<u>Project Title:</u> The Wind River Indian Reservation's Vulnerability to the Impacts of Drought and the Development of Decision Tools to Support Drought Preparedness

<u>Principal Investigator (PI):</u> Dr. Cody Knutson, Research Associate Professor and Leader of the Planning and Social Science Program, National Drought Mitigation Center (NDMC), School of Natural Resources, University of Nebraska-Lincoln, (402) 472-6718, cknutson1@unl.edu

<u>Project Contact:</u> Jeanne Wicks, Director, Office of Sponsored Programs, University of Nebraska-Lincoln, unlosp@unl.edu

<u>Co-PIs:</u> Mitchel Cottenoir, Tribal Water Engineer, Shoshone and Arapaho Tribes Office of the Tribal Water Engineer; Jennifer Wellman, Hydrologist, Wyoming Experimental Program to Stimulate Competitive Research (EPSCoR) Coordinator at Wind River Reservation; Dr. Shannon McNeeley, Research Scientist, Colorado State University/North Central Climate Science Center (NCCSC); and Mark Svoboda, Climatologist and Leader of the Monitoring Program, NDMC, University of Nebraska-Lincoln
<u>Project Management Team (PMT):</u> The PIs listed above plus Northern Arapaho Tribal Liaison, Gary Collins, and Al C'Bearing, Baptiste Weed, Jim Pogue, Office of the Tribal Water Engineer

<u>Proposed start date and estimated duration of project:</u> 6/1/15-5/31/17 (24 months)
<u>Total funding requested from the CSC</u>: $393,618
<u>Other funding sources:</u> NOAA National Integrated Drought Information System Office, NCCSC/Colorado State University, USDA Northern Plains Regional Climate Hub, High Plains Regional Climate Center, University of Wyoming (EPSCoR), NOAA Western Water Assessment; Wyoming State Climate Office

<u>Keywords:</u> adaptation, decision-making, drought, tribal, vulnerability, Wind River

<u>Project Summary:</u>
The Wind River Indian Reservation (WRIR) in west-central Wyoming is home to the Eastern Shoshone and Northern Arapaho tribes who reside near and depend on snowpack and glacier-fed tributaries to the Wind River, headwaters of the Missouri Basin. The region experiences frequent, severe drought events that cause devastating impacts to the social and ecological systems. The WRIR does not have an established process for collecting drought-related data or managing drought conditions. Therefore, this project will conduct an assessment of key climatological and social-ecological vulnerabilities, risks, and response capacities of the WRIR to inform the development of a drought management plan. This is essential for allocating critical water resources to meet agricultural and other societal needs while maintaining ecosystem health. It will be guided by tribal needs, Traditional Ecological Knowledge (TEK) and indigenous observations of drought, and will utilize collaborative community outreach and education efforts. The project will apply innovative vulnerability assessment models and methods and serve as a leading example for other tribes' drought preparedness. The project team will leverage the activities of several state and federal agencies in the region to achieve project goals. This project will add to the scientific base of integrated social-ecological-climate vulnerability assessment, as well as document the process and "lessons learned" to be transferred to other tribes and vulnerable communities throughout the north central region and beyond.

B. General Public Summary

This project will conduct an interdisciplinary, technical assessment of key social-ecological vulnerabilities, risks, and response capacities of the Wind River Indian Reservation (WRIR) to inform development of decision tools to support drought preparedness. It will also provide opportunities for 1) development of tribal technical capacity for drought preparedness, and 2) educational programming guided by tribal needs, Traditional Ecological Knowledge (TEK), and indigenous observations of drought for tribal members, with a longer-term goal of transferring lessons learned to other tribes and non-tribal entities. This project has foundational partnerships between the Eastern Shoshone and Northern Arapaho tribes of the WRIR, the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln, the North Central Climate Science Center (NCCSC) at Colorado State University and multiple government agencies and university partners to develop decision tools to support drought preparedness. The project's decision target is a WRIR Drought Management Plan that integrates state-of-the art climate science with hydrologic, social, and ecological vulnerabilities and risks, and identifies response capacities and strategies to support the Tribal Water Code and related resources management.

