North Central Climate Adaptation Science Center

FINAL REPORT

October 1, 2018 - January 30, 2025

Submitted by:
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1. ADMINISTRATIVE

Principal Investigator (PI): Dr. William R. Travis (william.travis@colorado.edu)
Institution of the Award Recipient: University of Colorado Boulder (CU Boulder)
Issued to: The Regents of the University of Colorado
Attention: Genevieve Hurst
Office of Contracts and Grants
3100 Marine St, Boulder, CO 80303
Project Title: CU Boulder NC CASC: Driving innovation in co-producing science to help resource managers in the North Central region adapt to a changing world
Award Agreement Number: G18AC00325
Date of the Report: May 30, 2025
Performance Period: October 1, 2018 to January 30, 2025 (No Cost Extension of Budget Year 6 ended January 30, 2025)

2. PURPOSE AND OBJECTIVES

The University of Colorado Boulder (CU Boulder) via the Cooperative Institute for Research in Environmental Sciences (CIRES) became the host of the United States Geological Survey (USGS) North Central Climate Adaptation Science Center (NC CASC) on October 1, 2018. In this first host cooperative agreement with USGS (CU Boulder Cycle 1, hereafter referenced as Cycle 1), CU Boulder served as the regional hub for the NC CASC Consortium that represented a balanced collaboration among universities, conservation nonprofits and Tribal boundary organizations. Cycle 1 Consortium Partners (***Figure 1***) included: **Conservation Science Partners (CSP)**; **Great Plains Tribal Water Alliance (GPTWA)**; **South Dakota State University (SDSU)**; **University of Montana (UM)**; and the **Wildlife Conservation Society (WCS)**.

Figure 1. Map of the North Central Climate Adaptation Science Center Cycle 1 (October 1, 2018 to January 30, 2025).

Throughout Cycle 1, the CU Boulder/CIRES-hosted NC CASC Consortium significantly advanced the development and delivery of actionable climate adaptation science relevant to the NC CASC's mission *to deliver science to help fish, wildlife, water, land and people adapt to a changing environment*. The Consortium's successes are attributed to a committed team of research scientists and staff, and robust institutional and administrative support from CIRES.

Strong **Partnerships** with regional stakeholders, Tribal Nations, and other organizations, including the Department of Interior (DOI), U.S. Fish and Wildlife Service (USFWS), National Park Service (NPS) Climate Change Response Program, Bureau of Land Management (BLM), and the U.S. Department of Agriculture United States Forest Service (USFS) enabled the NC CASC Consortium to respond to high priority natural and cultural resource management challenges and foster substantive, sustained engagement between scientists and managers.

The center's **Science** activities included interdisciplinary research, syntheses, datasets and tool development, informed by collaborations with stakeholders and rightsholders, that provided usable science and applications for climate-informed resource management. Major science efforts in Cycle 1 included: (i) advancing the development of quantitative future climate scenarios for assessments of ecological impacts and adaptation strategies; (ii) research in ecological drought; (iii) ecological recovery and transformation from climate-induced disturbance; (iv) identifying key information needs and synthesizing climate and ecological sciences for the North Central grasslands; (v) assessing future fire risk in the NC CASC region and beyond; and (vi) developing and applying decision tools for managing natural and cultural resources under a changing climate.

Capacity Building activities helped build a community of researchers and managers and foster their leadership in science-based resource management. Cycle 1 capacity building activities provided training and research opportunities for students and postdoctoral research fellows, and training and support for stakeholders, rightsholders and partners in the North Central region.

Communications were embedded in all aspects of the NC CASC's activities and supported the integration of climate adaptation science into natural and cultural resource management. In Cycle 1, the NC CASC established a communications team dedicated to implementing a communications and outreach strategy that grew and evolved in response to the needs of our partners, and resulted in a variety of products and tools (see **5.0 OUTREACH**).

The NC CASC Consortium's cumulative successes throughout Cycle 1 (October 1, 2018 to September 30, 2024; No Cost Extension of Budget Year 6 ended January 30, 2025) were recognized in its Five-Year External Review [April 2023, North Central Climate Adaptation Science Center External Review Team Final Report]: *"the Host and Consortium effectively met the goals set out in its proposal to, and agreement with, USGS. The NC CASC has been effective over the last five years in conducting meaningful climate science, working with partners in co-producing much of that science, building capacity of the current and next generation of climate scientists, and effectively communicating its work to a variety of audiences."* Key milestone activities during Cycle 1 are summarized below and in ***Figure 2*** (refer also to Year 1-5 Annual Reports located on the NC CASC website (https://nccasc.colorado.edu/):

Year 1 Milestones:

- CIRES-hosted NC CASC website goes live with kick-off of Cycle 1 on October 1, 2018
- Host Team and Consortium Partners collectively set agenda for Consortium meetings and activities
- A roadmap for the Climate Science Support Platform is established
- Plans are initiated to launch the Tribal Climate Leaders Program (TCLP)

Year 2 Milestones:

- Host conducted a training needs assessment to identify management priorities and associated technical data challenges (Spring and Fall 2019)
- Launched bi-monthly NC CASC Newsletter (October 2019)
- Launched the NC CASC Tribal Climate Leaders Program (TCLP) that supported five Native American students from Tribal Nations pursuing a graduate degree at CU Boulder in the area of climate adaptation science
- Launched the *Grasslands Synthesis Project* (March 2020)
- Released a new R package: Climate Futures Toolbox (CFT) to support the data user needs of partners in the North Central region (April 2020)
- Host launched the NC CASC Webinar Series to highlight ongoing research, and feature relevant topics of interest to natural resource managers, stakeholders and rightsholders in the region (July 2020)

Year 3 Milestones:

- Host Team: Hosted Climate Data 101 in Python Workshop (October 2020)
- Host Team: Future of Fire National CASC Climate Adaptation Postdoctoral (CAP) Fellow begins research project at CU Boulder (Fall 2020)
- NC CASC Consortium engaged with USGS colleagues in a *Theory of Change* strategic planning process to develop a shared vision for the center *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.*
- UM: Hosted virtual fire manager workshop, Managing Post-Fire Vegetation Under Climate Change (February 2021)
- CSP: Worked with DOI partners (USFWS, NPS, BLM), USFS, and the National Oceanic and Atmospheric Administration (NOAA) to develop a research agenda for science to support the application of the Resist-Accept-Direct framework
- SDSU: Performed outreach to land managers to understand climate information needs
- WCS: Hosted stakeholder workshops on adaptation and conservation planning with the Wyoming Game & Fish Department; and a virtual meeting, Measuring Climate Adaptation Outcomes to share and solicit feedback on results from an evaluation of adaptation projects supported by the WCS Adaptation Fund (July 2021)

Year 4 Milestones:

- Host Team: Updated NC CASC Communication and Outreach Plan
- Host Team: Hosted virtual Climate Solutions Days during Earth Week (April 2022)
- Host Team: Upgraded bi-monthly NC CASC Newsletter to MailChimp Platform (July 2022)
- WCS: Convened virtual meeting of Climate Adaptation Fund grantees (including The Nature Conservancy, the Greater Yellowstone Coalition, the Big Hole Watershed Committee, Mountain Studies Institute, the Indigenous-founded and -led Piikani Lodge Health Institute, and the

Blackfeet Environmental Office) that are working on beaver-related adaptation approaches in the North Central region (September 2022)

Year 5 Milestones:

- GPTWA: Launched CP-funded project on Tribal climate adaptation water needs in South Dakota (October 2022)
- SDSU: Launched an evaluation of how managers prepare for and respond to environmental hazards (January 2023)
- Host Team: Led NC CASC Consortium Five-Year External Review (March 2023)
- Host Team: Launched pilot summer Rapid Climate Assessment Program (RCAP 2023 Projects; May-August 2023)
- Host Team: Hosted a 2-day Ecological Transformation Workshop (July 2023)
- CSP and collaborators: Convened a climate-informed wildlife crossings workshop (August 2023)

Year 6 Milestones:

- Host Team launches the NC CASC Year 6 summer RCAP 2024 Projects (May-August 2024)
- Host Team: Hosted the NC CASC Sagebrush & Climate Change Workshop (August 20-21, 2024)
- Host Team: Hosted NC CASC Consortium & Partners Workshop (August 22-23, 2024)

