ecosystems become more vulnerable to invasion. Changing climate will present both new challenges and new opportunities for where and how the risks associated with invasive and exotic species are managed.

Science Objectives:

4.1 Identify which invasive species will need to be managed and where.
4.2 Discern which species and ecosystems are most threatened by invasives or encroachment.
4.3 Identify successful adaptation options and key opportunities for management action.
4.4 Explore the interaction between changing habitat structure or connectivity and the spread of invasives.

Example Opportunities:

- Project future risk of encroachment and identify best land management practices for protecting grassland habitat, as expansion of woody vegetation into grasslands of the Northern Great Plains threatens native grassland conservation efforts.
- Examine the interacting effects of climate and management (e.g., grazing and fire) on the distribution and expansion of invasive or exotic grasses and the long-term impacts to forage and habitat.
- Understand how ecosystem composition and function will be altered by invasion and encroachment of species that are better adapted to future climate. Examples include, but are not limited to, exotic grass encroachment in native grasslands, cheatgrass invasion in sagebrush steppe, and warm-water adapted mussel encroachment.
- Increase the relevant science available for resource managers to make robust decisions about whether and how to address the encroachment of exotic and non-native species.

5. Wildfire

Climate change is expanding the spatial and temporal extent of wildfires,[19] reshaping the intensity and impacts of wildfire for natural and human dominated landscapes. All known major drivers of fire behavior are expected to change in the future, as urbanization increases ignition potential and climate change impacts fuel availability and weather conditions. Fire regimes and the landscapes prone to these regimes are likely to change, having large ecological, economic, and human-health related impacts.

Science Objectives:

5.1 Examine how a changing climate will alter fire probability and behavior.
5.2 Understand how species and ecosystems will respond to changing fire regimes.
5.3 Explore how post-fire restoration efforts will need to accommodate a changing climate.
5.4 Consider how wildfires will interact with climate and other disturbance processes (e.g., invasive species, pests) to precipitate ecological transformation.
5.5 Identify what adaptation options are available to resource managers for managing fire risk, intensity, and impact.

Example Opportunities:

- Understand 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.
- Understand how fire regimes are changing, leading to increased probability or more extreme fire behavior.

[19] Senande-Rivera, Insua-Costa, & Miguez-Macho. 2022. Spatial and temporal expansion of global wildland fire activity in response to climate change. https://doi.org/10.1038/s41467-022-28835-2.

- Initiate an effort to project post-fire regeneration potential based on climate, location, fire severity, and other factors.
- Examine the interacting effects of the distribution and expansion of invasive/exotic grasses and fire.

6. Phenology

Phenology refers to the study of the timing of plant and animal life cycle events, such as fruiting or migration, and how these are impacted by environmental conditions. Plants and animals can adapt in relation to changing weather and climate conditions, but not all species adapt concurrently or in compatible ways. Rapid climate change is anticipated to exacerbate phenological mismatch—disruptions in the timing of life cycle events for interdependent species. Recognizing the influence of changing climate conditions on phenology is imperative to assessing ecosystem function and strategizing adaptive management.

Science Objectives:

6.1 Understand the types of phenological shifts that are likely to occur in the future

6.2 Identify the primary environmental cues for species life histories and examine how they will be impacted by changing climate.

6.3 Explore the rate of phenological shift and to what degree behavioral changes can be adaptive versus maladaptive.

Example Opportunities:

- Evaluate how forage characteristics important to ungulates have changed over the past two decades and assess which remote-sensing metrics best represent on-the-ground phenological and forage quality changes and conditions. Given these findings, assess how potential land management and treatment alternatives could further affect forage characteristics.
- Examine climate change impacts to forage greenup timing, quality, and quantity in relation to ungulate migration timing and locations.

Table of Priorities and Objective

Science Plan Implementation

Selection and Funding of Projects and Activities

With regular input from our partners, the NC CASC will seek to both strategically and iteratively concentrate investment based on this plan and to ensure that a diversity of management priorities are addressed through annual funding cycles. In general, the NC CASC uses three methods to identify and implement projects:

1. *Project Solicitation Announcement*
   Project solicitations generally call for initial Statements of Interest with the NC CASC requesting full proposals from responding investigators such that at least 1-in-3 full proposal submissions are funded. Solicitations are coordinated to the fullest extent possible with the National and Regional CASC network.
2. *Direct Funded Projects*
   The NC CASC may also collaboratively develop projects with consortium or USGS scientists in order to directly respond to identified stakeholder needs.
3. *NC CASC Host and Consortium Activities*
   CU Boulder and consortium partners use resources provided under the hosting award to support needs identified by stakeholders. Further, they convene the Climate Science Support Platform community of practice and conduct foundational science to build knowledge on best practices for climate adaptation management actions.

Additional, more detailed, information about how the NC CASC approaches funding and evaluation of science and science support projects can be found in the full-length project solicitation guidance.[20]

[20] USGS Project Solicitation Manager: https://sciencebase.usgs.gov/psm/#/

Understanding Success

The National CASC conducts end-of-award reviews of the host institutions for each regional CASC utilizing External Review Teams (ERT) composed of experts familiar with both the CASC network and the region. These ERTs evaluate the status of commitments made in the hosting agreement to ensure that established goals and obligations are being met, as well as to identify obstacles and areas of improvement for future host competitions and agreements. Each review concludes with a written final report encapsulating the ERT's findings and results.[21]

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. The NC CASC approaches 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.

To this end, the NC CASC developed and deployed a survey instrument distributed to stakeholders involved in projects funded during the first cycle hosting agreement.[22] The questions in this instrument broadly covered stakeholder engagement in the research process, use of information, and perceptions of relationship building. We found that attempting to generate a summative "one size fits all" survey for such a broad set of objectives prevented us from examining the societal impact and characteristics of individual projects, even if it helped identify broad strategies used in projects found satisfactory by stakeholders. Building off this effort, we will continue to document (and implement) best practices for effective engagement of stakeholders and co-production of knowledge by scientists and managers.

[21] C[A]SC external review reports: https://www.usgs.gov/programs/climate-adaptation-science-centers/program-evaluation

[22] Bamzai-Dodson & McPherson. 2022. When Do Climate Services Achieve Societal Impact? Evaluations of Actionable Climate Adaptation Science. https://doi.org/10.3390/su142114026.