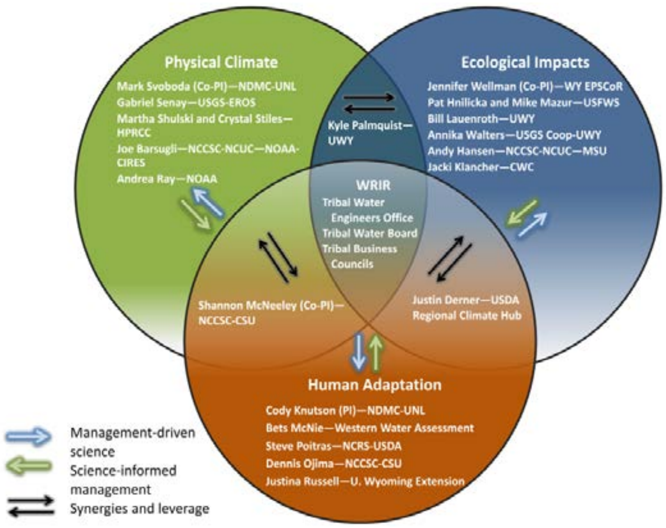
C. Proposal Body

Objectives/Justification: Native American communities throughout the US north central region are among the most vulnerable to drought and climate change, yet they often lack access to data and information, and technical expertise to prepare for it.[1] The Wind River Indian Reservation (WRIR) in west-central Wyoming does not have a systematic, reservation-wide process for collecting/utilizing relevant drought and climate-related information or the tools necessary for reducing the impacts of frequent, severe drought. The WRIR leadership has identified the following drought priorities: managing water and vegetation on agricultural and rangelands; minimizing impacts on ungulates (moose, deer, elk) and subsistence harvest and cultural activities; protecting fisheries health (native trout species, riparian corridor, and instream flows); and maintaining human health and well-being. Therefore, project objectives include: 1) To understand WRIR vulnerability and risks to drought impacts and inform tribal drought responses and preparedness planning by conducting a scientifically rigorous, culturally and tribally-driven, participatory, and interdisciplinary social-ecological systems (SES) vulnerability and risk assessment; 2) To engage tribal resource managers and co-produce usable drought-related information and tools to support decision making on the WRIR and foster technical capacity building, and engage other local and regional Department of Interior, tribal and non-tribal agencies; 3) To engage the tribal community, youth, and elders in drought science and preparedness educational programs to facilitate multi-generational and Traditional Ecological Knowledge (TEK) approaches to land, water, wildlife, and livestock management.; 4) To ensure research outcomes are actionable for drought preparedness and decision making on the WRIR and "best practices/lessons learned" transferable to other resources managers by ongoing evaluation of the project.

Background: The WRIR encompasses 2.2 million acres of semi-arid landscape that includes irrigated agriculture, desert grasslands, sagebrush steppe, and alpine, forested areas. The reservation is home to the Eastern Shoshone and Northern Arapaho tribes, a community of approximately 12,000 people who depend on snowpack and glacier-fed tributaries to the Wind River, headwaters of the Missouri Basin.[2] The region is also home to several native species of concern, including the rare Yellowstone cutthroat trout (*Oncorhynchus clarkii*) and Greater Sage-grouse (*Centrocercus urophasianus).* The region experiences frequent, severe drought events that cause devastating impacts to the social and ecological systems. For example, during the extreme 2012-2013 drought, reduced spring runoff led to a management crisis and drastically reduced summer irrigation season, which forced several local cattle producers to liquidate their herds and caused productive agricultural fields to die.[3] Other local social-ecological drought impacts include reduced instream flows for riparian ecosystem health and fisheries, altered vegetation (i.e., reduced plant biomass and mortality) that affect wildlife and livestock, increased frequency and severity of wildfires that lead to rangeland invasive grasses such as cheat grass (*Bromus tectorum*), and stress on municipal water systems. As a result, there is an urgent need for improved drought science to identify vulnerabilities and reduce drought-related risk.