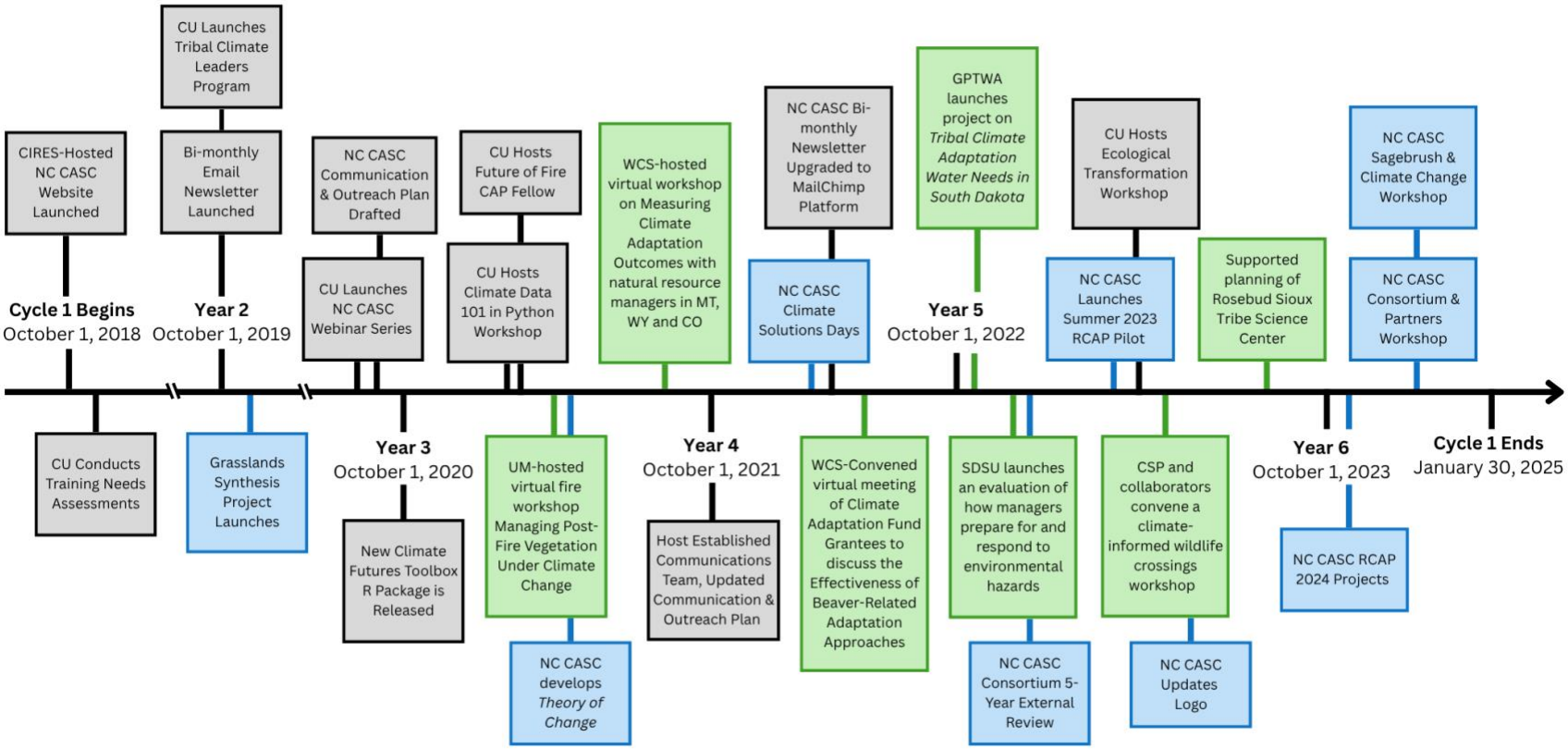

Figure 2. Key milestone activities during NC CASC Cycle 1. Host (CU Boulder) activities are outlined in black; Consortium Parter (CP) activities are outlined in green; and NC CASC joint Host, CP and USGS activities are outlined in blue.

3. ORGANIZATION AND APPROACH

Throughout Cycle 1, the Host Team successfully leveraged the efficient administrative, fiscal and compliance systems of CIRES and CU Boulder to effectively and responsibly manage the spending of the host cooperative agreement funds, five-subawards to Consortium Partner co-PIs, and 23-USGS funded Pass-Through Projects. Host management was structured to ensure that the mix of **administration**, **partnerships**, **science**, **capacity building**, and **communications and outreach** activities achieved the best possible outcomes for managing climate-sensitive natural and cultural resources in the region. In Year 5, the Host Team expanded its Leadership Team governance structure to include the University Director (William Travis), Deputy Director (Jane Wolken), Lead Climate Scientist (Imtiaz Rangwala) and Lead Social Scientist (Heather Yocum). Summary tables of CU Boulder personnel funded by the cooperative agreement and leveraged contributions from individuals funded outside of the host award in Year 6 are located in **APPENDIX I**; refer to the Year 1-5 Annual Reports for this information in prior years.

Institutions receiving sub-awards: Subawards to a consortium of universities, conservation nonprofits and Tribal boundary organizations in the region extended the technical expertise and informed the center's knowledge of regional climate adaptation challenges and opportunities. Cycle 1 Consortium Partners (CPs) included: **Conservation Science Partners (CSP)**: co-PI Caitlin Littlefield (initially Shelley Crausbay); **Great Plains Tribal Water Alliance (GPTWA)**: operated as an unfunded CP until Year 5; co-PI Reinique Beck (initially Stefan Tangen); **South Dakota State University (SDSU)**: co-PI Laura Edwards and Jennifer Zavaleta Cheek; **University of Montana (UM)**: co-PI Phil Higuera; and **Wildlife Conservation Society (WCS)**: co-PI Molly Cross. Despite significant delays getting a contract modification approved for CP subawards and the challenges associated with remote work during the COVID-19 pandemic, the CPs effectively engaged with the Host Team to co-develop actionable climate adaptation science with a variety of partners in the NC CASC region, as reported on throughout this document.

Consortium governance, operations, and interactions: Throughout Cycle 1, each Consortium Partner (CP) produced actionable climate adaptation science and served as a connector between researchers, stakeholders, rightsholders and partners in the NC CASC region. In Years 1-4, supported CP activities were co-determined by the CP co-PIs, and the University Director (William Travis; initially Jennifer Balch) and Deputy Director (Jane Wolken; initially Brian Johnson). Touch points for CP interactions included monthly CP meetings (Years 1-4), bi-weekly NC CASC all-hands calls with the NC CASC Host and USGS Teams (Years 5-6), monthly Climate Science Support Platform calls (Years 1-6), Consortium events, such as the Annual Cooperators Meetings (Years 1-4), NC CASC Theory of Change (Year 3), NC CASC Climate Solutions Days (Year 4), NC CASC External Review (Year 5), and NC CASC Consortium & Partners Workshop (Year 6); refer to ***Figure 2*** for a timeline of milestone activities.

4. RESULTS

Cycle 1 NC CASC Consortium activities are summarized below under four core goals: **Partnerships**, **Science**, **Capacity Building**, and **Communications and Outreach**. Key accomplishments include initiating a new partnership with BLM units in the region via the *Rapid Climate Assessment Program*; strengthening an existing partnership with USFWS via climate science support for lynx, fritillary butterfly, and 17 additional species status assessments (***Table 1***); and growing collaborations with other regional CASCs through our engagement in virtual and in-person meetings and trainings, and National CASC initiatives including the Climate Adaptation Postdoctoral Fellows Program and the Climate Adaptation Scientists of Tomorrow (CAST) program.

Table 1: Summary of NC CASC partners and collaborators by sector.

Partners and Collaborators	
Sector	**No.**
Federal Agencies	13
State Agencies	11
Tribal Colleges and Universities	11
Tribal Nations and Intertribal Organizations	29
Academic and Research Institutions	20
Regional CASCs	3
Non-Profit Organizations	14

Partnerships

Partnerships with regional stakeholders and rightsholders enable the NC CASC to respond to high-priority natural and cultural resource management challenges and foster substantive, sustained engagement between scientists and managers. Ongoing stakeholder tracking efforts throughout Cycle 1 indicate that the NC CASC Consortium engaged with 101 unique partners and collaborators across the region (***Table 1***) to inform the Consortium's science activities and build adaptive capacity. The *Grasslands Synthesis Project* (described below) was key to building partnerships with grasslands managers, and strengthening cross-CASC partnerships, while the Rapid Climate Assessment Program (RCAP) facilitated new partnerships with BLM (see **Science**). Additionally, James Rattling Leaf's outreach activities helped the NC CASC build and strengthen partnerships with Tribal organizations, and connect Tribes with relevant climate adaptation information and tools (see **APPENDIX II**).

The NC CASC has forged strong partnerships with organizations that develop and maintain tools in order to strengthen the process of tool development and maintenance. This is particularly salient for the tools that are more complex and versatile. A key partnership that the Host Team developed in Cycle 1 was with Dr. Katherine Hegewisch (University of California Merced), who is the developer of ClimateToolbox.org. This partnership has allowed the center to develop new tools and improve existing tools on ClimateToolbox.org (see **Science**) that directly benefits NC CASC science and provides significant support to partners. Other partnerships include those with the NOAA Physical Sciences Lab (for hosting the Landscape Evaporative Response Index) and with CIRES (for hosting the Drought Index Portal).

Science

NC CASC science activities have the goal of advancing the understanding of the impacts of climate change and variability on fish, wildlife, plants, water, land, and people to support sound resource management and adaptation. Throughout Cycle 1, the NC CASC Consortium provided *climate adaptation science support* to a variety of partners in the North Central region (***Table 1***).

Imtiaz Rangwala (Climate Science Lead) provided climate science support for 19 USFWS species status assessments (***Table 2***).

Table 2. Cycle 1 NC CASC supported U.S. Fish and Wildlife Service Species Status Assessments.

Species Status Assessments			
Species	**Report Year**	**Species**	**Report Year**
White-tailed ptarmigan (northern and southern Colorado population)	2	Western Bumble Bee	4
Skiff milkvetch (southwest Colorado)	2	Narrow Foot Hygrotus Diving Beetle	4
Monkey flower (Colorado Front Range)	2	Canada Lynx	4
North Park Phacelia (northern Colorado)	2	Ute Lady Tress	4
Desert tortoise and several other species (Mojave Desert, Utah)	2	Rio Grande Cutthroat Trout	5
Silverspot butterfly (southern Colorado)	2	Sicklefin and Sturgeon Chub	5
DeBeque Phacelia and Colorado Hookless Cactus	3	Wolverine	6
Cisco and Isely Milkvetch	3	Heliotrope Milkvetch	6
Brandegee's Buckwheat	3	Greenback Cutthroat Trout	6
Regal Fritillary Butterfly	4		

The NC CASC also supported the development of a number of ***tools*** throughout Cycle 1, which included:

1) Tools developed or improved in collaboration with ClimateToolbox.Org:

a) The **Future Climate Scenarios tool** was developed to generate quantitative summaries of future projections for climate metrics of interest for selected model(s)/scenarios. The output is a table (as .png or .csv) of model projections across a set of future climate scenarios and climate metrics that the user defines. An output table can also be created for all available metrics. This tool also outputs spatial files (as netcdf or Geotiff) for the selected variables.

b) Significant improvements were made to the **Future Climate Scatter tool** to visualize climate projections uncertainty and for aiding climate scenario selection, and to the **Future Time Series tool** for extracting time series data for individual projections.

c) A **climate scenario workflow** was developed to guide users in the use of various tools at ClimateToolbox.Org for identifying climate scenarios and generating relevant data and figures.

2) Nine R-Shiny Apps were developed to compute and project metrics related to drought, which included metrics like the Standardized Precipitation Evapotranspiration Index (SPEI) and the Evaporative Demand Drought Index (EDDI); Vapor Pressure Deficit (VPD) Extremes; the Forest Drought Stress Index (FDSI); and snowfall projections.

3) Two R-Shiny Apps were developed to examine and identify large-scale drivers of precipitation across the contiguous United States.

4) Drought Index Portal (DrIP) was developed to display, compare, and extract time series for various indicators of drought in the contiguous United States. The Host Team collaborated with CIRES IT to host the tool under the *colorado.edu* domain with updates and maintenance carried out by CIRES IT.

5) **NC CASC continues to update and maintain the Landscape Evaporative Response Index (LERI) webtool** in collaboration with NOAA's Physical Sciences Lab.

6) Rangwala (Climate Science Lead) and Thota (Graduate Research Assistant) **collaborated with Western Water Assessment to develop an Experimental Winter Precipitation Forecast tool for the Intermountain West** in collaboration with the University of Utah.

In Cycle 1, the NC CASC engaged in several cross-partner ***science synthesis*** efforts that leveraged the Cycle 1 hosting agreement:

1) **Rapid Climate Assessment Program**: In Year 5 (Summer 2023), the Host Team launched the Rapid Climate Assessment Program (RCAP) to create syntheses of science information to serve as a baseline for further research and a foundation for future stakeholder engagement. Since 2023, the RCAP has become an integral component of the NC CASC's portfolio of science activities. During Cycle 1 the ***RCAP supported twelve graduate research assistants, one undergraduate student, and one early career team member*** to conduct synthesis research on climate, ecological, and social science topics in partnership with federal, state, and Tribal resource managers across the NC CASC region. A detailed description of the RCAP projects in Year 5 (2023) and Year 6 (2024) is available on our website. The Cycle 1 RCAP products are summarized in ***Table 3***.

Table 3: Summary of Cycle 1 NC CASC Rapid Climate Assessment Program (RCAP) products.

RCAP 2023		RCAP 2024	
Product	**Quantity**	**Product**	**Quantity**
Presentations	8*	Presentations	10*
Summary document (2-pager, 4-pager)	3	Reports/ Impact assessments	1
R-Shiny Apps	2	Annotated Bibliography	1
Publications	2	Blog posts	3

**While all RCAP students presented their work to the team, Sarah Gonzalez Coffin (2023) also presented her work at a conference; Lauren Barrett and Katie Bardsley presented their work at the 2024 Sagebrush and Climate Change Workshop; and Prasad Thota and Hailey Robe presented their work at the 2024 Consortium & Partners Climate Adaptation Science Workshop.*

2) **Ecological Scenarios Project:** This project (PI Imtiaz Rangwala, postdoctoral research fellow Kyra Clark-Wolf, and USGS co-PIs: Wynne Moss, Brian Miller and Helen Sofaer) was funded by a USGS Pass-Through Project, *Crafting Ecological Scenarios for Decision Making,* and strongly leverages the NC CASC Host Award. The project aims to advance the application of the *Resist-Accept-Direct (RAD)* framework by developing methods to craft ecological scenarios for climate adaptation. Key objectives include creating a workflow for scenario development and testing its utility through a case study in the Nebraska Sandhills, partnering with USFWS and NPS. Expected outputs include peer-reviewed publications, training materials, and actionable scenarios for resource managers. A 16-member Ecological Scenarios Working Group—comprising scientists, boundary organizations, and federal agencies—was convened to refine methods via workshops and subgroup collaborations. Clark-Wolf led efforts, including a Nebraska Sandhills case study to address groundwater stability and woody encroachment. Field visits and literature reviews informed scenario development, with a planning workshop slated for 2025. Results include a consensus-driven *ecological scenarios workflow* integrating qualitative/quantitative methods, and progress on the Sandhills case study

(see Clark-Wolf et al. *In-Press*). Outreach featured presentations at the *Ecological Society of America* (2023) and a symposium at the *North American Congress for Conservation Biology* (2024). A 1-pager was developed for USFWS partners to communicate project goals. Next steps focus on completing the Sandhills scenarios development, and hosting the 2025 workshop. The project leverages NC CASC host award funding, with remaining budgets allocated to postdoctoral research fellow support and participant travel.

3) **Future of Fire Project:** This project was led by postdoctoral research fellow, Jilmarie Stephens; PI: Jennifer Balch; and mentors: Jane Wolken and Imtiaz Rangwala, and funded by the NC CASC Host Award and the National CASC Climate Adaptation Postdoctoral (CAP) Fellows Program. The research modeled the future size and number of fires, total burn area, and rates of change among years and across space in the contiguous United States (CONUS). CONUS-wide the number of fires and burned area per year increased by 56% and 59% from 2020-2060 compared to baseline (1990-2019). A manuscript titled, "Fires of unusual size: Future of extreme and novel wildfire in a warming United States (2020-2060)" is being revised for publication, and the data will be made publicly available. This research was done in conjunction with the National CASC CAP Fellows Program which generated a regional-to-national synthesis on the future of fire titled, "A fire-use decision model to improve the United States' wildfire management and support climate change adaptation" (see Russell et al. 2024).

4) **Grasslands Synthesis Project:** This project was led by PI Heather Yocum and Research Coordinator Christy Miller Hesed. The goal of the *Grasslands Synthesis Project* was to establish a baseline of information and understand science needs to inform NC CASC efforts to provide relevant climate science to grassland resource managers. The research was funded by a USGS CASC directed research grant, and leveraged NC CASC Host supported time for Heather Yocum, Bill Travis, Jilmarie Stephens, and Imtiaz Rangwala. Miller Hesed and Yocum coordinated with and leveraged the efforts of the U.S. Department of Agriculture Northern Plains Climate Hub to conduct a vulnerability assessment for USFS grasslands. Despite the challenges of the pandemic, this project was key to expanding partnerships, and successfully engaged 59 partners (including representatives from BLM, USFWS, NPS, USFS, Tribal Nations, state natural resource departments, and non-governmental organizations (NGOs)). The *Management Priorities Working Group* collected, reviewed, and synthesized grassland management plans and documents from federal, state, and Tribal agencies and

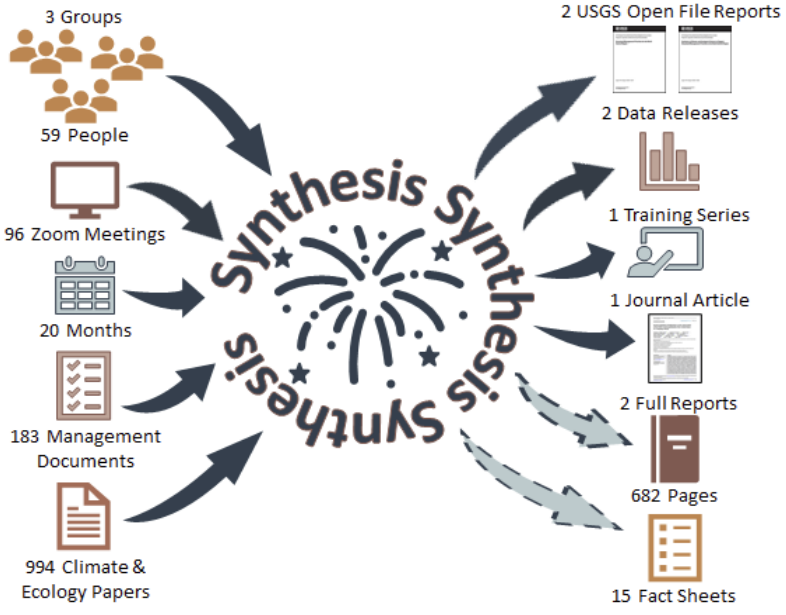

Figure 3. Summary of outputs from the Grasslands Synthesis Project.

NGOs in the North Central region. They identified the key science questions that, if answered, could help grassland managers be successful in meeting their goals and addressing their challenges in a changing climate. These questions were then addressed by the *Climate & Ecology Working Group*, which synthesized existing science to answer questions and identify areas where more research is needed. Outputs from this project (***Figure 3***) include: two-USGS Open File Reports, two-data releases, one-training series in collaboration with the South Central CASC and USFWS, one-paper published in *Conservation Science and Practice*, and six-fact sheets in the center's *Prairie Climate Companion* series. Three-multi-chapter reports are currently in press with USGS Scientific Publishing Network.

Capacity Building

Throughout Cycle 1, the NC CASC helped train the next generation of earth and environmental scientists and research managers. ***Table 4*** summarizes the number of undergraduate students, graduate research assistants and postdoctoral research fellows supported by the NC CASC Cycle 1 Host Award. Graduate students and postdocs that engaged in NC CASC research have gone on to work at USFS, USGS, and Tribal governments, while undergraduate students have pursued graduate studies at top programs in their chosen fields.

Table 4: Summary of NC CASC Fellows supported by the Cycle 1 Hosting Agreement.

NC CASC Fellows			
Year	**Undergraduate Students**	**Graduate Research Assistants**	**Postdoctoral Research Fellows**
1			
2	1	3	
3	1	5	1
4	2	1	1
5	1	8	2
6	1	6	1

The NC CASC leveraged additional funds from the CU Boulder and USGS to support two student programs – the CU-funded Tribal Climate Leaders Program and the National CASC's Climate Adaptation Scientists of Tomorrow (CAST) program. Heather Yocum (Social Science Lead) coordinated both programs. The Tribal Climate Leaders Program provided support to Native American graduate students to pursue graduate degrees related to climate adaptation at CU Boulder. The CU Boulder-hosted CAST program has funded six undergraduate research fellows and five graduate students to support research on understanding compound disturbances in streamflow, water quality, and forest regeneration in the mountains near Boulder, Colorado; a state vulnerability assessment; climate impacts on pollinators; a comparison of sustainability funding in the private sector; and water management.

Communications and Outreach

Communications and outreach are embedded in all NC CASC activities, and integrate our **Partnerships**, **Science**, **Capacity Building**, and **Communications and Outreach** efforts. In Cycle 1, the NC CASC increased its communication and outreach capacity with the establishment of a communication team comprised of Jane Wolken (Deputy Director); Ulyana Horodyskyj Peña (Communications Lead), who joined the NC CASC in September 2021; and Hailey Robe (Program Assistant; previously Dawn Umpleby), who joined the team in January 2023.

In June 2023, the *NC CASC Communication and Outreach Plan* was updated with more clearly defined communication goals, objectives and evaluation metrics for communication tools (described below). Areas of growth include *Spotlight Stories* and short *Science Byte*s for the website; Twitter campaigns to highlight NC CASC research and outreach efforts, using targeted hashtags to drive traffic (e.g., #climatetwitter, #TEK for Tribal posts and #grasslands to promote the *Grasslands Synthesis Project*); and the creation of video content for the center's YouTube Channel, including a Who We Are introduction video; a Research Reel highlighting some NC CASC scientists and their work; and The Future of Fire, focused on joint research with the NC CASC and USGS. Additionally, Peña participated in the American Geophysical Union's Voices for Science program, which trains scientists on best practices and strategies for communicating science to decision makers and public audiences. She leveraged this opportunity to provide two communication training sessions during *NC CASC Climate Solutions Days* on The Art of Science Storytelling and Stages of Filmmaking to NC CASC scientists and partners, as well as through other in-house trainings during the remainder of 2023 and 2024.