This project will help coordinate and leverage multiple ongoing research and outreach programs. The High Plains Regional Climate Center (HPRCC), National Drought Mitigation Center (NDMC), CSU/North Central Climate Science Center (NCCSC), and NOAA National Integrated Drought Information System (NIDIS) are working with the WRIR tribes to create a climate/drought newsletter to inform management activities, which will be enhanced by the proposed vulnerability research and education activities. Wyoming EPSCoR has established an office on the WRIR to provide technical resources and water science education throughout the community, which this project will leverage. This project also aligns with the Great Northern Landscape Conservation Cooperative's (GNLCC) goal of maintaining hydrologic regimes and aquatic integrity/connectivity that support native or desirable aquatic plant and animal communities. The WRIR includes this goal in the Tribal Water Code to utilize instream flows to support Yellowstone Cutthroat Trout and other native species' habitat and protecting cultural uses of water in the Wind River watershed.[4] Co-PI, McNeeley, also began conducting interviews as part of the larger NCCSC Drought Risk and Adaptation in the Interior (DRAI) effort in September 2014. McNeeley conducted six interviews with tribal water managers to understand their issues, knowledge, and observations related to drought impacts and risks on the WRIR. All interviewees expressed the need for the drought vulnerability research proposed herein.

Procedures/Methods: This project will follow the NCCSC ReVAMP (Resource for Vulnerability, Adaptation, and Mitigation Planning) approach[5] to address the research question of key social-ecological drought-related vulnerabilities on the WRIR, which will inform improvements in monitoring, management, and communication (Fig 1). Also, two Co-PIs and the Northern Arapaho liaison, Collins, attended the 2014 National Conservation Training Center training in Jackson, WY on Climate Change Vulnerability Assessment, and will use the tools and employ culturally-relevant approaches to focus on the tribes' drought priorities. A WRIR technical advisory group formed during this training that has met almost weekly since and will continue to meet with the project management team (PMT) to advise on research design, data collection, analyses, and outreach.



Objective 1 Methods: *Social-Ecological Systems Vulnerability Assessment.* The project will follow the four phases of the Glick et al. framework to work with the tribes to identify the decision target; conduct a vulnerability assessment of climate exposure, sensitivity, and adaptive capacity; identify response strategies; and implement the strategies. The decision target here is a WRIR drought management plan. Drought risk and adaptation are both social and biophysical processes.[6] So, we take the analysis further to include the social analysis of the social-ecological system following the approach of Turner et al. (2003) and others.[7,8] This approach includes humans as actors in the system, and social climate exposures, sensitivities, coping mechanisms, responses, and adaptations. An integrated social-ecological systems (SES) scientific approach to climate change, drought risk and adaptive capacity assessments ask who, what, where, how, and when "on the ground" was affected by a particular climate stressor.[9,10] Capacity to respond to drought can also be limited by social, political, and regulatory barriers, which are important to understand to build capacity and implement adaptation plans and strategies.[11–13] This approach will facilitate "ground truthing" drought indicators to local/regional conditions to support natural resources management, and the integration of western science with indigenous observations and TEK.[14]

A. Human Adaptation Social Science (Leads: McNeeley and Knutson)

The Drought Risk and Adaptation in the Interior (DRAI) project is an ongoing activity of the NCCSC, and this project will leverage funding from the NCCSC foundational science areas to apply the science and tools from those activities to the WRIR. The research employs an iterative, SES approach, to include the utilization of drought indicators with natural resource managers' knowledge and observations by conducting key stakeholder interviews and workshops. Initial, exploratory interviews with tribal water managers were conducted on the WRIR in September 2014. Additional interviews will be conducted in Year 1 of the project to inform the evolution of this larger interdisciplinary research effort and will inform the climate and ecosystems analyses of drought indicators proposed. This iterative approach does not determine vulnerabilities and adaptive capacities a priori, but rather, with the stakeholders themselves.[15] This is extremely important for working with tribes to build cross-cultural trust and relationships. This approach requires empirically documenting and analyzing these aspects of decision making through interviews with tribal managers and analysis of those interviews alongside drought indicators to get a full picture of drought risk. NCCSC adaptation science co-lead, McNeeley, implemented this approach working with tribes in Alaska and found that the approach elucidated nuances of local biophysical and social experience that were masked by conventional statistical analysis of trends.[16] For this proposed project, questions asked will be about the local indicators used to understand drought in their landscape, decision calendars, and coping and adaptive capacities to both respond to and prepare for future extreme drought. Data collected will be analyzed via qualitative and quantitative data analysis using Atlas.ti (www.atlasti.com) analytical software and a modified grounded theory approach to identify the determinants of vulnerability adaptive capacity. This is an inductive approach of coding nominal variables, themes, and relationships in narrative data that can then be queried and geo-coded to analyze patterns among and linkages between variables.[17–21]