The NC CASC used the following ***communications tools*** to share news about the center's activities with partners, stakeholders and rightsholders:

- ***NC CASC Website:*** With increased communication effort from Peña and Robe, the center increased the number of *Spotlight Stories* (2021: 4 stories; 2022: 6 stories; 2023: 4 stories; 2024: 10 stories; 2025 (as of April 30): 3 stories) and *Science Bytes* (2022: 4 stories; 2023: 36 stories; 2024: 35 stories; 2025 (as of April 30): 10 stories) for the website (***Figure 4***) and videos for the YouTube channel. The current *Spotlight Story* and *Science Byte* appear on the NC CASC landing page of the website. The center also hosts a page that contains content organized by Kynser Wahwahsuck and Janna Black (Tribal Climate Resilience Liaisons), including archived issues of the Tribal Climate Adaptation Newsletter and videos of the Tribal Climate Webinars. Additionally, new pages were added under "Resources" including Grasslands to highlight the work of the *Grasslands Synthesis Project*. From this page, users can access the USGS open file reports, as well as issues of the 'Prairie Climate Companion,' which is a series of 2-pagers focused on different grasslands management concerns. The NCA5 page was added as a resource for sorting through key messages from this important report. Additionally, a student blog was started to support student writing from the RCAP program.

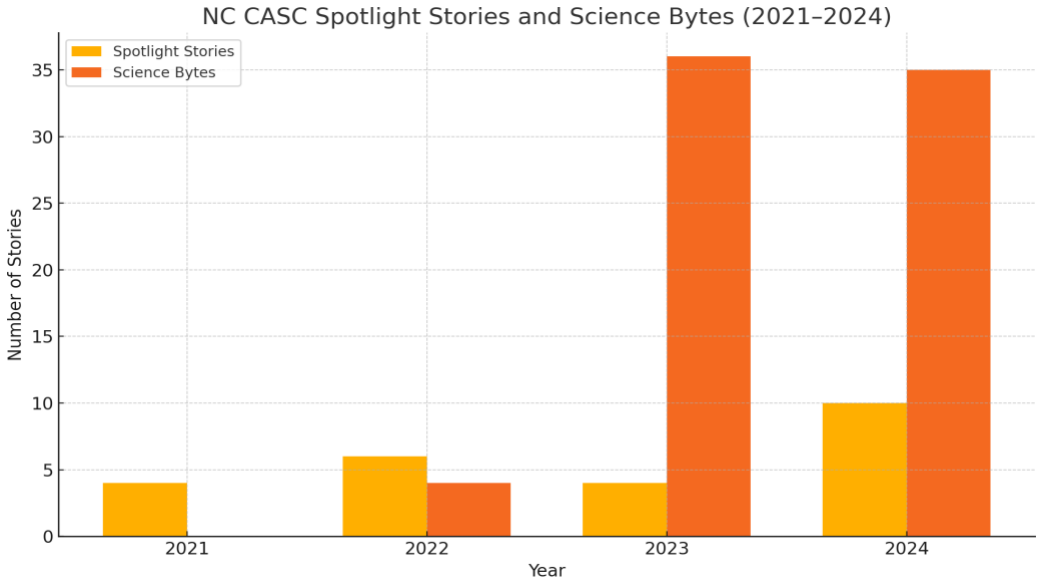

Figure 4. Number of Spotlight Stories and Science Bytes written from 2021 - 2024.

- ***NC CASC Newsletter:*** The newsletter is issued on a bi-monthly basis and distributed via MailChimp. It was converted from a PDF format to an interactive MailChimp email newsletter starting with the July/August 2022 issue. The MailChimp email newsletter effectively drives traffic to the center's website and enables the tracking of metrics on what types of content readers interact with. ***Figure 5*** shows the distribution of average clicks, with the majority directed to the NC CASC webpage and *Spotlight Stories*.

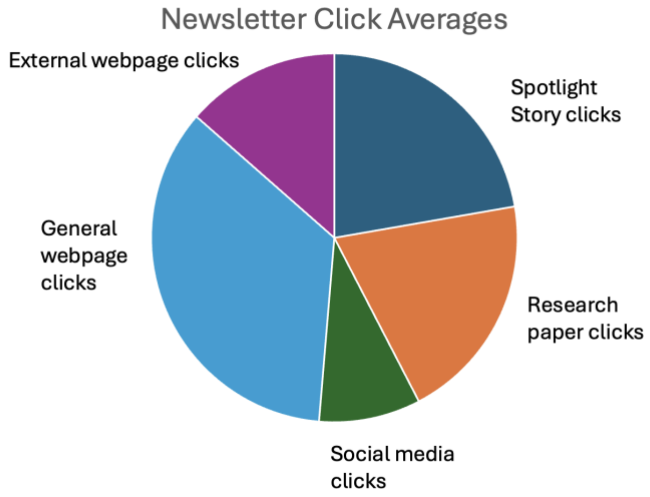

Figure 5. Average clicks within the MailChimp email newsletter since launching this communications tool in Summer 2022. The majority of clicks direct readers to the NC CASC's landing page, featured Spotlight Stories on the website, and highlighted research papers.

- ***Social Media/Subscribers*****:** Since 2022, the NC CASC's social media presence and subscriber engagement have shown meaningful growth, reflecting the expanding reach and impact of the center's communications efforts. Social media efforts focused on **Twitter** (current: 1082 followers; 1,145 followers in 2023, up from 965 in 2022), demonstrate a sustained interest in real-time updates and climate-related content. Some growth also occurred for **Facebook** (current: 388 followers; 329 followers in 2023, up from 322 followers in 2022 and 281 in 2021), showcasing a consistent increase in community engagement over time. The **NC CASC Mailchimp** subscriber list has remained strong, with 1,321 current contacts—holding steady from 1,330 in 2023 and reflecting significant growth from 1,185 in 2022. This stability suggests continued interest in NC CASC news and events among key stakeholders and audiences.

- ***NC CASC YouTube Channel:*** The center's YouTube channel (https://www.youtube.com/@NorthCentralCASC) stands out as a particularly impactful platform for expanding public engagement. Since 2022, the channel has experienced substantial growth in both subscribers and content. Subscribers have risen from 141 in 2022 to 181 in 2023 and now total 235 in 2025—an increase of over 66% since 2022. The volume of video content has also expanded dramatically, growing from 75 videos posted between 2018 and 2022 to a total of 192 videos currently available. Most notably, total views have jumped from 18,000 during the 2018–2022 timeframe to 24,845 as of 2025, demonstrating the center's increasing visibility and influence. These numbers reinforce the effectiveness of the center's digital outreach and content strategy.

- ***NC CASC Webinar Series:*** The NC CASC Webinar Series has been held monthly from July 2020 through the present. The webinars highlight ongoing research from the NC CASC network, as well as feature topics of critical importance to natural resource managers and other stakeholders in the

region. Since July 2020, the center has hosted 33 webinars, with 5,418 total views. There was a marked increase in views when the NC CASC added follow-up webinar emails (with direct links to the YouTube webinar videos) in late 2022.

- ***NC CASC Help Tickets:*** The NC CASC help ticket system (Spiceworks) is utilized by the communications team to process communication requests internally and collect content for the submission of *Weekly Highlights* to the National CASC. For the period October 1, 2022 to present (May 2025), Robe and Peña processed over 100 individual help ticket requests, with the majority of tickets requiring multiple responses.

5. OUTREACH

In Cycle 1, the NC CASC Consortium produced numerous outreach products and engaged with partners and practitioners in the North Central region. ***Table 5*** summarizes the Cycle 1 outreach products and activities by category; see **APPENDIX II** for a detailed list of these products and activities for Year 6. For a detailed list of outreach products in prior years of the Host Agreement, refer to Year 1-5 Annual Reports located on the NC CASC website (https://nccasc.colorado.edu/).

Table 5: Summary of NC CASC Consortium outreach products and activities by category for Cycle 1 (October 1, 2018 to January 30, 2025).

Outreach Product/Activity	Funded by the Host Agreement	Leveraged the Expertise of NC CASC Consortium Personnel
Peer Reviewed Journal Articles and Technical Reports	47	53
Conference Presentations, Seminars, Webinars, and Public Presentations	123	16
Major Engagements with Regional Decision-Makers, Stakeholders, and Resource Managers	65	11
Other Products: Webpages, Videos, Factsheets and Research Briefs	30	4
Data Releases	4	0
New Climate Tools and Applications	6	3
Media Mentions	12	5

6. SUMMARY

During Cycle 1, the NC CASC Consortium successfully developed and delivered actionable science relevant to the NC CASC's mission *to deliver science to help fish, wildlife, water, land, and people adapt to a changing climate*. The Host Team leveraged the efficient administrative, fiscal and compliance systems of CIRES and CU Boulder to effectively and responsibly manage the spending of the host agreement funds, subawards to Consortium Partner institutions, and USGS funded Pass-Through and direct-funded projects. The Host Team and its five Consortium Partners had the requisite skills to remain nimble and responsive in carrying out the proposed work, and *"applied creative solutions for the challenging problems it faced during the award period,"* North Central Climate Adaptation Science Center External Review Final Report [April 2023, North Central Climate Adaptation Science Center External Review Team Final Report].

7. BUDGET

Budget Section Removed from this Version of the Final Report

APPENDIX I: Funded University of Colorado (CU) Personnel (Table A) and Leveraged Contributions from Personnel Funded Outside of the Host Agreement (Table B) for Year 6

APPENDIX I Table A: *Total months of effort of University of Colorado Boulder (CU) personnel funded on the Host Agreement during the Budget Year 5 No Cost Extension (10/1/2023 to 9/30/2024), Budget Year 6 (10/1/2023 to 9/30/2024) and Budget Year 6 No Cost Extension (10/1/2024 to 1/30/2025) periods; CIRES=Cooperative Institute for Research in Environmental Sciences; CP=Consortium Partner; NCASC CAP Fellows Program=National Climate Adaptation Science Center Climate Adaptation Postdoctoral Fellows Program; RCAP=Rapid Climate Assessment Program; and NCE=No Cost Extension.*

Person	Role	Responsibility	Total Months of Effort on Host Agreement for BY5 NCE (10/1/2023 to 9/30/2024), BY6 (10/1/2023 to 9/30/2024), and BY6 NCE (10/1/2024 to 1/30/2025) funds
William Travis	University Director/ NC CASC CU Leadership Team	Oversaw all elements of the host cooperative agreement.	***Content Removed from this Version of the Final Report***
Jane Wolken	University Deputy Director/ NC CASC CU Leadership Team	Oversaw the day-to-day university operations of the NC CASC, coordinated with CIRES Finance to manage the host funding, CP subaward activities and Pass-Through Projects, engaged in cross-CASC activities (e.g., network calls/meetings, working groups and National CASC CAP Fellows Program support), supervised the communications team, and mentored postdoctoral research fellows.	
Imtiaz Rangwala	Climate Science Lead/ NC CASC CU Leadership Team	Provided primary climate expertise to the NC CASC-directed projects, worked with boundary organizations to facilitate effective integration of climate research into natural resource management and planning, conducted research on ecological drought and transformation, co-hosted the NC CASC Webinar Series, and mentored postdoctoral research fellows and graduate students.	
Heather Yocum	Social Science Lead/ NC CASC CU Leadership Team	Provided social science expertise to NC CASC projects, facilitated co-production and creation of useable science, led the RCAP, co-hosted the NC CASC Webinar Series, led NC CASC undergraduate and graduate student research programs, served as the PI for the *Grasslands Synthesis Project*, and mentored postdoctoral research fellows and graduate students.	