For agricultural landscapes on the WRIR, drought management also involves increasing the resilience of agricultural enterprises that are vulnerable to many production risks.[22] The WRIR is in the beginning phase of an Agricultural Resource Management Plan (ARMP) process (funded by the BIA), which this project will work with to provide additional assessment capacity of agricultural drought risk. The purpose of the ARMP is to provide the framework to manage and monitor Indian agricultural lands within the boundary of the WRIR, and understanding drought and climate change will be critical to this effort. The local USDA NRCS office along with the USDA Northern Plains Regional Climate Hub will support this effort by extending lessons learned from an Adaptive Grazing Management grazing project in Colorado that addressed multiple livestock production and vegetation objectives (see http://www.ars.usda.gov/Main/Docs.htm?docid=24218) in the face of changing drought and other climatic conditions (see USDA letter of support).

B. Physical Climate Science (Lead: Svoboda)

i. Historical drought analysis: The DRAI interviews will inform creation of local "drought stories" that include drought risk perceptions, decisions, adaptive capacities, past climate trends, and climate projections. Seasonal timing of impacts along with local decision calendars and drought indicators will be used to identify the most important data sets, the parameters of analysis, and the temporal and spatial scales of that analysis. Data from the HPRCC will be used to analyze historical and context-relevant precipitation and temperature data to create regional storylines for historical trends that are place- and decision-context specific. This analysis will provide the basic climatological history for temperature and precipitation trends in the region to compare with interviews and drought indicators and projections described below. The NDMC Drought Risk Atlas (DRA) (http://droughtatlas.unl.edu) will be used for conducting drought-indices and historical drought climatology analyses for those stations in and around the WRIR. The DRA brings precise climatological data down to spatial scales that allows decision makers to better understand drought characteristics (frequency, severity, duration, magnitude) in their region and to make more informed decisions. The Standardized Precipitation Index, Standardized Precipitation-Evapotranspiration Index, Palmer Drought Severity Index, Deciles and the United States Drought Monitor, and other climate data are included in the DRA. The project team will work to use the DRA to localize these data at the appropriate temporal and spatial scales for the land and resource units, management decisions, and needs identified through interviews with tribal managers. We will use the Vegetation Drought Response Index (VegDRI) as it integrates satellite-based observations of vegetation conditions, climate data, and other biophysical information such as land cover/land use type, soil characteristics, and ecological setting. We will also use a satellite-based operational actual evapotranspiration (ET) dataset from USGS EROS, which captures drought signals within diverse ecosystems, including irrigated and rainfed crop systems in addition to rangelands. These dataset are operationally updated every 10-days. The historical dataset is available since 2000 and is based on the MODerate resolution Imaging Spectroradiometer (MODIS) Thermal sensor with a spatial resolution of 1 km. An example of contrasting ET anomalies for wet (2011) and dry (2012) seasons are shown for the study site in Figure 2.

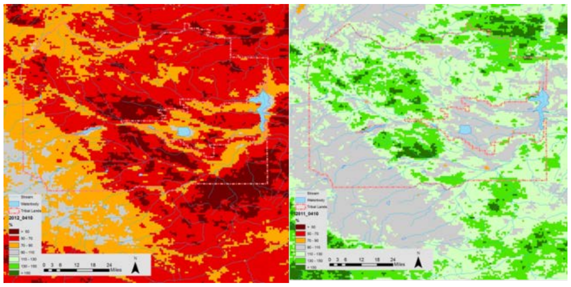


Fig 2. Remote sensing based seasonal (Apr-Oct) ET anomaly for wet 2011 (left) and below normal conditions in 2012 (right). Gray is normal; "green" above normal; and "red" is below normal, as low as 50% lower ET than average years (2000-2013).