Christy Miller Hesed	Regional Climate Adaptation Scientist	Provided social science expertise to NC CASC projects, supported the RCAP by supervising graduate students, served as the Research Coordinator for the Grasslands Synthesis Project, and supported development of the NC CASC outputs and products.	***Content Removed from this Version of the Final Report***
Ulyana Horodyskyj Peña	Communications Lead	Translated the science, education and outreach activities of the NC CASC into engaging communication products for a variety of audiences and outlets, updated the NC CASC communication and outreach plan, and supported the science communication activities of the CASC-network.	
Hailey Robe	Program Assistant	Assisted the Host Team with daily operational activities, coordinated with the Communications Lead to keep the website and social media platforms up-to-date, compiled the *Weekly Highlights*, created communication products, supported event planning activities for the center, and performed a literature review for a RCAP 2024 project.	
James Rattling Leaf, Sr.	Tribal Engagement Specialist	Performed outreach and engagement activities to build/strengthen partnerships with Tribal organizations and colleges in the North Central region.	
Luca Polasti	Graduate Research Assistant	Reviewed the literature on the creation and usefulness of climate scenarios, and built an online library.	
Prasad Thota	Graduate Research Assistant	Developed climate datasets, workflows and tools.	
Katie Bardsley	Graduate Research Assistant	Conducted a literature review in support of the RCAP.	
Lauren Lee Barrett	Graduate Research Assistant	Conducted a literature review in support of the RCAP.	
Andrew Veselka	Graduate Research Assistant	Conducted a literature review in support of the RCAP.	
Anna LoPresti	Graduate Research Assistant	Conducted a literature review in support of the RCAP.	
Shelby Ross	Graduate Research Assistant	Conducted a literature review in support of the RCAP.	
Kyle Schutz	Graduate Research Assistant	Conducted a literature review in support of the RCAP.	
Kylee Shrank	Undergraduate Student	Recorded notes during the Year 6 Annual Consortium and Partners Meeting.	

APPENDIX I Table B: *Leveraged contributions from personnel funded outside of the Host Agreement.*

Person	Institution	Role	Responsibility
Kyra Clark-Wolf	CU Boulder	Postdoctoral Research Fellow funded by a USGS Pass-Through Project	Provided expertise on ecological impacts and transformation under climate change, and assisted with collaborative research, science synthesis, and communication and outreach activities to support scenario planning, adaptation, conservation and resource management in the NC CASC region.
Katherine Hegewisch	University of California Merced	Project Scientist and Web Developer	Co-developed new tools and improved existing tools on ClimateToolbox.Org.

APPENDIX II: NC CASC Consortium Outreach Products and Activities

In Year 6, the NC CASC Consortium developed/engaged in a variety of outreach products/activities. Note that NC CASC CU and USGS researchers, Consortium Partners, and graduate research assistants appear in **bold** text; ***** indicates a product was not funded by the NC CASC, but leverages the expertise of NC CASC personnel:

Published peer reviewed journal articles and technical reports:

- Ahler, S., **Clark-Wolf, K.**, Dixon, C., **Rangwala, I.**, and **Miller Hesed, C.D.** (2025). Climate change impacts on introduced grass invasion in the Prairie Pothole Region of the United States Great Plains. *The Prairie Naturalist,* Special Issue 2:102-113, https://www.eaglehill.us/prna-pdfs-special/spec02/007-Dixon.pdf.
- ***Clark-Wolf, K.D.**, **Higuera, P.E.**, McLauchlan, K.K., Shuman, B.N., and Parish, M.C. (2023). Fire-regime variability and ecosystem resilience over four millennia in a Rocky Mountain subalpine watershed. *Journal of Ecology,* 111: 2549-2780, doi.org/10.1111/1365-2745.14201.
- **Crausbay, S.**, Hall, K., **Cross, M.**, Halabisky, M., **Rangwala I.**, Anderson, J., and Schwend, A. (2024). A flexible data-driven approach to co-producing drought vulnerability assessments. *Ecosphere*, http://dx.doi.org/10.1002/ecs2.70040.
- *Davis, K.T., **Peeler, J.L.,** Fargione, J.E., Haugo, R.D., Metlen, K.L., Robles, M.D., and Woolley, T. (2024). Tamm Review: A meta-analysis of thinning, prescribed fire, and wildfire effects on subsequent wildfire severity. *Forest Ecology and Management*, 561: 121885.
- Duan, Y., Kumar, S., Maruf, M., Kavoo, T.M., **Rangwala, I.**, Richter, J.H., Glanville, A.A., King, T., Esit, M., Raczka, B. and Raeder, K. (2025). Enhancing sub-seasonal soil moisture forecasts through land initialization. *npj Climate and Atmospheric Science*, https://doi.org/10.1038/s41612-025-00987-0
- Hefty, K., Fox Rushing, J., Ben-Horin, D., Spencer, A., Grant-Hoffman, M., Weeks, D., **Clark-Wolf, K.**, **Rangwala, I.**, Parks, S., Klasner, F. and Hollingsworth, T. (2025). RAD Decisions in Rad Landscapes: Black Ridge Canyons Wilderness. Aldo Leopold Wilderness Research Institute, Rocky Mountain Research Station, USDA Forest Service.
- *Kreider, M.R., **Higuera, P.E.**, Parks, S.A., Rice, W.L., White, N., and Larson, A.J. (2024). Fire suppression makes wildfires more severe and accentuates impacts of climate change and fuel accumulation. *Nature Communications*, 15: 2412, https://www.nature.com/articles/s41467-024-46702-0.
- *Kuster, E., and **Miller Hesed, C.D**. (2024). Designing and delivering climate training for natural resource managers: Increasing climate literacy and action through education and engagement. *Conservation Science and Practice* 6(10): e13226, https://doi.org/10.1111/csp2.13226.
- *Lacey, L.M., Suraci, J.P., **Littlefield, C.E.**, Busse, B.S., and Dickson, B.G. (2024). Informing proactive wildfire management that benefits vulnerable communities and ecological values. *People and Nature*, 7(1):52-66, https://besjournals.onlinelibrary.wiley.com/doi/10.1002/pan3.10733.
- **Littlefield, C.E.**, Suraci, J.P., Kintsch, J., Callahan, R., Cramer, P., Cross, M.S., Dickson, B.G., Duncan, L.A., Fisher, J.R.B., Freeman, P.T., Seidler, R., Wearn, A., Andrews, K.M., Brocki, M., Dodd, N., Gagnon, J., Johnson, A., Krosby, M., Skroch, M., and Sutherland, R. (2024). Evaluating and elevating the role of wildlife road crossings in climate adaptation. *Frontiers in Ecology and the Environment*, 23(1):e2816, https://esajournals.onlinelibrary.wiley.com/doi/10.1002/fee.2816.
- **Miller Hesed, C.D.**, **Yocum, H.M.**, **Cross, M.**, **Bamzai-Dodson, A.**, Wheeler, B., Beckmann, J.P., Ahlering, M., Hall, K.R., Boyd-Valandra, E., **Mosher, D.**, **Miller, B.W.**, and Jaffe, S. (2023). Seventy questions of importance to the conservation of the North Central Grasslands of the United States in a changing climate. *Conservation Science and Practice*, e12998, https://doi.org/10.1111/csp2.12998.

- *Mozelewski, T.G., Freeman P.T., Kumar, A.V., Naugle, D.E., Olimpi, E.M., Morford, S.L., Jeffries, M.I., Pilliod, D.S., **Littlefield, C.E.**, McCord, S.E., Wichman, L.A., Kachergis, E.J., and Doherty, K.E. (2024). Closing the conservation gap: spatial targeting and exception coordination are needed to stop ecosystem losses. *Rangeland Ecology & Management*, 97:12-24, https://www.sciencedirect.com/science/article/pii/S1550742424001301.
- ***Oldfather, M.F., Ennis, A., Miller, B.W., Clark-Wolf, K.**, **Rangwala, I.**, **Robe, H.**, and **Littlefield, C.** (2025). Climate change impacts and adaptation in U.S. Rocky Mountain high-elevation ecosystems. *Arctic, Antarctic, and Alpine Research*, 57:2450089, https://doi.org/10.1080/15230430.2025.2450089.
- *Olimpi, E., Mozelewski, T., Gage, J., Kumar, A.V., **Littlefield, C.E.**, and Doherty, K. (2024). An interactive tool to promote stepping down the Sagebrush Conservation Design to local conservation planning. *Rangeland Ecology & Management*, 97:107-114, https://www.sciencedirect.com/science/article/pii/S1550742424001325.
- *Pourmohamad, Y., Abatzoglou, J.T., Belval, E.J., Fleishman, E., Short, K., Reeves, M.C., Nauslar, N., **Higuera, P.E.**, Henderson, E., Ball, S., AghaKouchak, A., Prestemon, J.P., Olszewski, J., and Sadegh, M. (2024). Physical, social, and biological attributes for improved understanding and prediction of wildfires: FPA FOD-Attributes dataset. *Earth System Science Data*, 16(6): 3045-3060, https://doi.org/10.5194/essd-16-3045-2024.
- Russell, A., Fontana, N., Hoecker, T., Kamanu, A., Majumder, R., **Stephens, J.**, Young. A.M., Cravens A.E., Giardina, C., Hiers, K., Littell, J., and Terando, A. (2024). A fire-use decision model to improve the United States' wildfire management and support climate change adaptation. *Cell Reports Sustainability*, 1(6): 100125, https://www.sciencedirect.com/science/article/pii/S2949790624002003.
- *Sudol, T.A., **Miller Hesed, C.D.**, Clark, J.M., and Moser, F.C. (2023). Resisting-accepting-directing sea level rise on the Chesapeake Bay: Agricultural producers' motivations and actions. *Journal of Environmental Management,* 332, https://doi.org/10.1016/j.jenvman.2023.117355.
- *Vieira, S.T., Davis, K.T., Holden, Z., Larson, A.J., and **Higuera, P.E.** (2024). Western larch regeneration more sensitive to wildfire-related factors than seasonal climate variability. *Forest Ecology and Management*, 565: 122001, https://doi.org/10.1016/j.foreco.2024.122011.