ii. Future Climate Projections: The NCCSC is in the early stage of conducting a drought-climate analysis across the central and northern Great Plains that we plan to leverage. Historic drought trend analyses may be augmented with gridded data (DAYMET and PRISM), and climate derivatives, such as potential evapotranspiration, soil moisture levels, and heat indices for various thresholds for plants and livestock, as they are ready and relevant to the other research findings in this study. The NCCSC drought-climate analysis will also investigate drought characteristics in climate projections from the Coupled Model Intercomparison Project phases 3 and 5 (CMIP3 and CMIP5) and in downscaled data derived from these climate projections, which were analyzed and reported on in the IPCC Fourth Assessment Report (AR-4), the US National Climate Assessment, and the recently released IPCC AR-5, respectively. Downscaled datasets at the USGS GeoDataPortal, and from the NASA NEX project will be readily available for evaluation and analysis of the WRIR lands. Methods for PET sensitivity analysis will include standard sensitivity analyses of the Penman-Monteith formulation by computing the partial derivative with respect to the forcing variables, filtered on time scales from daily, monthly, annual, and long-term (projected) change. Methods for identifying drivers will include standard correlation and regression analyses, including pattern-based analyses. The NCCSC foundational climate science team (Barsugli) will provide analysis of drought projections and scenarios, which will rely on analysis of the raw, daily CMIP5 GCM output and existing statistically downscaled datasets. The NASA NEX dataset using the BCSD downscaling method is already in use in several projects in the NCCSC.[23] To obtain a complete suite of hydrologic projections, the new statistically downscaled CMIP5 climate and hydrology (http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html), which uses a different variant of the BCSD method, will also be evaluated.

C. **Ecological Impacts (Lead: Wellman**)

Because of the participatory, iterative nature of this project, much of the ecosystem modeling work will be determined as the team moves forward with the tribes to determine their needs. That said, as a start we propose that Drs. Lauenroth and Palmquist, UW, and Dr. Bradford, USGS, utilize a process-based soil water balance model (SOILWAT) to produce maps of current and future (RCP4.5 & RCP8.5) soil water balance for the WRIR. SOILWAT uses daily precipitation and temperature data, monthly information about vegetation structure (i.e. rooting depth, biomass), and soil attributes from multiple soil layers to model all components of daily water balance, including interception, evaporation, infiltration, percolation, and transpiration.[24–26] Output variables from the model include all components of the water balance, including soil water content for each soil layer, calculated on daily, monthly, and annual time scales. Particularly useful output that could inform drought planning efforts on the WRIR include the start and end of dry periods and the total number of days soil layers are dry. Past, present or future climate inputs generated from GCMs can be inputted into SOILWAT. Thus, this simulation modeling approach can estimate current soil water status or predict how soil water resources will change in the future.[27,28] This modeling approach can also be the basis for inference about how plant biomass and composition (i.e. grasses, shrubs, trees) will change on the WRIR in response to shifting soil water availability. Available data will allow us to simulate the reservation at a 10 km^2 grid scale (~90 grid cells). With additional resources we can collect new weather data and run the simulations at a 1 km^2 scale (~9000 grid cells).

In addition, the PMT will collaborate with Dr. Annika Walters from the USGS University of Wyoming Cooperative Unit. Walters is an expert in applied aquatic ecology and population and community ecology, fisheries, and conservation biology. She will explore the resistance and resilience of aquatic communities to disturbance in the Wind River Basin, based in part, on information derived from her participation in the BLM Rapid Ecoregional Assessment for the Wyoming Basin (http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas.html).

D. Integration and Synthesis (Lead: McNeeley)

Co-PI, McNeeley, will lead the science integration and synthesis effort with expertise in integration across knowledge types, including TEK.[16,29] McNeeley played a lead role in synthesizing enormous amounts of information across disciplines and sectors for the National Climate Assessment's Great Plains technical report and Adaptation chapter.[1,30] McNeeley will lead the team integration efforts by synthesizing existing literature as well as outcomes from the scientific activities proposed herein to provide both scientific reports as well as culturally-relevant and usable materials for the tribes themselves. This will also follow other tribal efforts such as was conducted for the Navajo.[31]

Objective 2 Methods (Lead: Cottenoir) *Engagement with tribal resource managers and decision support tool development.* The results from the social, ecological, and climate analyses will be integrated using a Geographic Information System (GIS) to co-produce information relevant to decision making on the WRIR. Using a collaborative process, technical staff from the WRIR Office of the Tribal Water Engineer (including Shoshone and Arapaho student interns) and the NCCSC will support data integration for visualizing drought impacts and vulnerabilities with ESRI ArcGIS mapping software. In addition, through localizing State Climate Office, HPRCC, and NDMC data and tools (e.g., Drought Risk Atlas, USDM, DIR, and VegDRI) for WRIR tribal managers, the results from the social and climate analyses will be used to create site-specific regional "drought stories" for scientists and managers to use. These stories will include a tailored compilation of interview highlights, drought maps, indices, and (where appropriate) projections for their region. The Water Resources Data System and Wyoming State Climate Office (WRDS/SCO) at UWY also provides climatological and hydrologic data for state, federal, and local agencies, funded by the Wyoming Water Development Commission. The WRDS/SCO will support the WRIR in acquiring climate data to assist with ongoing drought preparedness efforts as well as provide precipitation gauges, at no cost, to members of the tribal community to collect precipitation data through CoCoRaHS program (Community Collaborative Rain, Hail and Snow Network). They can also provide WRIR with E/T gauges to compliment precipitation measurements to further "ground truth" the analyses. Results will be shared with other tribal resource managers through project training workshops. This capacity building will allow WRIR partners to provide input on local conditions into WRIR climate/drought updates and the U.S. Drought Monitor.

Objective 3: (Leads: Cottenoir, Wellman) *Community, youth, and non-tribal managers' engagement.* Utilizing the research results and input from tribal leadership, the PMT will leverage WY EPSCoR resources to develop outreach materials that display historic and contemporary approaches to drought assessment and management on the WRIR. Audio-visual presentations and materials that highlight local and traditional means of adapting and responding to drought will enable students, community members, elders, and outside agencies to contribute to understanding drought and climate change. Fieldtrips to local stock watering ponds, range units, and irrigation facilities will engage the community and non-tribal managers in understanding *in situ* techniques for water management and habitat protection. In addition, students and community members will tour drinking water and wastewater treatment facilities to comprehend the science and practice of water use on the WRIR and discuss strategies for protecting human health and water resources in the future. The project will partner with local schools, the Boys' and Girls' Club, and the Wind River Community 4-H Program to engage youth in mapping their watershed and identifying potential future challenges to land and water management. Utilizing the outdoor classroom in various locations on the WRIR will allow students and community members to inventory water bodies on the WRIR and become more familiar with drought science; engaging inquiry-based learning and hands-on hydrologic understanding of drought.

Objective 4 Methods: *Procedural and Project Evaluation and Transferring Best Practices/Lessons Learned.* We will partner on this objective with the NOAA RISA Western Water Assessment (WWA) at University of Colorado, Boulder (leveraging WWA resources), which has extensive experience in conducting and evaluating "actionable research," that is, research that is co-produced with stakeholders to ensure that the information produced is relevant, is of high quality, and is trusted by the users to be free from political suasion or bias. WWA participation in this project will be undertaken in collaboration with the PMT (and a post-doc from the NDMC). First, we will collect baseline evaluation data on stakeholder expectations and metrics for success at a NIDIS-funded drought preparedness workshop planned for October 21-22 at WRIR. Second, a preliminary assessment will be conducted of the research and programmatic design to recommend adjustments to research and engagement agendas. Third, continuous assessment will be conducted throughout the duration of the project to recommend additional adjustments as necessary to optimize programmatic functions. Fourth, an evaluation of the research program upon its completion will be carried out to identify what knowledge was produced, how it was or was not used by stakeholders, and why the information and engagement processes were considered useful. This work will be conducted in a manner that is non-invasive, time efficient, and culturally sensitive.

Geographic Scope: Wind River Indian Reservation with lessons learned distributed nationally.