Pre-published research:

- Lynch, A.J., Ashander, J.D., **Ciocco, T.W.**, Cravens, A.E., Dassow, C.J., Dee, L.E., Dunham, J.B., Eaton, M.J., Embke, H.S., Hennessy, J.M., Latzka, A.W., Lawrence, D.J., Littell, J.S., **Miller, B.W.,** Palasti, L.A., Runge, M.C., Sass, G.G., Shultz, A.D., Siegel, K.J., Svancara, L.K., Thompson, L.M., Thurman, L.L., Valler, J.B., Weiskopf, S.R., and **Yocum, H.M.** (*In Press*). RAD (Resist-Accept-Direct) switch points and triggers for adaptation planning. *Journal of Environmental Management.*
- **Clark-Wolf, K.**, Moss, W.E., Miller, M.W., **Rangwala, I.**, Sofaer, H.R., Schuurman, G., Magness, D., Symstad, A., Coop, J.D., Bachelet, D.B., Barsugli, J.J., **Ciocco, T.,** Crausbay, S.D., Hoecker, T., Lewinsohn, J.S., **Oldfather, M.F.**, Richmond, O.M.W., Rondeau, R., Runyon, A., Russell, R.E., and Wilkening, J.L. (*In Press*). Ecological scenarios: embracing ecological uncertainty in an era of global change. *Ecosphere*.
- **Hulugh, V.**, **Cheek, J.Z.**, and Redmore, L. (*In Prep*). Assessing Conservation Planning in South Dakota: Challenges in Collaboration, Public Participation, and Climate Information. *Parks Stewardship Forum.*
- Michalak, J.L., **Littlefield, C.E.**, Gross, J.E., Lawler, J.J., and Mozelewski, T.G. (*In Prep*). Most U.S. National Parks face potential transformational changes under global warming.
- ***Oldfather, M.**, Runyon, A., **Clark-Wolf, K.**, Moss, W.**, Rangwala, I., Ciocco, A., Bamzai-Dodson, A.**, Sofaer, H., and **Miller, B.** (*In Press*). Drought and deluge – Opportunities for climate change adaptation in U.S. National Parks. *Frontiers in Ecology and the Environment*.

Data releases:

- **Thota, S.S.S.P**., Hegewisch, K., and **Rangwala, I.** (2025). Standardized Precipitation Evapotranspiration Index (SPEI) projections for the Contiguous United States based on the CMIP5 MACAv2-METDATA downscaled climate dataset: *US Geological Survey Data Release Sciencebase*, https://doi.org/10.5066/P1SV9SPJ.
- Szcodronski, K.E., Burton, S.E., Wade, A.A., **Rangwala, I.**, **Thota, P.**, and Hossack, B.R. (2024). Riparian climate refugia data in western and central USA for 2040-2069 and 2070-2099: *U.S. Geological Survey data release*, https://doi.org/10.5066/P96WZLMS.

New climate tools and applications released:

- **IVT World App**: This application performs a systematic space-time analysis of Integrated Vapor Transport (IVT) over the entire world for the user-selected period and season. The application allows the user to examine the different and complex patterns of moisture transport globally, and navigate through various tabs to explore composites, trends, and examine anomalies and climatologies of IVT. With the capability to customize parameters such as the selected season, period of the record, and significance levels. This app allows users to gain valuable insights into the trends and dynamics of climatic phenomena, https://nccasc.shinyapps.io/IVT_World_App/.
- ***Experimental Winter Precipitation Forecast**: The Experimental Winter Precipitation Forecast provides a forecast of winter precipitation (December-March) for the western United States and is determined using both Pacific and Atlantic Ocean temperatures. Forecasts are available November - February and use the most recent 2-3 months of observed Pacific Ocean temperatures (El Niño Southern Oscillation or ENSO temperature index) and observed Atlantic Ocean temperatures (Atlantic Quadpole Mode or AQM temperature index). The '*Documentation*' tab at the top right of the page provides more detailed information on the climate and atmospheric science used to develop the forecast. Use the '*Validation*' tab to see how well the Experimental Winter Precipitation Forecast performs using historical winter precipitation (1892-2024). The Experimental Winter Precipitation Forecast Tool and the underlying research was developed by scientists at the University of Utah in close collaboration with Salt Lake City Department of Public Utilities and Western Water Assessment, part of the Cooperative Institute for Research in Environmental Sciences at the University of Colorado Boulder, https://nccasc.shinyapps.io/Winter-Precipitation-Forecast-Tool/.
- ***Improvements to Future Time Series Tool on Climate Toolbox:** Addition of individual model projections; addition of the SPEI dataset; https://climatetoolbox.org/tool/Future-Time-Series.
- ***Development of Climate Scenario Workflow:** Documentation to guide the use of different tools on Climate Toolbox to inform climate scenarios development; https://climatetoolbox.org/climate-scenario-workflow.

Project-related conference presentations, seminars, webinars, workshops, and public presentations:

- BlackDeer, A.A., Brooker, C.J., Shakespeare, M., Catanzaro, M., Butler, K., McGrath, S., Thumbadoo, R.V., Goparaki, L.N., Ramage, S., Cruz, K., Letaapo, T., **Rattling Leaf, J.**, and Alunowska Figueroa, M. (October 27, 2023): Amplifying Indigenous perspectives and knowledge systems. *GEO Indigenous Water Summit*, Virtual presentation.
- Bridge, G. and **Rattling Leaf, J.** (October 11, 2023): Indigenous approaches to advance climate and biodiversity solutions: The role for Traditional Ecological Knowledge. *Colorado State University, Salazar Center Symposium on Conservation*, Denver, CO.
- **Cheek, J.Z.**, and **Hulugh, V.** (January 30, 2024): Assessing Conservation Planning in South Dakota: Opportunities for Improvement. Oral presentation by Vivian Hulugh at the *84th Midwest Fish & Wildlife Conference*, Sioux Falls, SD.

- **Cheek, J.Z.**, and **Hulugh, V.** (October 17-19, 2023): Improving Conservation Planning in South Dakota With Climate Science, Collaboration, and Public Participation. Oral presentation at the *South Dakota Parks and Recreation Association Annual Conference*, Huron, SD.
- ***Cheek, J.Z.**, and **Hulugh, V.** (October 28-30, 2023): Improving Conservation Planning in South Dakota With Climate Science, Collaboration, and Public Participation. Poster presentation by Vivian Hulugh at the *Graduate Climate Conference* organized by the Massachusetts Institute of Technology and the Woods Hole Oceanographic Institution, Boston, MA.
- ***Cheek, J.Z.**, and **Hulugh, V.** (November 9-10, 2023): Improving Conservation Planning in South Dakota Using Collaboration, Climate Science, and Public Participation. Oral presentation by Vivian Hulugh at *The Policy Sciences Annual Institute* at The World Bank, Washington D.C.
- Christianson, A.C., Lake, F.K., Martinez, D., **Peeler, J.L.**, Wynecoop, M., Christopherson, C., Copes-Gerbitz, K., Essen, M., Hoagland, S., Middleton Manning, B.R., and Riley, K. (2023): An Indian seldom does anything except by necessity": Acknowledging a history of Indigenous erasure and racism in fire ecology and looking toward a more inclusive future. *International Fire Ecology and Management Congress*, Monterey, CA.
- **Clark-Wolf, K.**, Moss, W., **Rangwala, I.**, **Miller, B.**, and Sofaer, H.R. (June 26, 2024): The challenge of uncertainty in climate adaptation and the need for scenario-based approaches. Special session talk. *North American Congress for Conservation Biology*, Vancouver, BC, Canada.
- ***Clark-Wolf, K.** (May 28, 2024): Science for climate adaptation: exploring ecological pasts, exploring ecological futures. *Environmental Data Science Seminar*, Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, Boulder, CO.
- ***Clark-Wolf, K.** (March 20, 2024): Science for climate adaptation: exploring ecological pasts, exploring ecological futures. *Wildland Resources Department Seminar*, Utah State University, Logan, UT.
- **Higuera, P.E.**, Cook M.W., Balch, J.K., Stavros, E.N., Mahood, A., and St Denis, L.A. (December 6, 2023): Shifting social-ecological fire regimes explain rapidly increasing home and structure loss from Western wildfires. *10th International Fire Ecology and Management Congress*, Monterey, CA.
- **Higuera, P.E.** (October 2024): Adaptation strategies to promote public health while living with more fire. *Rocky Mountain Wildfire Smoke Symposium*, Missoula, MT.
- ***Higuera, P.E.** (June 13, 2024): The Social-Ecological Consequences of Future Wildfire in the West (@ 1:25). Invited panel presenter for the *National Academies of Sciences Workshop*, https://www.nationalacademies.org/event/42562_06-2024_the-social-ecological-consequences-of-future-wildfire-in-the-west-a-workshop#:~:text=This%20workshop%20is%20about%20understanding,work%20together%20to%20fill%20those.
- *Kuster, E., Elliott-Smith, E., Finn, S., and **Miller Hesed, C.D.** (November 1-3, 2023): Ecosystem-focused trainings for wildlife managers. Presented by Emma Kuster at the *South Central CASC Fall Science Meeting 2023*, Lubbock, TX.
- **Miller Hesed, C.D.**, **Yocum, H.**, and Gonzalez Coffin, S. (June 6, 2024): Synthesizing Great Plains science. *The Nature Conservancy Inner Mongolia Learning Exchange*, Virtual presentation.
- **Miller Hesed, C.D.**, and **Yocum, H**. (December 12, 2023): Grasslands Synthesis Project: Key findings and remaining questions. *US Fish and Wildlife Service Grasslands Ecosystem Team Bi-Weekly Meeting*, Virtual presentation.
- **Miller Hesed, C.D.** (September 7, 2023): Patch-burn grazing: Addressing broadly shared grassland management goals and questions. *Patch Burn Grazing Working Group Meeting*, Auburn Community Center, Auburn, KS.

- Kuster, E., Elliott-Smith, E., Finn, S., **Miller Hesed, C.D.**, and McPherson, R. (April 1-5, 2024): Fostering climate-informed decisions through ecosystem-based training, *International Association for Landscape Ecology – North America Annual Meeting*, Oklahoma City, OK.
- **Miller Hesed, C.D.** (January 29, 2024): Questions of importance to the conservation of North Central Grasslands of the United States in a changing climate. *Society for Range Management Annual Conference: Change on the Range*, Sparks, NV.
- Gonzalez Coffin, S. and **Miller Hesed, C.D**. (September 29-October 1, 2023): Synthesizing Great Plains Social Science: Interdisciplinary Solutions and Responses to Climate Change for Grassland Managers in North Central USA. *Initiative on Climate Adaptation Research and Understanding through the Social Sciences (ICARUS) VI Workshop*, Ann Arbor, MI.
- ***Miller Hesed, C.D.** and Van Dolah, E.R., *Panel Co-Chairs* (March 30, 2023): Is conservation "For the Birds?": Challenges and opportunities for incorporating human dimensions into natural resource management and conservation for more equitable and just outcomes, Part II. *Society for Applied Anthropology 83rd Annual Meeting: Applied Anthropology at a Crossroad*, Hilton Cincinnati Netherland Plaza Hotel, Cincinnati, OH.
- **Miller Hesed, C.D.** (November 19, 2024): Weaving the Knowledge into Cloth: Science Synthesis at the North Central Climate Adaptation Science Center. *CASC Futures Forum*, San Diego, CA.
- **Miller Hesed, C.D.** (November 19, 2024): Solving the Puzzles Together: Coproduction at the North Central Climate Adaptation Science Center. *CASC Futures Forum*, San Diego, CA.
- **Peeler, J.L.**, McCauley, L., Metlen, K.L., Woolley, T., Davis, K.T., Robles, M.D., Haugo, R.D., Riley, K.L., **Higuera, P.E.**, Fargione, J.E., Addington, R.N., Bassett, S., Blankenship, K., Case, M.J., Chapman, T.B., Smith, E., Swaty, R., and Welch, N. (December 6, 2023): Identifying opportunity hot spots for reducing the risk of wildfire-caused carbon loss in western US conifer forests. *10th International Fire Ecology and Management Congress*, Monterey, CA.
- **Peeler, J.L.** (February 2024): Reducing the risk of wildfire-caused carbon loss at multiple scales. *Missoula Fire Lab Seminar Series*, Missoula, MT.
- **Peeler, J.L.** (February 2024): Reducing the risk of wildfire-caused carbon loss at multiple scales. *Rocky Mountain Research Station Human Dimensions Wildfire Risk Management Science Seminar*, Missoula, MT.
- **Peeler, J.L.** (August 2024): Reducing the risk of wildfire-caused carbon loss at multiple scales. *Ecological Society of America*, Long Beach, CA.
- **Peeler, J.L.** and O'Connor, C.D. (November 2024): Using strategic pre-fire planning to avoid wildfire-caused loss of irrecoverable carbon. *Southwest Fire Ecology Conference*. Santa Fe, NM.
- **Peeler, J.L.** (October 2024): Identifying opportunity hot spots for prescribed burning. *Rocky Mountain Wildfire Smoke Symposium*, Missoula, MT.
- ***Peña, U.H., Robe, H., Wolken, J.** and **Travis, W.** (May 16, 2024): NC CASC and the art of science storytelling. *CIRES Rendezvous 2024*, Boulder, CO.
- **Peña, U.H., Robe, H., Wolken, J., Travis, W., Rangwala, I., Hesed, C.M.** and **Yocum, H.** (May 16, 2024): The NC CASC: Generating the science to help resource managers adapt to a changing world. *CIRES Rendezvous 2024*, Boulder, CO.
- **Rangwala, I.** (February 2, 2025): Droughts and Deluge: Climate Change and the Shifting Water Cycle. *Colorado Jewish Climate Summit 2025*, https://www.coloradojewishclimateaction.org/speakers-2025.
- **Rangwala, I.** (June 22, 2024): Presentation to The Nature Conservancy's Learning Exchange: Inner Mongolia - North Central Climate Adaptation Science Center.
- **Rangwala, I.** (September 19, 2024): Climate Tools & Methods for Climate Adaptation. *Great Plains Tribal Water Alliance 2024 Fall Meeting*, Flandreau, SD.

- **Rangwala, I.** (November 19, 2024): Climate Tools & Methods for Climate Adaptation. *CASC Futures Forum*, San Diego, CA.
- **Rattling Leaf, J.**, and Waasegiizhig Price, M. (October 9, 2023): Leading with Indigenous cultural intelligence to advance equity in a changing climate. *Michigan Technological University*, Houghton, MI.
- **Rattling Leaf, J.**, Fakhruddin, B.S., Lilja Bye, B., Fisher, J.B., Barca, B., Goldman, E., and Khan, Z. (October 26, 2023): GEO Indigenous Alliance. *GEO Indigenous Water Summit*, Virtual presentation.
- **Rattling Leaf, J.** (November 2, 2023): Rosebud Sioux Tribe Climate Center update. *National Tribal Resilience Action Database*, Virtual presentation.
- **Rattling Leaf, J.** (November 6, 2023): DOI TEK Handbook 301 DM7. *USGS Biodiversity and Assessment Working Group*. Virtual presentation on DOI Handbook 301 DM7.
- **Rattling Leaf, J.** (November 16, 2023): Tribal engagement and TEK. *DOI Indigenous Knowledge Training Workshop*, Shepherdstown, WV.
- **Rattling Leaf, J.** (December 6, 2023): Utilizing Indigenous Leadership to Advance Equity in a Changing Climate. *Great Plains Tribal Water Alliance Meeting*, Rapid City, SD.
- **Rattling Leaf, J.** (January 19, 2024): NCA5 Public Engagement Webinar: Tribes and Indigenous Peoples. *U.S. Global Change Research Program*, Virtual presentation.
- **Rattling Leaf, J.** (April 5, 2024): Traditional Ecological Knowledge. *National Nature Assessment Technical Advisor*, Virtual presentation.
- **Rattling Leaf, J.** (August 27, 2024): Data Sovereignty and Just Compensation for ITEK. *WILD 12 Wilderness Conservation Congress*, Rapid City, SD.
- *Van Dolah, E.R. and **Miller Hesed, C.D.,** *Panel Co-Chairs* (March 30, 2023): Is Conservation "For the Birds?": Challenges and Opportunities for Incorporating Human Dimensions into Natural Resource Management and Conservation for More Equitable and Just Outcomes, Part I. *Society for Applied Anthropology 83rd Annual Meeting: Applied Anthropology at a Crossroad*, Hilton Cincinnati Netherland Plaza Hotel, Cincinnati, OH.
- *****Van Dolah, E.R. and **Miller Hesed, C.D.**, *Panel Co-Chairs* (March 29, 2024): Is conservation "For the Birds?": More lessons learned and pathways for integrating the social sciences into equitable conservation and natural resource management, at the *Society for Applied Anthropology 84th Annual Meeting: Enchantment and Transformation*, Santa Fe, NM.
- **Thota, S.S.S.P.**, Rajagopalan, B. and **Rangwala, I.** (December 11, 2024): Drivers and Predictability of the Warm-Season Precipitation in the Northern Great Plains. *American Geophysical Union Fall Meeting*, Washington, D.C.
- **Wolken, J.M.** (November 20, 2024): NC CASC Early Career Opportunities: Rapid Climate Assessment Program. *CASC Futures Forum*, San Diego, CA.
- **Yocum, H.**, **Rangwala, I.**, **Clark-Wolf, K.**, **Miller Hesed, C.D.**, **Horodyskyj Peña, U.**, **Robe, H.**, **Wolken, J.**, and **Travis, W**. (May 16, 2024): North Central Climate Adaptation Science Center's Rapid Climate Assessment Program (RCAP). *CIRES Rendezvous 2024*, Boulder, CO.
- **Yocum, H.M.** and **Miller Hesed, C.D**. (October 17, 2023): Grasslands Synthesis Project. *US Fish and Wildlife Service Grasslands Ecosystem Team Bi-Weekly Meeting*, Virtual presentation.

<u>Major engagements with regional decision-makers, stakeholders, and resource managers:</u>

- Elliot-Smith, E., Finn, S., Kuster, E., **Miller Hesed, C.D.**, and Carlson, J. (January 24-25, 2023): *Grasslands-Climate Workshop*, USFWS Region 6 Headquarters, Lakewood, CO. Approximately 40 U.S. Fish and Wildlife Service (FWS) staff and partners working on grassland conservation met in person in Lakewood, CO for the *Grasslands-Climate Workshop.* This workshop was collaboratively organized by the North Central CASC, Northwest CASC, South Central CASC, and the FWS to equip FWS with tools and practice in incorporating considerations of climate change into management

decisions. The workshop used a broad Learn-Do-Reflect approach and included information delivery, hands-on tool training, peer-to-peer networking, and a scenario-based exercise. **Imtiaz Rangwala** of the North Central CASC presented on the use of the Climate Toolbox. The workshop focused on Central North American Grasslands (Tallgrass, Northern Mixed Grass, Central Mixed Grass and Shortgrass Ecoregions and the Sagebrush-Grassland Ecotone) with some relevance to southern and montane grassland systems. This in-person workshop followed four recorded web-based training modules that can be viewed here.