Expected Results and Products: The project's decision target is a WRIR Drought Management Plan that integrates state-of-the art climate science along with hydrological, social, and ecological vulnerabilities, risks, and response capacities and strategies necessary to support the management framework set forth by the Tribal Water Code and the Joint Business Council. Products from this work will include multiple reports, scientific publications, and GIS maps of historical, current, and future climate, soil moisture content for WRIR at daily, monthly, and annual time scales. A comprehensive document will be produced synthesizing and outlining these project results along with audio-visual materials described above. This project will include "ground truthing" drought indicator data with local knowledge and use a data management plan approved by the tribes. The outcomes of this research will inform the Office of the Tribal Water Engineer, Wind River Water Resources Control Board and the Eastern Shoshone and Northern Arapaho Business Councils to enhance the current process for declaring drought conditions, allocating scarce water resources, and for water resource protection on the reservation. It will also add to the scientific base of

integrated social-ecological-climate vulnerability assessment as well as document the process and "lessons learned" to be transferred to other tribes, agencies and vulnerable communities throughout the north central region and beyond.[32]
Technology/Information Transfer: Project results will be made available to tribal officials and students on the WRIR. This project will also benefit from NDMC and NIDIS' expertise in supporting other tribal efforts. Products from those efforts are transferrable to this project and vice versa.[33–35] This will add to the scientific base of integrated social-ecological-climate vulnerability assessment as well as document the process and "best practices/lessons learned" to be transferred. We will also coordinate with state and regional conservation efforts to make sure that scientific results are distributed more broadly; these include the Great Northern Landscape Conservation Cooperative (GNLCC), the Wyoming Landscape Conservation Initiative (WLCI), the Indian Nations Conservation Alliance (INCA), the Institute for Tribal Environmental Professionals (ITEP), UCAR Rising Voices of Indigenous People in Weather and Climate Science, the American Indian Higher Education Consortium (AIHEC), and, of course, the NCCSC, other CSCs, and NCCWSC. ***Documentation of Management Application/Relevance:*** At the beginning of the project, the team and Western Water Assessment will gather preliminary information about the expectations of stakeholders (including the NCCSC and the LCC) regarding what constitutes utility and success for the project and what processes of engagement may prove useful when working on this project. The project team also includes investigators from the Wind River Indian Reservation, which will help ensure that project outputs meet tribal needs. ***Cooperators/Partners:*** *Technical Advisory Committee:* Gary Collins, Arapaho Tribal Liaison; Shoshone Tribal Liaison [tbd]; Pat Hnilicka/Mike Mazur, USFWS, Lander; Steve Poitras, NRCS, Fort Washakie; Jacki Klancher, Central Wyoming College; Jolene Catron, Air Quality Coordinator, Wind River Enviro. Quality Commission; Justina Russell, UW Ext., WRIR. *Other Collaborators:* Martha Shulski/Crystal Stiles, High Plains Regional Climate Center, UNL; The NCCSC science leads Barsugli, Hansen, Ojima; NCCSC USGS/NCUC staff; Lisa Dilling/Elizabeth McNie, NOAA Western Water Assessment; Annika Walters, USGS Coop; Chad McNutt, NOAA NIDIS; Justin Derner, USDA Northern Plains Regional Climate Hub; Indy Burke, Bill Lauenroth, Kyle Palmquist, UW; John Bradford, USGS; Chris Nicholson, WY State Climate Office. Due to space limitations, full contact information for all partners is available upon award or request. ***Facilities/Equipment/Study Area(s):*** NDMC & HPRCC labs and the NCCSC facilities including Arc GIS support & the RAM (Resource for Advanced Modeling) at USGS. The Office of the Tribal Water Engineer also has GIS/computing capacity for the project.
Work Plan and Schedule of Activities:

	Year 1		Year 2	
Task	Q1-Q2	Q3-Q4	Q1-Q2	Q3-Q4
Conduct/analyze interviews with WRIR resource managers	X	X		
WRIR meetings, workshops, webinars	X	X	X	X
Summarize findings from DRAI interviews on drought indicators		X	X	X
Geocoding and GIS mapping of management decisions		X	X	
Ground truthing of drought indicators	X	X	X	X
Climate and ecological impacts projections			X	X
Workshops with managers on results		X		X
Summarize all results in usable formats for scientists and managers	X	X	X	X

Qualifications of Project Personnel: see CV's for qualifications. ***Legal and Policy-Sensitive Aspects:*** Authorization from the Shoshone and Arapaho Business Councils and the Joint Tribes Wind River Water Resource Control Board. ***Human Subjects:*** Approval by UNL's and CSU's Institutional Review Boards will be obtained.

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