- **Clark-Wolf, K.**, **Rangwala, I.**, **Miller Hesed, C.D.**, and Bradford, J. (August 20-21, 2024): *NC CASC Sagebrush and Climate Change Workshop*, University of Colorado Boulder, Boulder, CO. This workshop convened approximately 23 experts and partners from a range of agencies, institutions, and geographies to discuss research and synthesis needs in the eastern sagebrush biome (WT, CO, MT). Participants discussed current management challenges, existing resources, and uncertainties for understanding and responding to threats from climate change and other change drivers. The workshop facilitated the identification of specific research and capacity needs that will be the focus of an in-depth multi-year working group effort led by the NC CASC.
- **Hulugh, V.** (August 1-2, 2023): South Dakota State University graduate student Vivian Hulugh participated in the *South Dakota Climate Summit* organized by the South Dakota State University Extension at Oacoma, South Dakota. The event provided an opportunity for state and federal agencies, nonprofits, conservation groups, and citizens to gather, network, and provide feedback on weather and climate information, tools, and resources.
- **Littlefield, C.E.** and collaborators (2024): NC CASC Consortium Partner Caitlin Littlefield (Conservation Science Partners (CSP)) and collaborators leveraged the successful climate-informed wildlife crossing effort in southwestern Durango, Colorado into a new co-produced effort with the Nevada Department of Transportation (NDOT); additional support was provided by The Pew Charitable Trusts. This effort supported NDOT in refining wildlife highway crossing candidate locations to better address likely climate-driven movements. The CSP team is building upon these two prototypes – for southwestern Colorado and for Nevada – to develop a transferable model to support wildlife and transportation agencies across states to better account for climate impacts in their highway mitigation strategies.
- **Littlefield, C.E.** (2024): As part of the Northwest (NW) CASC- and NC CASC-funded project entitled "Informing decisions to resist, accept, or direct post-fire vegetation transitions," Littlefield and Dr. Kim Davis (U.S. Forest Service) met with resource managers at North Cascades and Mount Rainier National Park to tour recently burned areas and better understand the decision-space surrounding post-fire forest management. These partners are among 20 throughout the NC CASC and NW CASC regions that the broader project team has engaged to develop an interactive, web-based decision-support tool. The team has iteratively solicited feedback from stakeholders (e.g., on vegetation data aggregation, spatial resolution of products, summary statistics, etc.) and is planning to launch a beta version of the web application with in-person trainings anticipated in 2025.
- ***Miller Hesed, C.D.** (December 5, 2023): *Community Conversation on Flooding in Peabody*, Peabody-Burns Elementary School Cafeteria, Peabody, KS. Twenty-eight Peabody residents attended this event to learn about the work of the North Central Climate Adaptation Science Center, share their perspectives on local environmental change, learn about past and projected precipitation patterns, and discuss Peabody's vulnerability to flooding and identify possible adaptation strategies.
- ***Miller Hesed, C.D.**, Cibils, A., and Goodman, L. (February 8, 2024): *Using Climate Data to Achieve Your Natural Resource Objectives*, Kansas Natural Resources Conference, Hilton Garden Inn, Manhattan, KS. This event convened approximately 15 Kansas natural resource management professionals to provide an introduction and training on climate data tools and their application to resource management in Kansas. Miller Hesed facilitated the discussion and activities that identified

areas in which the North Central Climate Adaptation Science Center and U.S. Department of Agriculture Southern Plains Climate Hub could provide additional support to Kansas natural resource managers.

- **Peeler, J.L.** (May 2024): Facilitated *Actionable Science Workshop* with resource specialists and fire managers at Arapaho-Roosevelt National Forest.
- **Wolken, J.**, **Travis, W., Rangwala, I.**, **Yocum, H.**, **Miller Hesed, C.D.**, **Clark-Wolf, K.**, and **Robe, H**. (August 22-23, 2024): *NC CASC Consortium & Partners Climate Adaptation Science Workshop*, University of Colorado Boulder, Boulder, CO. This workshop convened approximately 46 experts, partners, and practitioners to update the status of and prospects for climate adaptation science and applications, with a focus on the North Central region, activities of the NC CASC, and work by consortium partners, cooperators, agencies, non-government organizations, and others. The workshop provided opportunities to assess accomplishments and constraints, inventory the NC CASC toolkit, network, and develop collaborations. Facilitated discussions looked ahead to emerging needs, options, and challenges for improving climate adaptation of natural and cultural resources in the region.
- **Rangwala, I., Clark-Wolf, K.,** and Richmond, O. (November 8-9, 2023): Field visit to Nebraska Sandhills National Wildlife Refuges. This team visited three National Wildlife Refuges to inform ongoing work developing future ecological scenarios for the Sandhills ecoregion to support refuge planning. The visit involved tours of the refuges and informal conversations with refuge managers focused on building relationships, understanding management priorities and concerns, and discussing potential climate change impacts on the refuges.
- **Travis, W**. (Fall 2024): NC CASC University Director William Travis consulted with the State of Colorado on their Climate Preparedness Plan and Climate Roadmap.

Other products: Webpages, videos, fact sheets and research briefs:

- Dondrub, P. and **Robe, H.** (2023). Traditional Ecological Knowledge: Engaging with Indigenous peoples in braiding Traditional Ecological Knowledge and western science [Storymap: https://nccasc.colorado.edu/node/9702]. Research and synthesis by Dondrub, P.; storymap created by Robe, H.
- *__Miller Hesed, C.D.__ (2024). Peabody Community Conversation on Flooding: Final Workshop Report. North Central Climate Adaptation Science Center: Boulder, CO. 15pp, https://www.sciencebase.gov/catalog/item/673532b2d34e6fbce7b5d52d.
- ***Clark-Wolf, K.D.** and **Higuera P.E.** (2023). What 2,500 years of wildfire evidence and the extreme fire seasons of 1910 and 2020 tell us about the future of fire in the West. *The Conversation*, https://theconversation.com/what-2-500-years-of-wildfire-evidence-and-the-extreme-fire-seasons-of-1910-and-2020-tell-us-about-the-future-of-fire-in-the-west-215221.
- ***Clark-Wolf, K.D.** (2023). Variability is the name of the game: diverse effects of fire in a N. American subalpine forest over 4000 years. *Journal of Ecology Blog*, https://jecologyblog.com/2023/10/17/variability-is-the-name-of-the-game-diverse-effects-of-fire-in-a-n-american-subalpine-forest-over-4000-yrs/.
- **Clark-Wolf, K.**, **Miller Hesed, C.D.**, Bradford, J., **Barrett, L., Bardsley, K.,** and **Rangwala, I.** (2024). Sagebrush & Climate Change: NC CASC Workshop August 20 - 21, 2024. North Central Climate Adaptation Science Center, Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, Boulder, CO. 9pp, https://nccasc.colorado.edu/sites/default/files/2024-11/Sagebrush%20Workshop%20Report.pdf.
- **Clark-Wolf, K.**, Ahler, S., **Rangwala, I.**, Dixon, C., and **Miller Hesed, C.D.** (2023). Rapid Climate Assessment–Climate Change Impacts on Introduced Cool-Season (C3) Grasses in the Prairie Pothole Region, USA. North Central Climate Adaptation Science Center, University of Colorado Boulder,

Boulder, CO. 4pp, https://nccasc.colorado.edu/sites/default/files/2023-11/PrairiePotholes_RCAP4-pager.pdf.

- **Miller Hesed, C.D.**, **Yocum, H.**, Symstad, A., Nippert, J., **Rangwala, I.**, and **Peña, U.** (2023). *Prairie Climate Companion: Woody Encroachment*. North Central Climate Adaptation Science Center, Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, Boulder, CO. 2pp, https://nccasc.colorado.edu/sites/default/files/2023-08/grasslands_woody_encroachment_FINAL.pdf.
- **Oldfather, M.,** Ennis, A., **Rangwala, I.**, **Clark-Wolf, K.**, **Littlefield, C.**, and **Robe, H.** (2023). Rapid Climate Assessment–Climate adaptation in the North Central mountains: Alpine tundra and treeline. North Central Climate Adaptation Science Center, Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, Boulder, CO. 4pp, https://nccasc.colorado.edu/sites/default/files/2023-10/Final%20Alpine%20RCAP%204-pager.pdf.
- **Robe, H., Wolken, J., Rangwala, I., Peña, U.**, and Knapp, C. (2024). Downscaled NCA5 Key Messages for Practitioners in the North Central Region, [Web tool: https://nccasc.colorado.edu/nca5-key-messages-tool].
- **Thota S.S.S.P.**, **Rangwala I.**, Rajagopalan B. (2024). Rapid Climate Assessment: Examination of large-scale drivers of water availability in the Northern Great Plains. North Central Climate Adaptation Science Center, University of Colorado Boulder, Boulder, CO, https://nccasc.colorado.edu/sites/default/files/2024-03/Examination%20of%20large-scale%20drivers%20of%20water%20availability%20in%20the%20US%20Great%20Plains%20-%20RCAP%20-%206%20-%20pager%20-%20FINAL.pdf.
- Veselka, A., **Clark-Wolf**, **K.** and **Rangwala, I.** (2024). Rapid Climate Assessment: Climate Change Impact Assessment for the Upper Missouri River Breaks National Monument. North Central Climate Adaptation Science Center, Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, Boulder, CO. 27 pp, https://nccasc.colorado.edu/sites/default/files/2024-10/FINAL - UMRBNM.pdf.

Media mentions and interviews:

- ***Clark-Wolf, K.** (November 3, 2023): Michael Booth with *The Colorado Sun* reports on wildfire research by NC CASC scientist, Colorado lakes can tell a happy story about wildfires. But for how much longer?, https://coloradosun.com/2023/11/03/colorado-forest-wildfire-resiliency-climate-change/.
- ***Clark-Wolf, K.** and **Higuera, P.** (October 17, 2023): This web story by Stephanie Maltarich in the *Cooperative Institute for Research in Environmental Sciences* at the University of Colorado Boulder highlights published research by NC CASC scientists, Subalpine forests in the Northern Rockies are fire resilient—for now, https://cires.colorado.edu/news/subalpine-forests-northern-rockies-are-fire-resilient%E2%80%94-now.
- **Higuera, P.E.** (January 2025): As Big Sky firefighters return from L.A. wildfires, experts warn of growing risk at home. *Explore Big Sky,* https://www.explorebigsky.com/as-big-sky-firefighters-return-from-l-a-wildfires-experts-warn-of-growing-risk-at-home/66367.
- **Higuera, P.E.** (August 30, 2024): These Oregon ranchers say the losses from summer range fires will be huge. *NPR National News,* https://www.npr.org/transcripts/g-s1-19942.
- **Higuera, P.E. (**March 28, 2024): Montana researchers say quick wildfire suppression leads to larger, more intense fires. *Daily Montanan,* https://dailymontanan.com/2024/03/28/montana-researchers-say-quick-wildfire-suppression-leads-to-larger-more-intense-fires/.
- **Yocum, H.** and **Miller Hesed, C.** (August 14, 2023): This web story by Stephanie Maltarich in the *Cooperative Institute for Research in Environmental Sciences* at the University of Colorado Boulder highlighted the new grasslands report that synthesizes research needed to adapt to climate change.

The CU Boulder-led project focuses on actionable science to address next steps, https://cires.colorado.edu/news/new-grasslands-report-synthesizes-research-needed-adapt-climate-change.